Title: Encyclopaedia Britannica, 11th Edition, "Indole" to "Insanity"

Author: Various

Release date: June 16, 2012 [EBook #40009]

Language: English

Credits: Produced by Marius Masi, Don Kretz and the Online
Distributed Proofreading Team at http://www.pgdp.net

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THE ENCYCLOPÆDIA BRITANNICA

A DICTIONARY OF ARTS, SCIENCES, LITERATURE AND GENERAL INFORMATION

ELEVENTH EDITION

VOLUME XIV SLICE V

Indole to Insanity

Articles in This Slice

INDOLE, or Benzopyrrol, C_8H_7N, a substance first prepared by A. Baeyer in 1868. It may be synthetically obtained by distilling oxindole (C_8H_8NO) with zinc dust; by heating ortho-nitrocinnamic acid with potash and iron filings; by the reduction of indigo blue; by the action of sodium ethylate on ortho-aminochlorstyrene; by boiling aniline with dichloracetaldehyde; by the dry distillation of ortho-tolyloxamic acid; by heating aniline with dichloracetal; by distilling a mixture of calcium formate and calcium anilidoacetate; and by heating pyruvic acid phenyl hydrazone with anhydrous zinc chloride. It is also formed in the pancreatic fermentation of albumen, and, in small quantities, by passing the vapours of mono- and dialkyl-anilines through a red-hot tube. It crystallizes in shining leaflets, which melt at 52° C. and boil at 245° C. (with decomposition), and is volatile in a current of steam. It is a feeble base, and gives a cherry-red coloration with a pine shaving. Many derivatives of indole are known. B-methylindol or skatole occurs in human faeces.

INDONESIAN, a term invented by James Richardson Logan to describe the light-coloured non-Malay inhabitants of the Eastern Archipelago. It now denotes all those peoples of Malaysia and Polynesia who are not to be classified as Malays or Papuans, but are of Caucasic type. Among these are the Battaks of north Sumatra; many of the Bornean Dyaks and Philippine Islanders, and the large brown race of east Polynesia which includes Samoans, Maoris, Tongans, Tahitians, Marquesas Islanders and the Hawaiians.

See J. Richardson Logan, *The Languages and Ethnology of the Indian Archipelago* (1857).

INDORE, a native state of India in the central India agency, comprising the dominions of the Maharaja Holkar. Its area, exclusive of guaranteed holdings on which it has claims, is 9500 sq. m. and the population in 1901 was 850,690, showing a decrease of 23% in the decade, owing to the results of famine. As in the case of most states in central India the territory is not homogeneous, but distributed over several political charges. It has portions in four out of the seven charges of central India, and in one small portion in the Rajputana agency. The Vindhya range traverses the S. division of the state in a direction from east to west, a small part of the territory lying to the north of the mountains, but by much the larger part to the south. The latter is a portion of the valley of the Nerbudda, and is bounded on the south by the Satpura hills. Basalt and other volcanic formations predominate in both ranges, although there is also much sandstone. The Nerbudda flows through the state; and the valley at Mandlesar, in the central part, is between 600 and 700 ft. above the sea. The revenue is estimated at £350,000. The metre gauge railway from Khandwa to Mhow and Indore city, continued to Neemuch and Ajmere, was constructed in 1876.

The state had its origin in an assignment of lands made early in the 18th century to Malhar Rao Holkar, who held a command in the army of the Mahratta Peshwa. Of the Dhangar or shepherd caste, he was born in 1694 at the village of Hol near Poona, and from this circumstance the family derives its surname of Holkar. Before his death in 1766 Malhar Rao had added to his assignment large territorial possessions acquired by his armed power during the confusion of the period. By the end of that century the rulership had passed to another leader of the same clan, Tukoji Holkar, whose son, Jaswant Rao, took an important part in the contest for predominance in the Mahratta confederation. He did not, however, join the combined army of Sindha and the raja of Berar in their war against the British in 1803, though after its termination he provoked hostilities which led to his complete discomfiture. At first he defeated a British force that had marched against him under Colonel Monson; but when he made an inroad into British territory he was completely defeated by Lord Lake, and compelled to sign a treaty which deprived him of a large portion of his possessions. After his death his favourite mistress, Tulsi Bai, assumed the regency, until in 1817 she was murdered by the military

commanders of the Indore troops, who declared for the peshwa on his rupture with the British government. After their defeat at Mehidpur in 1818, the state submitted by treaty to the loss of more territory, transferred to the British government its suzerainty over a number of minor tributary states, and acknowledged the British protectorate. For many years afterwards the administration of the Holkar princes was troubled by intestine quarrels, misrule and dynastic contentions, necessitating the frequent interposition of British authority; and in 1857 the army, breaking away from the chief's control, besieged the British residency, and took advantage of the mutiny of the Bengal sepoys to spread disorder over that part of central India. The country was pacified after some fighting. In 1899 a British resident was appointed to Indore, which had formerly been directly under the agent to the governor-general in central India. At the same time a change was made in the system of administration, which was from that date carried on by a council. In 1903 the Maharaja, Shivaji Rao Holkar, G.C.S.I., abdicated in favour of his son Tukoji Rao, a boy of twelve, and died in 1908.

The City of Indore is situated 1738 ft. above the sea, on the river Saraswati, near its junction with the Khan. Pop. (1901) 86,686. These figures do not include the tract assigned to the resident, known as "the camp" (pop. 11,118), which is under British administration. The city is one of the most important trading centres in central India.

Indore Residency, a political charge in central India, is not co-extensive with the state, though it includes all of it except some outlying tracts. Area, 8960 sq. m.; pop. (1901) 833,410.

(J. S. Co.)

INDORSEMENT, or Endorsement (from Med. Lat. *indorsare*, to write upon the *dorsum*, or back), anything written or printed upon the back of a document. In its technical sense, it is the writing upon a bill of exchange, cheque or other negotiable instrument, by one who has a right to the instrument and who thereby transmits the right and incurs certain liabilities. See Bill of Exchange.

INDO-SCYTHIANS, a name commonly given to various tribes from central Asia, who invaded northern India and founded kingdoms there. They comprise the Sakas, the Yue-Chi or Kushans and the Ephthalites or Hūnas.

INDRA, in early Hindu mythology, god of the clear sky and greatest of the Vedic deities. The origin of the name is doubtful, but is by some connected with *indu*, drop. His importance is shown by the fact that about 250 hymns celebrate his greatness, nearly one-fourth of the total number in the Rig Veda. He is represented as specially lord of the elements, the thunder-god. But Indra was more than a great god in the ancient Vedic pantheon. He is the patron-deity of the invading Aryan race in India, the god of battle to whose help they look in their struggles with the dark aborigines. Indra is the child of Dyaus, the Heaven. In Indian art he is represented as a man with four arms and hands; in two he holds a lance and in the third a thunderbolt. He is often painted with eyes all over his body and then he is called Sahasraksha, "the thousand eyed." He lost much of his supremacy when the triad Brahma, Siva and Vishnu became predominant. He gradually became identified merely with the headship of Swarga, a local vice-regent of the abode of the gods.

See A. A. Macdonell, *Vedic Mythology* (Strassburg, 1897).

INDRE, a department of central France, formed in 1790 from parts of the old provinces of Berry, Orléanais, Marche and Touraine. Pop. (1906) 290,216. Area 2666 sq. m. It is bounded N. by the department of Loir-et-Cher, E. by Cher, S. by Creuse and Haute-Vienne, S.W. by Vienne and N.W. by Indre-et-Loire. It takes its name from the river Indre, which flows through it. The surface forms a vast plateau divided into three districts, the Boischaut, Champagne and Brenne. The Boischaut is a large well-wooded plain comprising seven-tenths of the entire area and covering the south, east and centre of the department. The Champagne, a monotonous but fertile district in the north, produces abundant cereal crops, and affords excellent pasturage for large numbers of sheep, celebrated for the fineness of their wool. The Brenne, which occupies the west of the department, was formerly marshy and unhealthy, but draining and afforestation have brought about considerable improvement.

The department is divided into the arrondissements of Châteauroux, Le Blanc, La Châtre and Issoudun, with 23 cantons and 245 communes. At Neuvy-St-Sépulchre there is a circular church of the 11th century, to which a nave was added in the 12th century, and at Mézières-en-Brenne there is an interesting church of the 14th century. At Levroux there is a fine church of the 13th century and the remains of a feudal fortress, and there is a magnificent château in the Renaissance style at Valençay.

INDRE-ET-LOIRE, a department of central France, consisting of nearly the whole of the old province of Touraine and of small portions of Orléanais, Anjou and Poitou. Pop. (1906) 337,916. Area 2377 sq. m. It is bounded N. by the departments of Sarthe and Loir-et-Cher, E. by Loir-et-Cher and Indre, S. and S.W. by Vienne and W. by Maine-et-Loire. It takes its name from the Loire and its tributary the Indre, which enter it on its eastern border and unite not far from

its western border. The other chief affluents of the Loire in the department are the Cher, which joins it below Tours, and the Vienne, which waters the department's southern region. Indre-et-Loire is generally level and comprises the following districts: the Gâtine, a pebbly and sterile region to the north of the Loire, largely consisting of forests and heaths with numerous small lakes; the fertile Varenne or valley of the Loire; the Champeigne, a chain of vine-clad slopes, separating the valleys of the Cher and Indre; the Véron, a region of vines and orchards, in the angle formed by the Loire and Vienne; the plateau of Sainte-Maure, a hilly and unproductive district in the centre of which are found extensive deposits of shell-marl; and in the south the Brenne, traversed by the Claise and the Creuse and forming part of the marshy territory which extends under the same name into Indre.

Indre-et-Loire is divided into the arrondissements of Tours, Loches and Chinon, with 24 cantons and 282 communes. The chief town is Tours, which is the seat of an archbishopric; and Chinon, Loches, Amboise, Chenonceaux, Langeais and Azay-le-Rideau are also important places with châteaus. The Renaissance château of Ussé, and those of Luynes (15th and 16th centuries) and Pressigny-le-Grand (17th century) are also of note. Montbazon possesses the imposing ruins of a square donjon of the 11th and 12th centuries. Preuilly has the most beautiful Romanesque church in Touraine. The Sainte Chapelle (16th century) at Champigny is a survival of a château of the dukes of Bourbon-Montpensier. The church of Montrésor (1532) with its mausoleum of the family of Montrésor; that of St Denis-Hors (12th and 16th century) close to Amboise, with the curious mausoleum of Philibert Babou, minister of finance under Francis I. and Henry II.; and that of Ste Catherine de Fierbois, of the 15th century, are of architectural interest. The town of Richelieu, founded 1631 by the famous minister of Louis XIII., preserves the enceinte and many of the buildings of the 17th century. Megalithic monuments are numerous in the department.

INDRI, a Malagasy word believed to mean "there it goes," but now accepted as the designation of the largest of the existing Malagasy (and indeed of all) lemurs. Belonging to the family *Lemuridae* (see Primates) it typifies the subfamily *Indrisinae*, which includes the avahi and the sifakas (*q.v.*). From both the latter it is distinguished by its rudimentary tail, measuring only a couple of inches in length, whence its name of *Indris brevicaudatus*. Measuring about 24 in. in length, exclusive of the tail, the indri varies considerably in colour, but is usually black, with a variable number of whitish patches, chiefly about the loins and on the fore-limbs. The forests of a comparatively small tract on the east coast of Madagascar form its home. Shoots, flowers and berries form the food of the indri, which was first discovered by the French traveller and naturalist Pierre Sonnerat in 1780.

(R. L.*)

INDUCTION (from Lat. *inducere*, to lead into; cf. Gr. ἐπαγωγή), in logic, the term applied to the process of discovering principles by the observation and combination of particular instances. Aristotle, who did so much to establish the laws of deductive reasoning, neglected induction, which he identified with a complete enumeration of facts; and the schoolmen were wholly concerned with syllogistic logic. A new era opens with Bacon, whose writings all preach the principle of investigating the laws of nature with the purpose of improving the conditions of human life. 502 Unluckily his mind was still enslaved by the formulae of the quasi-mechanical scholastic logic. He supposed that natural laws would disclose themselves by the accumulation and due arrangement of instances without any need for original speculation on the part of the investigator. In his *Novum Organum* there are directions for drawing up the various kinds of lists of instances. For two hundred years after Bacon's death little was done towards the theory of induction; the reason being, probably, that the practical scientists knew no logic, while the university logicians, with their conservative devotion to the syllogism, knew no science. Whewell's *Philosophy of the Inductive Sciences* (1840), the work of a thoroughly equipped scientist, if not of a great philosopher, shows due appreciation of the cardinal point neglected by Bacon, the function of theorizing in inductive research. He saw that science advances only in so far as the mind of the inquirer is able to suggest organizing ideas whereby our observations and experiments are colligated into intelligible system. In this respect J. S. Mill is inferior to Whewell: throughout his *System of Logic* (1843) he ignores the constitutive work of the mind, and regards knowledge as the merely passive reception of sensuous impressions. His work was intended mainly to reduce the procedure of induction to a regular demonstrative system like that of the syllogism; and it was for this purpose that he formulated his famous Four Methods of Experimental Inquiry. His work has contributed greatly to the systematic treatment of induction. But it must be remarked that his Four Methods are not methods of formal proof, as their author supposed, but methods whereby hypotheses are suggested or tested. The actual proof of an hypothesis is never formal, but always lies in the tests of experiment or observation to which it is subjected.

The current theory of induction as set forth in the standard works is so far satisfactory that it combines the merit of Whewell's treatment with that of Mill's; and yet it is plain that there is much for the logician of the future to accomplish. The most important faculty in scientific inquiry is the faculty of suggesting new and valuable hypotheses. But no one has ever given any explanation how the hypotheses arise in the mind: we attribute it to "genius," which, of course, is no explanation at all. The logic of discovery, in the higher sense of the term, simply has no existence. Another important but neglected province of the subject is the relation of scientific induction to the inductions of everyday life. There are some who think that a study of this relation would quite transform the accepted view of induction. Consider such a piece of reasoning as may be heard any day in a court of justice, a detective who explains how in his opinion a certain burglary was effected. If all reasoning is either deductive or inductive, this must be induction. And yet it does not answer to the accepted definition of induction, "the process of discovering a general principle by observation of particular instances": what the detective does is to reconstruct a particular crime; he evolves no general principle. Such reasoning is used by every man in every hour of his life: by it we understand what people are doing around us, and what is the meaning of the sense-impressions which we receive. In the logic of the future it will probably be recognized that scientific induction is only one form of this universal constructive or reconstructive faculty. Another most important question closely akin to that just mentioned is the true relation between these reasoning processes and our general life as active intelligent beings. How is it that the detective is able to understand the burglar's plan of action?—the military commander to forecast the enemy's plan of campaign? Primarily, because he himself is capable of making such plans. Men as active creatures co-operating with their fellow-men are incessantly engaged in forming plans and in apprehending the plans of those around them. Every plan may be viewed as a form of induction; it is a scheme invented to meet a given situation, an hypothesis which is put to the test of events, and is verified or refuted by practical success

or failure. Such considerations widen still farther our view of scientific induction and help us to understand its relation to ordinary human thought and activity. The scientific investigator in his inductive stage is endeavouring to make out the plan on which his material is constructed. The phenomena serve as indications to help him in framing his hypothesis, generally a guess at first, which he proceeds to verify by experiment and the collection of additional facts. In the deductive stage he assumes that he has made out the plan and can apply it to the discovery of further detail. He has the capacity of detecting plans in nature because he is wont to form plans for practical purposes.

There are good recent accounts of induction in Welton's *Manual of Logic*, ii., in H. W. B. Joseph's *Introduction to Logic*, and in W. R. Boyce Gibson's *Problem of Logic*; see also LOGIC.

(H. ST.)

INDUCTION COIL, an electrical instrument consisting of two coils of wire wound one over the other upon a core consisting of a bundle of iron wires. One of these circuits is called the primary circuit and the other the secondary circuit. If an alternating or intermittent continuous current is passed through the primary circuit, it creates an alternating or intermittent magnetization in the iron core, and this in turn creates in the secondary circuit a secondary current which is called the induced current. For most purposes an induction coil is required which is capable of giving in the secondary circuit intermittent currents of very high electromotive force, and to attain this result the secondary circuit must as a rule consist of a very large number of turns of wire. Induction coils are employed for physiological purposes and also in connexion with telephones, but their great use at the present time is in connexion with the production of high frequency electric currents, for Röntgen ray work and wireless telegraphy.

Early history.

The instrument began to be developed soon after Faraday's discovery of induced currents in 1831, and the subsequent researches of Joseph Henry, C. G. Page and W. Sturgeon on the induction of a current. N. J. Callan described in 1836 the construction of an electromagnet with two separate insulated wires, one thick and the other thin, wound on an iron core together. He provided the primary circuit of this instrument with an interrupter, and found that when the primary current was rapidly intermitted, a series of secondary currents was induced in the fine wire, of high electromotive force and considerable strength. Sturgeon in 1837 constructed a similar coil, and provided the primary circuit with a mercury interrupter operated by hand. Various other experimentalists took up the construction of the induction coil, and to G. H. Bachhoffner is due the suggestion of employing an iron core made of a bundle of fine iron wires. At a somewhat later date Callan constructed a very large induction coil containing a secondary circuit of very great length of wire. C. G. Page and J. H. Abbot in the United States, between 1838 and 1840, also constructed some large induction coils.[1] In all these cases the primary circuit was interrupted by a mechanically worked interrupter. On the continent of Europe the invention of the automatic primary circuit interrupter is generally attributed to C. E. Neeff and to J. P. Wagner, but it is probable that J. W. M'Gauley, of Dublin, independently invented the form of hammer break now employed. In this break the magnetization of the iron core by the primary current is made to attract an iron block fixed to the end of a spring, in such a way that two platinum points are separated and the primary circuit thus interrupted. It was not until 1853 that H. L. Fizeau added to the break the condenser which greatly improved the operation of the coil. It 1851 H. D. Rühmkorff (1803-1877), an instrument-maker in Paris, profiting by all previous experience, addressed himself to the problem of increasing the electromotive force in the secondary circuit, and induction coils with a secondary circuit of long fine wire have generally, but unnecessarily, been called Rühmkorff coils. Rühmkorff, however, greatly lengthened the secondary circuit, employing in some coils 5 or 6 m. of wire. The secondary wire was insulated with silk and shellac varnish, and each layer of wire was separated from the next by means of varnished silk or shellac paper; the secondary circuit was also carefully insulated from the primary circuit by a glass tube. Rühmkorff, by providing with his coil an automatic break of the hammer type, and equipping it with a condenser as suggested by Fizeau, arrived at the modern form of induction coil. J. N. Hearder in England and E. S. Ritchie in the United States began the construction of large coils, the last named constructing a specially large one to the order of J. P. Gassiot in 1858. In the following decade A. Apps devoted great attention to the production of large induction coils, constructing some of the most powerful coils in existence, and introduced the important improvement of making the secondary circuit of numerous flat coils of wire insulated by varnished or paraffined paper. In 1869 he built for the old Polytechnic Institution in London a coil having a secondary circuit 150 m. in length. The diameter of the wire was 0.014 in., and the secondary bobbin when complete had an external diameter of 2 ft. and a length of 4 ft. 10 ins. The primary bobbin weighed 145 lb, and consisted of 6000 turns of copper wire 3770 yds. in length, the wire being .095 of an inch in diameter. Excited by the current from 40 large Bunsen cells, this coil could give secondary sparks 30 in. in length. Subsequently, in 1876, Apps constructed a still larger coil for William Spottiswoode, which is now in the possession of the Royal Institution. The secondary circuit consisted of 280 m. of copper wire about 0.01 of an inch in diameter, forming a cylinder 37 in. long and 20 in. in external diameter; it was wound in flat disks in a large number of separate sections, the total number of turns being 341,850. Various primary circuits were employed with this coil, which when at its best could give a spark of 42 in. in length.

Construction.

A general description of the mode of constructing a modern induction coil, such as is used for wireless telegraphy or Röntgen ray apparatus, is as follows: The iron core consists of a bundle of soft iron wires inserted in the interior of an ebonite tube. On the outside of this tube is wound the primary circuit, which generally consists of several distinct wires capable of being joined either in series or parallel as required. Over the primary circuit is placed another thick ebonite tube, the thickness of the walls of which is proportional to the spark-producing power of the secondary circuit. The primary coil must be wholly enclosed in ebonite, and the tube containing it is generally longer than the secondary bobbin. The second circuit consists of a number of flat coils wound up between paraffined or shellaced paper, much as a sailor coils a rope. It is essential that no joints in this wire shall occur in inaccessible places in the interior. A machine has been devised by Leslie Miller for winding secondary circuits in flat sections without any joints in the wire at all (British Patent, No. 5811, 1903). A coil intended to give a 10 or 12 in. spark is generally wound in this fashion in several hundred sections, the object of this mode of division being to prevent any two parts of the secondary circuit which are at great differences of potential from being near to one another, unless effectively insulated by a sufficient thickness of shellaced or paraffined paper. A 10-in. coil, a size very commonly used for Röntgen ray work or wireless telegraphy, has an iron core made of a bundle of soft iron wires No. 22 S.W.G., 2 in. in diameter and 18 in. in length. The primary coil wound over this core consists of No. 14 S.W.G. copper wire, insulated with white silk laid on in three layers and having a resistance of about half an ohm. The insulating ebonite tube for such a coil should not be less than ¼ in. in thickness, and should have two ebonite cheeks on it placed 14 in. apart. This tube is supported on two hollow pedestals down which the ends of the primary wire are brought. The secondary coil consists of No. 36 or No. 32 silk-covered copper wire, and each of the sections is prepared by winding, in a suitable winding machine, a flat coiled wire in such a way that the two ends of the coil are on the outside. The coil should not be wound

in less than a hundred sections, and a larger number would be still better. The adjacent ends of consecutive sections are soldered together and insulated, and the whole secondary coil should be immersed in paraffin wax. The completed coil (fig. 1) is covered with a sheet of ebonite and mounted on a base board which, in some cases, contains the primary condenser within it and carries on its upper surface a hammer break. For many purposes, however, it is better to separate the condenser and the break from the coil. Assuming that a hammer break is employed, it is generally of the Apps form. The interruption of the primary circuit is made between two contact studs which ought to be of massive platinum, and across the break points is joined the primary condenser. This consists of a number of sheets of paraffined paper interposed between sheets of tin foil, alternate sheets of the tin foil being joined together (see Leyden Jar). This condenser serves to quench the break spark. If the primary condenser is not inserted, the arc or spark which takes place at the contact points prolongs the fall of magnetism in the core, and since the secondary electromotive force is proportional to the rate at which this magnetism changes, the secondary electromotive force is greatly reduced by the presence of an arc-spark at the contact points. The primary condenser therefore serves to increase the suddenness with which the primary current is interrupted, and so greatly increases the electromotive force in the secondary circuit. Lord Rayleigh showed (*Phil. Mag.*, 1901, 581) that if the primary circuit is interrupted with sufficient suddenness, as for instance if it is severed by a bullet from a gun, then no condenser is needed. No current flows in the secondary circuit so long as a steady direct current is passing through the primary, but at the moments that the primary circuit is closed and opened two electromotive forces are set up in the secondary; these are opposite in direction, the one induced by the breaking of the primary circuit being by far the stronger. Hence the necessity for some form of circuit breaker, by the continuous action of which there results a series of discharges from one secondary terminal to the other in the form of sparks.

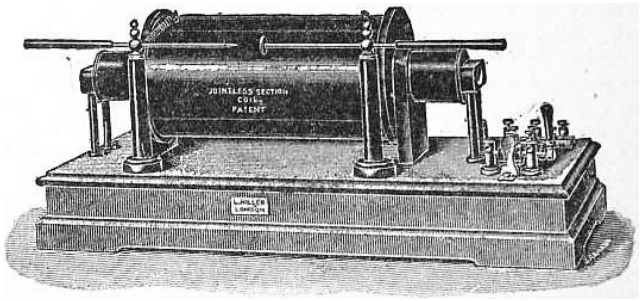


FIG. 1.

Interrupters or Breaks.

The hammer break is somewhat irregular in action and gives a good deal of trouble in prolonged use; hence many other forms of primary circuit interrupters have been devised. These may be classified as (1) hand- or motor-worked dipping interrupters employing mercury or platinum contacts; (2) turbine mercury interrupters; (3) electrolytic interrupters. In the first class a steel or platinum point, operated by hand or by a motor, is periodically immersed in mercury and so serves to close the primary circuit. To prevent oxidation of the mercury by the spark and break it must be covered with oil or alcohol. In some cases the interruption is caused by the continuous rotation of a motor either working an eccentric which operates the plunger, or, as in the Mackenzie-Davidson break, rotating a slate disk having a metal stud on its surface, which is thus periodically immersed in mercury in a vessel. A better class of interrupter is the mercury turbine interrupter. In this some form of rotating turbine pump pumps mercury from a vessel and squirts it in a jet against a copper plate. Either the copper plate or the jet is made to revolve rapidly by a motor, so that the jet by turns impinges against the plate and escapes it; the mercury and plate are both covered with a deep layer of alcohol or paraffin oil, so that the jet is immersed in an insulating fluid. In a recent form the chamber in which the jet works is filled with coal gas. The current supplied to the primary circuit of the coil travels from the mercury in the vessel through the jet to the copper plate, and hence is periodically interrupted when the jet does not impinge against the plate. Mercury turbine breaks are much employed in connexion with large induction coils used for wireless telegraphy on account of their regular action and the fact that the number of interruptions per second can be controlled easily by regulating the speed of the motor which rotates the jet. But all mercury breaks employing paraffin or alcohol as an insulating medium are somewhat troublesome to use because of the necessity of periodically cleaning the mercury. Electrolytic interrupters were first brought to notice by Dr A. R. B. Wehnelt in 1898 (*Elektrotechnische Zeitschrift*, January 20th, 1899). He showed that if a large lead plate was placed in dilute sulphuric acid as a cathode, and a thick platinum wire protruding for a distance of about one millimetre beyond a glass or porcelain tube into which it tightly fitted was used as an anode, such an arrangement when inserted in the circuit of a primary coil gave rise to a rapid intermittency in the primary current. It is essential that the platinum wire should be the anode or positive pole. The frequency of the Wehnelt break can be adjusted by regulating the extent to which the platinum wire protrudes through the porcelain tube, and in modern electrolytic breaks several platinum anodes are employed. This break can be employed with any voltage between 30 and 250. The Caldwell interrupter, a modification of the Wehnelt break, consists of two electrodes immersed in dilute sulphuric acid, one of them being enclosed by a glass vessel which has a small hole in it capable of being more or less closed by a tapered glass plug. It differs from the Wehnelt break in that there is no platinum to wear away and it requires less current; hence finer regulation of the coil to the current can be obtained. It will also work with either direct or alternating currents. The hammer and mercury turbine breaks can be arranged to give interruptions from about 10 per second up to about 50 or 60. The electrolytic breaks are capable of working at a higher speed, and under some conditions will give interruptions up to a thousand per second. If the secondary terminals of the induction coils are connected to spark balls placed a short distance apart, then with an electrolytic break the discharge has a flame-like character resembling an alternating current arc. This type of break is therefore preferred for Röntgen ray work since it makes less flickering upon the screen, but its advantages in the case of wireless telegraphy are not so marked. In the Grisson interrupter the primary circuit of the induction coil is divided into two parts by a middle terminal, so that a current flowing in at this point and dividing equally between the two halves does not magnetize the iron. This terminal is connected to one pole of the battery, the other two terminals being connected alternately to the opposite pole by means of a revolving commutator which (1) passes a current through one half of the primary, thus magnetizing the core; (2) passes a current through both halves in opposite directions, thus annulling the magnetization; (3) passes a current through the second half of the primary, thus reversing the magnetization of the core; and (4) passes a current in both halves through opposite directions, thus again annulling the magnetization. As this series of operations can be performed without interrupting a large current through the inductive circuit there is not much spark at the commutator, and the speed of commutation can be regulated so as to obtain the best results due to a resonance between the primary and secondary circuits. Another device due to Grisson is the electrolytic condenser interrupter. If a plate of aluminium and one of carbon or iron is placed in an electrolyte yielding oxygen, this aluminium-carbon or aluminium-iron cell can pass current in one direction but not in the other. Much greater resistance is experienced by a

current flowing from the aluminium to the iron than in the opposite direction, owing to the formation of a film of aluminic hydroxide on the aluminium. If then a cell consisting of a number of aluminium plates alternating with iron plates or carbon in alkaline solution is inserted in the primary circuit of an induction coil, the application of an electromotive force in the right direction will cause a transitory current to flow through the coil until the electrolytic condenser is charged. By the use of a proper commutator the position of the electrolytic cell in the circuit can be reversed and another transitory primary current created. This interrupted flow of electricity through the primary circuit provides the intermittent magnetization of the core necessary to produce the secondary electromotive force. This operation of commutation can be conducted without much spark at the commutator because the circuit is interrupted at the time when there is no current in it. In the case of the electrolytic condenser no supplementary paraffined paper condenser is necessary as in the case of the hammer or mercury interrupters.

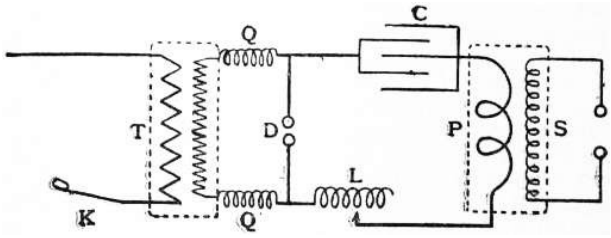


FIG. 2.—Arrangements for producing High Frequency Currents.

T, Transformer or induction coil.
Q, Q, Choking coils.
D, Spark balls.
C, Condenser.
L, Inductance.
P, Primary circuit of high frequency coil.
S, Secondary circuit.

High Frequency Coils.

An induction coil for the transformation of alternating current is called a transformer (*q.v.*). One type of high frequency current transformer is called an *oscillation transformer* or sometimes a *Tesla coil*. The construction of such a coil is based on different principles from that of the coil just described. If the secondary terminals of an ordinary induction coil or transformer are connected to a pair of spark balls (fig. 2), and if these are also connected to a glass plate condenser or Leyden jar of ordinary type joined in series with a coil of wire of low resistance and few turns, then at each break of the primary circuit of the ordinary induction coil a secondary electromotive force is set up which charges the Leyden jar, and if the spark balls are set at the proper distance, this charge is succeeded by a discharge consisting of a movement of electricity backwards and forwards across the spark gap, constituting an oscillatory electric discharge (see ELECTROKINETICS). Each charge of the jar may produce from a dozen to a hundred electric oscillations which are in fact brief electric currents of gradually decreasing strength. If the circuit of few turns and low resistance through which this discharge takes place is overlaid with another circuit well insulated from it consisting of a large number of turns of finer wire, the inductive action between the two circuits creates in the secondary a smaller series of electric oscillations of higher potential. Between the terminals of this last-named coil we can then produce a series of discharges each of which consists in an extremely rapid motion of electricity to and fro, the groups of oscillations being separated by intervals of time corresponding to the frequency of the break in the primary circuit of the ordinary induction coil charging the Leyden jar or condenser. These high frequency discharges differ altogether in character from the secondary discharges of the ordinary induction coil. Theory shows that to produce the best results the primary circuit of the oscillation transformer should consist of only one thick turn of wire or, at most, but of a few turns. It is also necessary that the two circuits, primary and secondary, should be well insulated from one another, and for this purpose the oscillation transformer is immersed in a box or vessel full of highly insulating oil. For full details N. Tesla's original Papers must be consulted (see *Journ. Inst. Elect. Eng.* 21, 62).

In some cases the two circuits of the Tesla coil, the primary and secondary, are sections of one single coil. In this form the arrangement is called a *resonator* or *auto transformer*, and is much used for producing high frequency discharges for medical purposes. The construction of a resonator is as follows: A bare copper wire is wound upon an ebonite or wooden cylinder or frame, and one end of it is connected to the outside of a Leyden jar or battery of Leyden jars, the inner coating of which is connected to one spark ball of the ordinary induction coil. The other spark ball is connected to a point on the above-named copper wire not very far from the lower end. By adjusting this contact, which is movable, the electric oscillations created in the short section of the resonator coil produce by resonance oscillations in the longer free section, and a powerful high frequency electric brush or discharge is produced at the free end of the resonator spiral. An electrode or wire connected with this free end therefore furnishes a high frequency glow discharge which has been found to have valuable therapeutic powers.

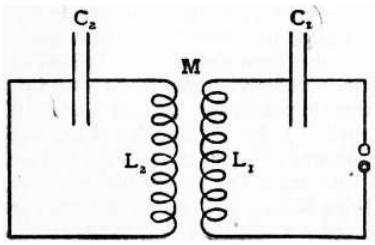


FIG. 3.

C_1, Condenser in primary circuit.
C_2, Condenser in secondary circuit.
L_1, Inductance in primary circuit.
L_2, Inductance in secondary circuit.

The general theory of an oscillation transformer containing capacity and inductance in each circuit has been given by Oberbeck, Bjerknes and Drude.[2] Suppose there are two circuits, each consisting of a coil of wire, the two being superimposed or adjacent, and let each circuit contain a condenser or Leyden jar in series with the circuit, and let one

Theory of Oscillation Transformers. of these circuits contain a spark gap, the other being closed (fig. 3). If to the spark balls the secondary terminals of an ordinary induction coil are connected, and these spark balls are adjusted near one another, then when the ordinary coil is set in operation, sparks pass between the balls and oscillatory discharges take place in the circuit containing the spark gap. These oscillations induce other oscillations in the second circuit. The two circuits have a certain mutual inductance M, and each circuit has self inductance L_1 and L_2. If then the capacities in the two circuits are denoted by C_1 and C_2 the following simultaneous equations express the relation of the currents, i_1 and i_2, and potentials, v_1, and v_2, in the primary and secondary circuits respectively at any instant:—

$$L_1 \frac{di_1}{dt} + M \frac{di_2}{dt} + R_1 i_1 + v_1 = 0,$$
$$L_2 \frac{di_2}{dt} + M \frac{di_1}{dt} + R_2 i_2 + v_2 = 0,$$

R_1 and R_2 being the resistances of the two circuits. If for the moment we neglect the resistances of the two circuits, and consider that the oscillations in each circuit follow a simple harmonic law $i = I \sin pt$ we can transform the above equations into a biquadratic

$$p^4 + p^2 \frac{L_1C_1 + L_2C_2}{C_1C_2\,(L_1L_2 - M^2)} + \frac{1}{C_1C_2(L_1L_2 - M^2)} = 0.$$

The capacity and inductance in each circuit can be so adjusted that their products are the same number, that is $C_1L_1 = C_2L_2 = CL$. The two circuits are then said to be in resonance or to be tuned together. In this particular and unique case the above biquadratic reduces to

$$p^2 = \frac{1}{CL} \cdot \frac{1 \pm k}{1 - k^2},$$

where k is written for $M \surd (L_1L_2)$ and is called the *coefficient of coupling*. In this case of resonant circuits it can also be shown that the maximum potential differences at the primary and secondary condenser terminals are determined by the rule $V_1/V_2 = 2\surd C_2/\surd C_1$. Hence the transformation ratio is not determined by the relative number of turns on the primary and secondary circuits, as in the case of an ordinary alternating current transformer (see TRANSFORMERS), but by the ratio of the capacity in the two oscillation circuits. For full proofs of the above the reader is referred to the original papers.

Each of the two circuits constituting the oscillation transformer taken separately has a natural time period of oscillation; that is to say, if the electric charge in it is disturbed, it oscillates to and fro in a certain constant period like a pendulum and therefore with a certain frequency. If the circuits have the same frequency when separated they are said to be isochronous. If n stands for the natural frequency of each circuit, where $n = p/2\pi$ the above equations show that when the two circuits are coupled together, oscillations set up in one circuit create oscillations of two frequencies in the secondary circuit. A mechanical analogue to the above electrical effect can be obtained as follows: Let a string be strung loosely between two fixed points, and from it let two other strings of equal length hang down at a certain distance apart, each of them having a weight at the bottom and forming a simple pendulum. If one pendulum is set in oscillation it will gradually impart this motion to the second, but in so doing it will bring itself to rest; in like manner the second pendulum being set in oscillation gives back its motion to the first. The graphic representation, therefore, of the motion of each pendulum would be a line as in fig. 4. Such a curve represents the effect in music known as beats, and can easily be shown to be due to the combined effect of two simple harmonic motions or simple periodic curves of different frequency superimposed. Accordingly, the effect of inductively coupling together two electrical circuits, each having capacity and inductance, is that if oscillations are started in one circuit, oscillations of two frequencies are found in the secondary circuit, the frequencies differing from one another and differing from the natural frequency of each circuit taken alone. This matter is of importance in connexion with wireless telegraphy (see TELEGRAPH), as in apparatus for conducting it, oscillation transformers as above described, having two circuits in resonance with one another, are employed.

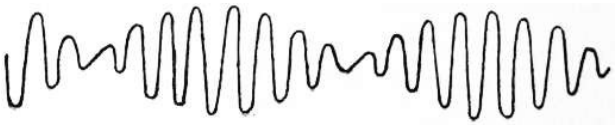


FIG. 4.

REFERENCES.—J. A. Fleming, *The Alternate Current Transformer* (2 vols., London, 1900), containing a full history of the induction coil; id., *Electric Wave Telegraphy* (London, 1906), dealing in chap. i., with the construction of the induction coil and various forms of interrupter as well as with the theory of oscillation transformers; A. T. Hare, *The Construction of Large Induction Coils* (London, 1900); J. Trowbridge, "On the Induction Coil," *Phil. Mag.* (1902), 3, p. 393; Lord Rayleigh, "On the Induction Coil," *Phil. Mag.* (1901), 2, p. 581; J. E. Ives, "Contributions to the Study of the Induction Coil," *Physical Review* (1902), vols. 14 and 15.

(J. A. F.)

1 For a full history of the early development of the induction coil see J. A. Fleming, *The Alternate Current Transformer*, vol. ii., chap. i.

2 See A. Oberbeck, *Wied. Ann.* (1895), 55, p. 623; V. F. R. Bjerknes, d. (1895), 55, p. 121, and (1891), 44, p. 74; and P. K. L. Drude, *Ann. Phys.* (1904), 13, p. 512.

INDULGENCE (Lat. *indulgentia*, *indulgere*, to grant, concede), in theology, a term defined by the official catechism of the Roman Catholic Church in England as "the remission of the temporal punishment which often remains due to sin after its guilt has been forgiven." This remission may be either total (*plenary*) or partial, according to the terms of the Indulgence. Such remission was popularly called a *pardon* in the middle ages—a term which still survives, *e.g.* in Brittany.

The theory of Indulgences is based by theologians on the following texts: 2 Samuel (Vulgate, 2 Kings) xii. 14; Matt. xvi. 19 and xviii. 17, 18; 1 Cor. v. 4, 5; 2 Cor. ii. 6-11; but the practice itself is confessedly of later growth. As Bishop Fisher says in his Confutation of Luther, "in the early church, faith in Purgatory and in Indulgences was less necessary

than now.... But in our days a great part of the people would rather cast off Christianity than submit to the rigour of the [ancient] canons: wherefore it is a most wholesome dispensation of the Holy Ghost that, after so great a lapse of time, the belief in purgatory and the practice of Indulgences have become generally received among the orthodox" (*Confutatio*, cap. xviii.; cf. Cardinal Caietan, *Tract. XV. de Indulg.* cap. i.). The nearest equivalent in the ancient Church was the local and temporary African practice of restoring lapsed Christians to communion at the intercession of confessors and prospective martyrs in prison. But such reconciliations differed from later Indulgences in at least one essential particular, since they brought no remission of ecclesiastical penance save in very exceptional cases. However, as the primitive practice of public penance for sins died out in the Church, there grew up a system of equivalent, or nominally equivalent, private penances. Just as many of the punishments enjoined by the Roman criminal code were gradually commuted by medieval legislators for pecuniary fines, so the years or months of fasting enjoined by the earlier ecclesiastical codes were commuted for proportionate fines, the recitation of a certain number of psalms, and the like. "Historically speaking, it is indisputable that the practice of Indulgences in the medieval church arose out of the authoritative remission, in exceptional cases, of a certain proportion of this canonical penalty." At the same time, according to Catholic teaching, such Indulgence was not a mere permission to omit or postpone payment, but was in fact a *discharge* from the debt of temporal punishment which the sinner owed. The authority to grant such discharge was conceived to be included in the power of binding and loosing committed by Christ to His Church; and when in the course of time the vaguer theological conceptions of the first ages of Christianity assumed scientific form and shape at the hands of the Schoolmen, the doctrine came to prevail that this discharge of the sinner's debt was made through an application to the offender of what was called the "Treasure of the Church" (Thurston, p. 315). "What, then, is meant by the 'Treasure of the Church'?... It consists primarily and completely of the merit and satisfaction of Christ our Saviour. It includes also the superfluous merit and satisfaction of the Blessed Virgin and the Saints. What do we mean by the word 'superfluous'? In one way, as I need not say, a saint has no superfluous merit. Whatever he has, he wants it all for himself, because, the more he merits on earth (by Christ's grace) the greater is his glory in heaven. But, speaking of mere satisfaction for punishment due, there cannot be a doubt that some of the Saints have done more than was needed in justice to expiate the punishment due to their own sins.... It is this 'superfluous' expiation that accumulates in the Treasure of the Church" (Bp. of Newport, p. 166). It must be noted that this theory of the "Treasure" was not formulated until some time after Indulgences in the modern sense had become established in practice. The doctrine first appeared with Alexander of Hales (*c.* 1230) and was at once adopted by the leading schoolmen. Clement VI. formally confirmed it in 1350, and Pius VI. still more definitely in 1794.

The first definite instance of a *plenary* Indulgence is that of Urban II. for the First Crusade (1095). A little earlier had begun the practice of *partial* Indulgences, which are always expressed in terms of days or years. However definite may have been the ideas originally conveyed by these notes of time, their first meaning has long since been lost. Eusebius Amort, in 1735, admits the gravest differences of opinion; and the Bishop of Newport writes (p. 163) "to receive an Indulgence of a year, for example, is to have remitted to one so much temporal punishment as was represented by a year's canonical penance. If you ask me to define the amount more accurately, I say that it cannot be done. No one knows how severe or how long a Purgatory was, or is, implied in a hundred days of canonical penance." The rapid extension of these time-Indulgences is one of the most remarkable facts in the history of the subject. Innocent II., dedicating the great church of Cluny in 1132, granted as a great favour a forty days' Indulgence for the anniversary. A hundred years later, all churches of any importance had similar indulgences; yet Englishmen were glad even then to earn a pardon of forty days by the laborious journey to the nearest cathedral, and by making an offering there on one of a few privileged feast-days. A century later again, Wycliffe complains of Indulgences of two thousand years for a single prayer (ed. Arnold, i. 137). In 1456, the recitation of a few prayers before a church crucifix earned a Pardon of 20,000 years for every such repetition (Glassberger in *Analecta Franciscana*, ii. 368): "and at last Indulgences were so freely given that there is now scarcely a devotion or good work of any kind for which they cannot be obtained" (Arnold & Addis, *Catholic Dictionary*, s.v.). To quote again from Father Thurston (p. 318): "In imitation of the prodigality of her Divine Master, the Church has deliberately faced the risk of depreciation to which her treasure was exposed.... The growing effeminacy and corruption of mankind has found her censures unendurable ... and the Church, going out into the highways and the hedges, has tried to entice men with the offer of generous Indulgence." But it must be noted that, according to the orthodox doctrine, not only can an Indulgence not remit future sins, but even for the past it cannot take full effect unless the subject be truly contrite and have confessed (or intend shortly to confess) his sins.

This salutary doctrine, however, has undoubtedly been obscured to some extent by the phrase *a poena et a culpa*, which, from the 13th century to the Reformation, was applied to Plenary Indulgences. The prima-facie meaning of the phrase is that the Indulgence itself frees the sinner not only from the temporal penalty (*poena*) but also from the guilt (*culpa*) of all his sins: and the fact that a phrase so misleading remained so long current shows the truth of Father Thurston's remark: "The laity cared little about the analysis of it, but they knew that the *a culpa et poena* was the name for the biggest thing in the nature of an Indulgence which it was possible to get" (*Dublin Review*, Jan. 1900). The phrase, however, was far from being confined to the unlearned. Abbot Gilles li Muisis, for instance, records how, at the Jubilee of 1300, all the Papal Penitentiaries were in doubt about it, and appealed to the Pope. Boniface VIII. did indeed take the occasion of repeating (in the words of his Bull) that confession and contrition were necessary preliminaries; but he neither repudiated the misleading words nor vouchsafed any clear explanation of them. (*Chron. Aegidii li Muisis* ed. de Smet, p. 189.) His predecessor, Celestine V., had actually used them in a Bull.

The phrase exercised the minds of learned canonists all through the middle ages, but still held its ground. The most accepted modern theory is that it is merely a catchword surviving from a longer phrase which proclaimed how, during such Indulgences, ordinary confessors might absolve from sins usually "reserved" to the Bishop or the Pope. Nobody, however, has ventured exactly to reconstitute this hypothetical phrase; nor is the theory easy to reconcile with (i.) the uncertainty of canonists at the time when the locution was quite recent, (ii.) the fact that Clement V. and Cardinal Cusanus speak of absolution *a poena et a culpa* as a separate thing from (*a*) plenary absolution and (*b*) absolution from "reserved" sins (Clem. lib. v. tit. ix. c. 2, and Johann Busch (d. *c.* 1480) *Chron. Windeshemense*, cap. xxxvi.). But, however it originated, the phrase undoubtedly contributed to foster popular misconceptions as to the intrinsic value of Indulgences, apart from repentance and confession; though Dr Lea seems to press this point unduly (p. 54 ff.), and should be read in conjunction with Thurston (p. 324 ff.).

These misconceptions were certainly widespread from the 13th to the 16th century, and were often fostered by the "pardoners," or professional collectors of contributions for Indulgences. This can best be shown by a few quotations from eminent and orthodox churchmen during those centuries. Berthold of Regensburg (*c.* 1270) says, "Fie, penny-preacher! ... thou dost promise so much remission of sins for a mere halfpenny or penny, that thousands now trust thereto, and fondly dream to have atoned for all their sins with the halfpenny or penny, and thus go to hell" (ed. Pfeiffer, i. 393).[1] A century later, the author of *Piers Plowman* speaks of pardoners who "give pardon for pence poundmeal about" (*i.e.* wholesale; B. ii. 222); and his contemporary, Pope Boniface IX., complained of their absolving even impenitent sinners for ridiculously small sums (*pro qualibet parva pecuniarum summula*, Raynaldus, *Ann. Ecc.* 1390). In 1450 Thomas Gascoigne, the great Oxford Chancellor, wrote: "Sinners say nowadays 'I care not how many or how great sins I commit before God, for I shall easily and quickly get plenary remission of any guilt and penalty

whatsoever (*cujusdam culpae et poenae*) by absolution and indulgence granted to me from the Pope, whose writing and grant I have bought for 4d. or 6d. or for a game of tennis'"—or sometimes, he adds, by a still more disgraceful bargain (*pro actu meretricio*, Lib. Ver. p. 123, cf. 126). In 1523 the princes of Germany protested to the Pope in language almost equally strong (Browne, *Fasciculus*, i. 354). In 1562 the Council of Trent abolished the office of "pardoner."

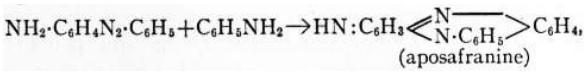
The greatest of all Plenary Indulgences is of course the Roman Jubilee. This was instituted in 1300 by Boniface VIII., who pleaded a popular tradition for its celebration every hundredth year, though no written evidence could be found. Clement VI. shortened the period to 50 years (1350): it was then further reduced to 33, and again in 1475 to 25 years.

See also the article on LUTHER. The latest and fullest authority on this subject is Dr H. C. Lea, *Hist, of Auricular Confession and Indulgences in the Latin Church* (Philadelphia, 1896); his standpoint is frankly non-Catholic, but he gives ample materials for judgment. The greatest orthodox authority is Eusebius Amort, *De Origine, &c., indulgentiarum* (1735). More popular and more easily accessible are Father Thurston's *The Holy Year of Jubilee* (1900), and an article by the Bishop of Newport in the *Nineteenth Century* for January 1901, with a reply by Mr Herbert Paul in the next number.

(G. G. Co.)

1 Equally strong assertions were made by the provincial council of Mainz in 1261; and Lea (p. 287) quotes the complaints of 36 similar church councils before 1538.

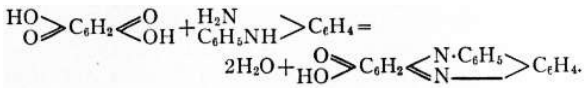
INDULINES, a series of dyestuffs of blue, bluish-red or black shades, formed by the interaction of para-amino azo compounds with primary monamines in the presence of a small quantity of a mineral acid. They were first discovered in 1863 (English patent 3307) by J. Dale and H. Caro, and since then have been examined by many chemists (see O. N. Witt, *Ber.*, 1884, 17, p. 74; O. Fischer and E. Hepp, *Ann.*, 1890, 256, pp. 233 et seq.; F. Kehrmann, *Ber.*, 1891, 24, pp. 584, 2167 et seq.). They are derivatives of the eurhodines (aminophenazines, aminonaphthophenazines), and by means of their diazo derivatives can be de-amidated, yielding in this way azonium salts; consequently they may be considered as amidated azonium salts. The first reaction giving a clue to their constitution was the isolation of the intermediate *azophenin* by O. Witt (*Jour. Chem. Soc.*, 1883, 43, p. 115), which was proved by Fischer and Hepp to be dianilidoquinone dianil, a similar intermediate compound being found shortly afterwards in the naphthalene series. *Azophenin*, $C_{30}H_{24}N_4$, is prepared by warming quinone dianil with aniline; by melting together quinone, aniline and aniline hydrochloride; or by the action of aniline on para-nitrosophenol or para-nitrosodiphenylamine. The indulines are prepared as mentioned above from aminoazo compounds:



$$NH_2{\cdot}C_6H_4N_2{\cdot}C_6H_5+C_6H_5NH_2\rightarrow HN{:}C_6H_3\langle{}^{N}_{N\cdot C_6H_5}\rangle C_6H_4,$$

(aposafranine)

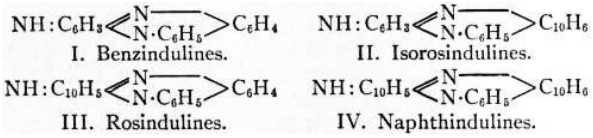
or by condensing oxy- and amido-quinones with phenylated ortho-diamines (F. Kehrmann, *Ber.*, 1895, 28, p. 1714):



$$HO\rangle C_6H_2\langle{}^{O}_{OH}+{}^{H_2N}_{C_6H_5NH}\rangle C_6H_4=$$

$$2H_2O+HO\rangle C_6H_2\langle{}^{N\cdot C_6H_5}_{N}\rangle C_6H_4.$$

The indulines may be subdivided into the following groups:— (1) benzindulines, derivatives of phenazine; (2) isorosindulines; and (3) rosindulines, both derived from naphthophenazine; and (4) naphthindulines, derived from naphthazine.



$NH{:}C_6H_3\langle{}^{N}_{N\cdot C_6H_5}\rangle C_6H_4$ — I. Benzindulines.

$NH{:}C_6H_3\langle{}^{N}_{N\cdot C_6H_5}\rangle C_{10}H_6$ — II. Isorosindulines.

$NH{:}C_{10}H_5\langle{}^{N}_{N\cdot C_6H_5}\rangle C_6H_4$ — III. Rosindulines.

$NH{:}C_{10}H_5\langle{}^{N}_{N\cdot C_6H_5}\rangle C_{10}H_6$ — IV. Naphthindulines.

The rosindulines and naphthindulines have a strongly basic character, and their salts possess a marked red colour and fluorescence. *Benzinduline* (aposafranine), $C_{18}H_{13}N_3$, is a strong base, but cannot be diazotized, unless it be dissolved in concentrated mineral acids. When warmed with aniline it yields anilido-aposafranine, which may also be obtained by the direct oxidation of ortho-aminodiphenylamine. *Isorosinduline* is obtained from quinone dichlorimide and phenyl-β-naphthylamine; *rosinduline* from benzene-azo-α-naphthylamine and aniline and *naphthinduline* from benzene-azo-α-naphthylamine and naphthylamine.

INDULT (Lat. *indultum*, from *indulgere*, grant, concede, allow), a, papal licence which authorizes the doing of something not sanctioned by the common law of the church; thus by an indult the pope authorizes a bishop to grant certain relaxations during the Lenten fast according to the necessities of the situation, climate, &c., of his diocese.

INDUNA, a Zulu-Bantu word for an officer or head of a regiment among the Kaffir (Zulu-Xosa) tribes of South Africa. It is formed from the inflexional prefix *in* and *duna*, a lord or master. Indunas originally obtained and retained their rank and authority by personal bravery and skill in war, and often proved a menace to their nominal lord. Where, under British influence, the purely military system of government among the Kaffir tribes has broken down or been modified, indunas are now administrators rather than warriors. They sit in a consultative gathering known as an indaba, and discuss the civil and military affairs of their tribe.

INDUS, one of the three greatest rivers of northern India.

A considerable accession of exact geographical knowledge has been gained of the upper reaches of the river Indus and its tributaries during those military and political movements which have been so constant on the northern frontiers of India of recent years. The sources of the Indus are to be traced to the glaciers of the great Kailas group of peaks in 32° 20′ N. and 81° E., which overlook the Mansarowar lake and the sources of the Brahmaputra, the Sutlej and the Gogra to the south-east. Three great affluents, flowing north-west, unite in about 80° E. to form the main stream, all of them, so far as we know at present, derived from the Kailas glaciers. Of these the northern tributary points the road from Ladakh to the Jhalung goldfields, and the southern, or Gar, forms a link in the great Janglam—the Tibetan trade route—which connects Ladakh with Lhasa and Lhasa with China. Gartok (about 50 m. from the source of this southern head of the Indus) is an important point on this trade route, and is now made accessible to Indian traders by treaty with Tibet and China. At Leh, the Ladakh capital, the river has already pursued an almost even north-westerly course for 300 m., except for a remarkable divergence to the south-west which carries it across, or through, the Ladakh range to follow the same course on the southern side that had been maintained on the north. This very remarkable instance of transverse drainage across a main mountain axis occurs in 79° E., about 100 m. above Leh. For another 230 m., in a north-westerly direction, the Indus pursues a comparatively gentle and placid course over its sandy bed between the giant chains of Ladakh to the north and Zaskar (the main “snowy range” of the Himalaya) to the south, amidst an array of mountain scenery which, for the majesty of sheer altitude, is unmatched by any in the world. Then the river takes up the waters of the Shyok from the north (a tributary nearly as great as itself), having already captured the Zasvar from the south, together with innumerable minor glacier-fed streams. The Shyok is an important feature in Trans-Himalayan hydrography. Rising near the southern foot of the well-known Karakoram pass on the high road between Ladakh and Kashgar, it first drains the southern slopes of the Karakoram range, and then breaks across the axis of the Muztagh chain (of which the Karakoram is now recognized as a subsidiary extension northwards) ere bending north-westwards to run a parallel course to the Indus for 150 m. before its junction with that river. The combined streams still hold on their north-westerly trend for another 100 m., deep hidden under the shadow of a vast array of snow-crowned summits, until they arrive within sight of the Rakapushi peak which pierces the north-western sky midway between Gilgit and Hunza. Here the great change of direction to the south-west occurs, which is thereafter maintained till the Indus reaches the ocean. At this point it receives the Gilgit river from the north-west, having dropped from 15,000 to 4000 ft. (at the junction of the rivers) after about 500 m. of mountain descent through the independent provinces of northern Kashmir. (See Gilgit.) A few miles below the junction it passes Bunji, and from that point to a point beyond Chilas (50 m. below Bunji) it runs within the sphere of British interests. Then once again it resumes its “independent” course through the wild mountains of Kohistan and Hazara, receiving tribute from both sides (the Buner contribution being the most noteworthy) till it emerges into the plains of the Punjab below Darband, in 34° 10′ N. All this part of the river has been mapped in more or less detail of late years. The hidden strongholds of those Hindostani fanatics who had found a refuge on its banks since Mutiny days have been swept clean, and many ancient mysteries have been solved in the course of its surveying.

In the Himalaya.

The Shyok affluent.

The Gilgit affluent.

From its entrance into the plains of India to its disappearance in the Indian Ocean, the Indus of to-day is the Indus of the ‘fifties—modified only in some interesting particulars. It has been bridged at several important points. There are bridges even in its upper mountain courses. There is a wooden pier bridge at Leh of two spans, and there are native suspension bridges of cane or twig-made rope swaying uneasily across the stream at many points intervening between Leh and Bunji; but the first English-made iron suspension bridge is a little above Bunji, linking up the highroad between Kashmir and Gilgit. Next occurs the iron girder railway bridge at Attock, connecting Rawalpindi with Peshawar, at which point the river narrows almost to a gorge, only 900 ft. above sea-level. Twenty miles below Attock the river has carved out a central trough which is believed to be 180 ft. deep. Forty miles below Attock another great bridge has been constructed at Kushalgarh, which carries the railway to Kohat and the Kurram valley. At Mari, beyond the series of gorges which continue from Kushalgarh to the borders of the Kohat district, on the Sind-Sagar line, a boat-bridge leads to Kalabagh (the Salt city) and northwards to Kohat. Another boat-bridge opposite Dera Ismail Khan connects that place with the railway; but there is nothing new in these southern sections of the Indus valley railway system except the extraordinary development of cultivation in their immediate neighbourhood. The Lansdowne bridge at Sukkur, whose huge cantilevers stand up as a monument of British enterprise visible over the flat plains for many miles around, is one of the greatest triumphs of Indian bridge-making. Kotri has recently been connected with Hyderabad in Sind, and the Indus is now one of the best-bridged rivers in India. The intermittent navigation which was maintained by the survivals of the Indus flotilla as far north as Dera Ismail Khan long after the establishment of the railway system has ceased to exist with the dissolution of the fleet, and the high-sterned flat Indus boats once again have the channels and sandbanks of the river all to themselves.

Indus of the plains.

Within the limits of Sind the vagaries of the Indus channels have necessitated a fresh survey of the entire riverain. The results, however, indicate not so much a marked departure in the general course of the river as a great variation in the channel beds within what may be termed its outside banks. Collaterally much new information has been obtained about the ancient beds of the river, the sites of ancient cities and the extraordinary developments of the Indus delta. The changing channels of the main stream since those prehistoric days when a branch of it found its way to the Runn of Cutch, through successive stages of its gradual shift westwards—a process of displacement which marked the disappearance of many populous places which were more or less dependent on the river for their water supply—to the last and greatest change of all, when the stream burst its way through the limestone ridges of Sukkur and assumed a course which has been fairly constant for 150 years, have all been traced out with systematic care by modern surveyors till the medieval history of the great river has been fully gathered from the characters written on the delta surface. That such changes of river bed and channel should have occurred within a comparatively limited period of time is the less astonishing if we remember that the Indus, like many of the greatest rivers of the world, carries down sufficient detritus to raise its own bed above the general level of the surrounding plains in an appreciable and measurable degree. At the present time the bed of the Indus is stated to be 70 ft. above the plains of the Sind frontier, some 50 m. to the west of it.

Lower Indus and delta.

The total length of the Indus, measured directly, is about 1500 m. With its many curves and windings it stretches to about 2000 m., the area of its basin being computed at 372,000 sq. m. Even at its lowest in winter it is 500 ft. wide at Iskardo (near the Gilgit junction) and 9 or 10 ft. deep. The temperature of the surface water during the cold season in the plains is found to be 5° below that of the air (64° and 69° F.). At the beginning of the hot season, when the river is bringing down snow water, the difference is 14° (87° and 101° June). At greater depths the difference is still greater. At Attock, where the river narrows between rocky banks, a height of 50 ft. in the flood season above lowest level is common, with a velocity of 13 m. per hour. The record rise (since British occupation of the Punjab) is 80 ft. At its junction with the Panjnad (the combined rivers of the Punjab east of the Indus) the Panjnad is twice the width of the Indus, but its mean depth is less, and its velocity little more than one-third. This discharge of the Panjnad at low season is 69,000 cubic ft. per second, that of the Indus 92,000. Below the junction the united discharge in flood season is 380,000 cubic ft., rising to 460,000 (the record in August). The Indus after receiving the other rivers carries down into Sind, in the high flood season, turbid water containing silt to the amount of $\frac{1}{229}$ part by weight, or $\frac{1}{410}$ by volume—equal to 6480 millions of cubic ft. in the three months of flood. This is rather less than the Ganges carries. The silt is very fine sand and clay. Unusual floods, owing to landslips or other exceptional causes, are not infrequent. The most disastrous flood of this nature occurred in 1858. It was then that the river rose 80 ft. at Attock. The most striking result of the rise was the reversal of the current of the Kabul river, which flowed backwards at the rate of 10 m. per hour, flooding Nowshera and causing immense damage to property. The prosperity of the province of Sind depends almost entirely on the waters of the Indus, as its various systems of canals command over nine million acres out of a cultivable area of twelve and a half million acres.

Statistics.

See Maclagan, *Proceedings R.G.S.*, vol. iii.; Haig, *The Indus Delta Country* (London, 1894); Godwin-Austen, *Proceedings R.G.S.* vol. vi.

(T. H. H.*)

INDUSTRIA (mod. Monteù da Po), an ancient town of Liguria, 20 m. N.E. of Augusta Taurinorum. Its original name was Bodincomagus, from the Ligurian name of the Padus (mod. Po), Bodincus, *i.e.* bottomless (Plin. *Hist. Nat.* iii. 122), and this still appears on inscriptions of the early imperial period. It stood on the right bank of the river, which has now changed its course over 1 m. to the north. It was a flourishing town, with municipal rights, as excavations (which have brought to light the forum, theatre, baths, &c.) have shown, but appears to have been deserted in the 4th century A.D.

See A. Fabietti in *Atti della Società di Archeologia di Torino*, iii, 17 seq.; Th. Mommsen in *Corp. Inscrip. Lat.* v. (Berlin, 1877), p. 845; E. Ferrero in *Notizie degli Scavi* (1903), p. 43.

INDUSTRIAL SCHOOL, in England a school, generally established by voluntary contributions, for the industrial training of children, in which children are lodged, clothed and fed, as well as taught. Industrial schools are chiefly for vagrant and neglected children and children not convicted of theft. Such schools are for children up to the age of fourteen, and the limit of detention is sixteen. They are regulated by the Children Act 1908, which repealed the Industrial Schools Act 1866, as amended by Acts of 1872, 1891 and 1901, and parallel legislation in the various Elementary Education Acts, besides some few local acts. The home secretary exercises powers of supervision, &c. See JUVENILE OFFENDERS.

INDUSTRY (Lat. *industria*, from *indu-*, a form of the preposition *in*, and either *stare*, to stand, or *struere*, to pile up), the quality of steady application to work, diligence; hence employment in some particular form of productive work, especially of manufacture; or a particular class of productive work itself, a trade or manufacture. See LABOUR LEGISLATION, &c.

INE, king of the West Saxons, succeeded Ceadwalla in 688, his title to the crown being derived from Ceawlin. In the earlier part of his reign he was at war with Kent, but peace was made in 694, when the men of Kent gave compensation for the death of Mul, brother of Ceadwalla, whom they had burned in 687. In 710 Ine was fighting in alliance with his kinsman Nun, probably king of Sussex, against Gerent of West Wales and, according to Florence of Worcester, he was victorious. In 715 he fought a battle with Ceolred, king of Mercia, at Woodborough in Wiltshire, but the result is not recorded. Shortly after this time a quarrel seems to have arisen in the royal family. In 721 Ine slew Cynewulf, and in 722 his queen Aethelburg destroyed Taunton, which her husband had built earlier in his reign. In 722 the South Saxons, previously subject to Ine, rose against him under the exile Aldbryht, who may have been a member of the West Saxon royal house. In 725 Ine fought with the South Saxons and slew Aldbryht. In 726 he resigned the crown and went to Rome, being succeeded by Aethelheard in Wessex. Ine is said to have built the minster at Glastonbury. The date of his death is not recorded. He issued a written code of laws for Wessex, which is still preserved.

See Bede, *Hist. Eccl.* (Plummer), iv. 15, v. 7; *Saxon Chronicle* (Earle and Plummer), s.a. 688e, 694, 710, 715, 721, 722, 725, 728; Thorpe, *Ancient Laws*, i. 2-25; Sehmid, *Gesetze der Angelsachsen* (Leipzig, 1858); Liebermann, *Gesetzeder Angelsachsen* (Halle, 1898-99).

INEBOLI, a town on the north coast of Asia Minor, 70 m. W. of Sinūb (Sinope). It is the first place of importance touched at by mercantile vessels plying eastwards from Constantinople, being the port for the districts of Changra and Kastamuni, and connected with the latter town by a carriage road (see KASTAMUNI). The roadstead is exposed, having no protection for shipping except a jetty 300 ft. long, so that in rough weather landing is impracticable. The exports (chiefly wool and mohair) are about £248,000 annually and the imports £200,000. The population is about 9000 (Moslems 7000, Christians 2000). Ineboli represents the ancient *Abonou-teichos*, famous as the birthplace of the false prophet Alexander, who established there (2nd century A.D.) an oracle of the snake-God Glycon-Asclepius. This impostor, immortalized by Lucian, obtained leave from the emperor Marcus Aurelius to change the name of the town to *Ionopolis*, whence the modern name is derived (see ALEXANDER THE PAPHLAGONIAN).

INEBRIETY, LAW OF. The legal relations to which inebriety (Lat. *in*, intensive, and *ebrietas*, drunkenness) gives rise are partly civil and partly criminal.

I. *Civil Capacity.*—The law of England as to the civil capacity of the drunkard is practically identified with, and has passed through substantially the same stages of development as the law in regard to the civil capacity of a person suffering from mental disease (see INSANITY). Unless (see III. *inf.*) a modification is effected in his condition by the fact that he has been brought under some form of legal control, a man may, in spite of intoxication, enter into a valid marriage or make a valid will, or bind himself by a contract, if he is sober enough to know what he is doing, and no improper advantage of his condition is taken (cf. *Matthews* v. *Baxter*, 1873, L.R. 8 Ex. 132; *Imperial Loan Co.* v. *Stone*, 1892, 1 Q.B. 599). The law is the same in Scotland and in Ireland; and the Sale of Goods Act 1893 (which applies to the whole United Kingdom) provides that where necessaries are sold and delivered to a person who by reason of drunkenness is incompetent to contract, he must pay a reasonable price for them; "necessaries" for the purposes of this provision mean goods suitable to the condition in life of such person and to his actual requirements at the time of the sale and delivery.

Under the Roman law, and under the Roman Dutch law as applied in South Africa, drunkenness, like insanity, appears to vitiate absolutely a contract made by a person under its influence (*Molyneux* v. *Natal Land and Colonization Co.*, 1905, A.C. 555).

In the United States, as in England, intoxication does not vitiate contractual capacity unless it is of such a degree as to prevent the person labouring under it from understanding the nature of the transaction into which he is entering (Bouvier, *Law Dict.*, s.v. "Drunkenness"; and cf. *Waldron* v. *Angleman*, 1004, 58 Atl. 568; *Fowler* v. *Meadow Brook Water Co.*, 1904, 57 Atl. 959; 208 Penn., 473). The same rule is by implication adopted in the Indian Contract Act (Act ix. of 1872), which provides (s. 12) that "a person is ... of sound mind for the purpose of making a contract if, at the time when he makes it, he is capable of understanding it and of forming a rational judgment as to its effect upon his interests." In some legal systems, however, habitual drunkenness is a ground for divorce or judicial separation (Sweden, Law of the 27th of April 1810; France, Code Civil, Art. 231, *Hirt* v. *Hirt*, Dalloz, 1898, pt. ii., p. 4, and n. 4).

II. *Criminal Responsibility.*—In English law, drunkenness, unlike insanity, was at one time regarded as in no way an excuse for crime. According to Coke (Co. Litt., 247) a drunkard, although he suffers from acquired insanity, *dementia affectata*, is *voluntarius daemon*, and therefore has no privilege in consequence of his state; "but what hurt or ill soever he doth, his drunkenness doth aggravate it." Sir Matthew Hale (P.C. 32) took a more moderate view, viz. that a person under the influence of this voluntarily contracted madness "shall have the same judgment as if he were in his right senses"; and admitted the existence of two "allays" or qualifying circumstances: (1) *temporary* frenzy induced by the unskilfulness of physicians or by drugging; and (2) *habitual* or fixed frenzy. Those early authorities have, however, undergone considerable development and modification.

Although the general principle that drunkenness is not an excuse for crime is still steadily maintained (see Russell, *Crimes*, 6th ed., i. 144; Archbold, *Cr. Pl.*, 23rd ed., p. 29), it is settled law that where a particular intent is one of the constituent elements of an offence, the fact that a prisoner was intoxicated at the time of its commission is relevant evidence to show that he had not the capacity to form that intent. Drunkenness is also a circumstance of which a jury may take account in considering whether an act was premeditated, or whether a prisoner acted in self-defence or under provocation, when the question is whether the danger apprehended or the provocation was sufficient to justify his conduct or to alter its legal character. Moreover, *delirium tremens*, if it produce such a degree of madness as to render a person incapable of distinguishing right from wrong, relieves him from criminal responsibility for any act committed by him while under its influence; and in one case at *nisi prius* (*R.* v. *Baines*, *The Times*, 25th Jan. 1886) this doctrine was extended by Mr Justice Day to temporary derangement occasioned by drink. The law of Scotland accepts, if it does not go somewhat beyond, the later developments of that of England in regard to criminal responsibility in drunkenness. Indian law on the point is similar to the English (Indian Penal Code, Act. xlv. of 1860, ss. 85, 86; Mayne, *Crim. Law of India*, ed. 1896, p. 391). In the United States the same view is the prevalent legal doctrine (see Bishop, *Crim. Law*, 8th ed., i, ss. 397-416). The Criminal Code of Queensland (No. 9 of 1899, Art. 28) provides that a person who becomes intoxicated intentionally is responsible for any crime that he commits while so intoxicated, whether his voluntary intoxication was induced so as to afford an excuse for the commission of an offence or not. As in England, however, when an intention to cause a specific result is an element of an offence, intoxication, whether complete or partial, and whether intentional or unintentional, may be regarded for the purpose of ascertaining whether such intention existed or not. There is a similar provision in the Penal Code of Ceylon (No. 2 of 1883, Art. 79). The Criminal Codes of Canada (1892, c. 29, ss. 7 et seq.) and New Zealand (No. 56 of 1893, ss. 21 et seq.) are silent on the subject of intoxication as an excuse for crime. The Criminal Code of Grenada (No. 2 of 1897, Art. 51) provides that "a person shall not, on the ground of intoxication, be deemed to have done any act involuntarily, or be exempt from any liability to punishment for any act: and a person who does an act while in a state of intoxication shall be deemed to have intended the natural and probable consequences of his act." There is a similar provision in the Criminal Code of the Gold Coast Colony (No. 12 of 1892, s. 54). Under the French Penal Code (Art. 64), "*il n'y a ni crime, ni délit, lorsque le prévenu était en état de démence au temps de l'action ou lorsqu'il aura été contraint par une force à laquelle il n' a pu résister.*" According to the balance of authority (Dalloz, *Rép.* tit., Peine, ss. 402 et seq.) intoxication is not assimilated to insanity, within the meaning of this article, but it may be and is taken account of by juries as an extenuating circumstance (Ortolan, *Droit Pénal* i. s. 323: Chauveau et Hélie i. s. 360). A provision in the German Penal Code (Art. 51) that an act is not punishable if its author, at the time of committing it, was in a condition of unconsciousness, or morbid disturbance of the activity of his mind which prevented the free exercise of his will, has been held not to extend to intoxication (Clunet, 1883, p. 311). But in Germany as in France, intoxication may apparently be an extenuating circumstance. Under the Italian Penal Code (Arts. 46-49) intoxication—unless voluntarily induced so as to afford an excuse for crime—may exclude or modify responsibility.

So far only the question whether drunkenness is an excuse for offences committed under its influence has been dealt with. There remains the question how far drunkenness itself is a crime. Mere private intoxication is not, either in England or in the United States (Bishop, *Crim. Law*, 8th ed., i. s. 399) indictable as an offence at common law; but in all civilized countries public drunkenness is punishable when it amounts to a breach of the peace (see Liquor Laws) or contravention of public order; and modern legislation in many countries provides for deprivation of personal liberty for long periods in case of a frequent repetition of the offence. Reference may be made in this connexion to the Inebriates Acts 1898, 1899 and 1900 (see iii. *inf.*), and also to similar legislation in the British colonies and in foreign legal systems (*e.g.* Cape of Good Hope, No. 32 of 1896; Ceylon, Licensing Ordinance 1891, ss. 23, 24, 29; New South Wales, Vagrants Punishment Act 1866; Massachusetts, Acts of 1891, c. 427, 1893, cc. 414, 44; France, Law of 23rd of Jan. 1873, Art. 6).

III. *State Action in Regard to Inebriety.*—This assumes a variety of forms. (*a*) Measures regulating the punishment of occasional or habitual drunkenness by fines or short terms of imprisonment. (*b*) Control in *penal* establishments for lengthened periods. (*c*) Laws prohibiting the sale of liquor to persons who are known inebriates: *e.g.* in England (Licensing Act 1902); Ontario (Rev. Stats. 1897, c. 245, ss. 124, 125); New South Wales (Liquor Act 1898, ss. 52, 53); Cape of Good Hope (No. 28 of 1883, s. 89); New York (Rev. Stats. 1889-1892, c. 20, Title iv.); California (Act to prevent sale of liquor to drunkards, 1889); Massachusetts (Pub. Stats., ed. 1902, c. 100, s. 9). (*d*) Laws regulating the appointment of some person or persons to act as guardian or guardians, or who may be endowed with legal powers over the person and estate of an inebriate. Thus in France (Code Civil, Arts. 489 et seq.), Germany (Civil Code, Art. 6 (39)) and Austria-Hungary (*Bürgerliches Gesetz-Buch*, ss. 21, 269, 270, 273), an inebriate may be judicially interdicted if he is squandering his property and thereby exposing his family to future destitution. Provision is also made for the interdiction of inebriates by the laws of Nova Scotia (Rev. Stats. 1900, c. 126, s. 2), Manitoba (Rev. Stat. 1902, c. 103, ss. 30 et seq.), British Columbia (Rev. Stat. 1897, c. 66), New South Wales (Inebriates Act 1900, s. 5), Tasmania (Inebriates Act 1885, No. 17, s. 23); Canton of Bâle (Trustee Law of the 23rd of Feb. 1880, s. 11), Orange River Colony (Code Laws, c. 108, s. 30), Maryland (Code General Laws, c. 474, s. 47). (*e*) Control for the purpose of reformation. Legislation of this character provides reformatory treatment: (1) for the inebriate who makes a voluntary application for admission; (2) by compulsory seclusion for the inebriate who refuses consent to treatment and yet manages to keep out of the reach of the law; (3) for the inebriate who is a police-court recidivist, or who has committed crime, caused or contributed to by drink. The legislation of the Cape of Good Hope (Inebriates Act 1896) and of North Dakota (Habitual Drunkards Act 1895) provides for the first of these methods of treatment alone. Compulsory detention for ordinary inebriates only is provided for by the laws of Delaware (Act of 1898), Massachusetts (Rev. Laws, c. 87), and of the Cantons of Berne (Law of the 24th of Nov. 1883) and Bâle (Law of the 21st of Feb. 1901). All three methods of treatment are in force in New South Wales (Inebriates Act 1900), Queensland (Inebriates Institutions Act 1896) and South Australia (Inebriates Act 1881). Provision is made only for voluntary application and compulsory detention of ordinary inebriates in Victoria (Inebriates Act 1890), Tasmania (Inebriates Act 1885; Inebriates Hospitals Act 1892) and New Zealand (Inebriates Institutions Act 1898). The legislation of the United Kingdom (Inebriates Acts 1879-1900) deals both with voluntary application and with the committal of criminal inebriates or of police-court recidivists. A brief sketch of the English system must suffice.

The Inebriates Acts of 1870-1900 deal in the first place with non-criminal, and in the second place with criminal, habitual drunkards.

For the purposes of the acts the term “habitual drunkard” means “a person who, not being amenable to any jurisdiction in lunacy, is notwithstanding, by reason of habitual intemperate drinking of intoxicating liquor, at times dangerous to himself or herself, or incapable of managing himself or herself and his or her affairs.” A person would become amenable to the lunacy jurisdiction not only where habitual drunkenness made him a “lunatic” in the legal sense of the term, but where it created, such a state of disease and consequential “mental infirmity” as to bring his case within section 116 of the Lunacy Act 1890, the effect of which is explained in the article Insanity. Any “habitual drunkard” within the above definition may obtain admission to a “licensed retreat” on a written application to the licensee, stating the time (the maximum period is two years) that he undertakes to remain in the retreat. The application must be accompanied by the statutory declaration of two persons that the applicant is an habitual drunkard, and its signature must be attested by a justice of the peace who has satisfied himself as to the fact, and who is required to state that the applicant understood the nature and effect of his application. Licences (each of which is subject to a duty and is impressed with a stamp of £5, and 10s. for every patient above ten in number) are granted for retreats by the borough council and the town clerk in boroughs, and elsewhere by the county council and the clerk of the county council. The maximum period for which a licence may be granted is two years, but licences may be renewed by the licensing authority on payment of a stamp duty of the same amount as on the original grant. When an habitual drunkard has once been committed to a retreat, he must remain in the retreat for the time that he has fixed in his application, subject to certain statutory provisions similar to those prescribed by the Lunacy Acts for asylums as to leave of absence and discharge; and he may be retaken and brought back to the retreat under a justice’s warrant. The term of detention may be extended on its expiry, or an inebriate may be readmitted, on a fresh application, without any statutory declaration, and without the attesting justice being required to satisfy himself that the applicant is an habitual drunkard. Licensed retreats are subject to inspection by an Inspector of Retreats appointed by the Home Secretary, to whom he makes an annual report. The Home Secretary is empowered to make rules and regulations for the management of retreats, and “regulations and orders,” not inconsistent with such rules, are to be prepared by the licensee within a month after the granting of his licence, and submitted to the inspector for approval. The rules now in force are dated as regards (*a*) England, 28th Feb. 1902; (*b*) Scotland, 14th April 1902; (*c*) Ireland, 3rd Feb. 1903. There are also statutory provisions, similar to those of the Lunacy Acts, as to offences—(i.) by licensees failing to comply with the requirements of the acts; (ii) by persons ill-treating patients, or helping them to escape, or unlawfully supplying them with intoxicating liquor; (iii.) by patients refusing to comply with the rules. The Home Secretary may (i.) authorize the establishment of “State Inebriate Reformatories,” to be paid for out of moneys provided by parliament; and (ii.) sanction “Certified Inebriates’ Reformatories” on the application of any borough or county council, or any person whatever, if satisfied concerning the reformatory and the persons proposing to maintain it. An Inspector of Certified Inebriate Reformatories has been appointed. Regulations for State Inebriate Reformatories and for Certified Inebriate Reformatories have been made, dated as follows: *State Inebriate Reformatories*:—England, 21st of June 1901, 29th of Dec. 1903, 29th of April 1904; Scotland, 9th of March 1900; Ireland, 16th of March 1899, 16th of April 1901, 10th of Feb. 1904. *Certified Inebriate Reformatories*:—England, Model Regulations, 17th of Dec. 1898; Scotland, Regulations, 14th of Feb. 1899; Ireland, Model Regulations, 29th of April 1899.

Any person convicted on indictment of an offence punishable with imprisonment or penal servitude (*i.e.* of any non-capital felony and of most misdemeanours), if the court is satisfied from the evidence that the offence was committed under the influence of drink, or that drink was a contributing cause of the offence, may, if he admits that he is, or is found by the jury to be, an habitual drunkard, in addition to or in substitution for any other sentence, be ordered to be detained in a state or certified inebriate reformatory, the managers of which are willing to receive him. Again, any habitual drunkard who is found drunk in any public place, or who commits any other of a series of similar offences under various statutes, after having within twelve months been convicted at least three times of a similar offence, may,

on conviction on indictment, or, if he consent, on summary conviction, be sent for detention in any certified inebriate reformatory. The expenses of prosecuting habitual drunkards under the above provisions are payable out of the local rates upon an order to that effect by the judge of assize or chairman of quarter-sessions if the prosecution be on indictment, or by a court of summary jurisdiction if the offence is dealt with summarily.

AUTHORITIES.—As to the history of legislation on the subject see Parl. Paper No. 242 of 1872; 1893 C. 7008. See also Wyatt Paine, *Inebriate Reformatories and Retreats* (London, 1899); Blackwell, *Inebriates Acts*, 1879-1898 (London, 1899); Wood Renton, *Lunacy* (London and Edinburgh, 1896); Kerr, *Inebriety* (3rd ed., London, 1894). An excellent account of the systems in force in other countries for the treatment of inebriates will be found in Parl. Pap. (1902), cd. 1474.

(A. W. R.)

INFALLIBILITY (Fr. *infaillibilité* and *infallibilité*, the latter now obsolete, Med. Lat. *infallibilitas*, *infallibilis*, formed from fallor, to make a mistake), the fact or quality of not being liable to err or fail. The word has thus the general sense of "certainty"; we may, *e.g.*, speak of a drug as an infallible specific, or of a man's judgment as infallible. In these cases, however, the "infallibility" connotes certainty only in so far as anything human can be certain. In the language of the Christian Church the word "infallibility" is used in a more absolute sense, as the freedom from ail possibility of error guaranteed by the direct action of the Spirit of God. This belief in the infallibility of revelation is involved in the very belief in revelation itself, and is common to all sections of Christians, who differ mainly as to the kind and measure of infallibility residing in the human instruments by which this revelation is interpreted to the world. Some see the guarantee, or at least the indication, of infallibility in the consensus of the Church (*quod semper, ubique, et ab omnibus*) expressed from time to time in general councils; others see it in the special grace conferred upon St Peter and his successors, the bishops of Rome, as heads of the Church; others again see it in the inspired Scriptures, God's Word. This last was the belief of the Protestant Reformers, for whom the Bible was in matters of doctrine the ultimate court of appeal. To the translation and interpretation of the Scriptures men might bring a fallible judgment, but this would be assisted by the direct action of the Spirit of God in proportion to their faith. As for infallibility, this was a direct grace of God, given only to the few. "What ever was perfect under the sun," ask the translators of the Authorized Version (1611) in their preface, "where apostles and apostolick men, that is, men endued with an extraordinary measure of God's Spirit, and privileged with the privilege of infallibility, had not their hand?" In modern Protestantism, on the other hand, the idea of an infallible authority whether in the Church or the Bible has tended to disappear, religious truths being conceived as valuable only as they are apprehended and made real to the individual mind and soul by the grace of God, not by reason of any submission to an external authority. (See also INSPIRATION.)

At the present time, then, the idea of infallibility in religious matters is most commonly associated with the claim of the Roman Catholic Church, and more especially of the pope personally as head of that Church, to possess the privilege of infallibility, and it is with the meaning and limits of this claim that the present article deals.

The substance of the claim to infallibility made by the Roman Catholic Church is that the Church and the pope cannot err when solemnly enunciating, as binding on all the faithful, a decision on a question of faith or morals. The infallibility of the Church, thus limited, is a necessary outcome of the fundamental conception of the Catholic Church and its mission. Every society of men must have a supreme authority, whether individual or collective, empowered to give a final decision in the controversies which concern it. A community whose mission it is to teach religious truth, which involves on the part of its members the obligation of belief in this truth, must, if it is not to fail of its object, possess an authority capable of maintaining the faith in its purity, and consequently capable of keeping it free from and condemning errors. To perform this function without fear of error, this authority must be infallible in its own sphere. The Christian Church has expressly claimed this infallibility for its formal dogmatic teaching. In the very earliest centuries we find the episcopate, united in council, drawing up symbols of faith, which every believer was bound to accept under pain of exclusion, condemning heresies, and casting out heretics. From Nicaea and Chalcedon to Florence and Trent, and to the present day, the Church has excluded from her communion all those who do not profess her own faith, *i.e.* all the religious truths which she represents and imposes as obligatory. This is infallibility put into practice by definite acts.

The infallibility of the pope was not defined until 1870 at the Vatican Council; this definition does not constitute, strictly speaking, a dogmatic innovation, as if the pope had not hitherto enjoyed this privilege, or as if the Church, as a whole, had admitted the contrary; it is the newly formulated definition of a dogma which, like all those defined by the Councils, continued to grow into an ever more definite form, ripening, as it were, in the always living community of the Church. The exact formula for the papal infallibility is given by the Vatican Council in the following terms (Constit. *Pastor aeternus*, cap. iv.); "we teach and define as a divinely revealed dogma, that the Roman Pontiff, when he speaks *ex cathedra—i.e.* when, in his character as Pastor and Doctor of all Christians, and in virtue of his supreme apostolic authority, he lays down that a certain doctrine concerning faith or morals is binding upon the universal Church,—possesses, by the Divine assistance which was promised to him in the person of the blessed Saint Peter, that same infallibility with which the Divine Redeemer thought fit to endow His Church, to define its doctrine with regard to faith and morals; and, consequently, that these definitions of the Roman Pontiff are irreformable in themselves, and not in consequence of the consent of the Church." A few notes will suffice to elucidate this pronouncement.

(*a*) As the Council expressly says, the infallibility of the pope is not other than that of the Church; this is a point which is too often forgotten or misunderstood. The pope enjoys it in person, but solely *qua* head of the Church, and as the authorized organ of the ecclesiastical body. For this exercise of the primacy as for the others, we must conceive of the pope and the episcopate united to him as a continuation of the Apostolic College and its head Peter. The head of the College possesses and exercises by himself alone the same powers as the College which is united with him; not by delegation from his colleagues, but because he is their established chief. The pope when teaching *ex cathedra* acts as head of the whole episcopal body and of the whole Church.

(*b*) If the Divine constitution of the Church has not changed in its essential points since our Lord, the mode of exercise of the various powers of its head has varied; and that of the supreme teaching power as of the others. This explains the late date at which the dogma was defined, and the assertion that the dogma was already contained in that of the papal primacy established by our Lord himself in the person of St Peter. A certain dogmatic development is not denied, nor an evolution in the direction of a centralization in the hands of the pope of the exercise of his powers as primate; it is merely required that this evolution should be well understood and considered as legitimate.

(*c*) As a matter of fact the infallibility of the pope, when giving decisions in his character as head of the Church, was generally admitted before the Vatican Council. The only reservation which the most advanced Gallicans dared to

formulate, in the terms of the celebrated declaration of the clergy of France (1682), had as its object the irreformable character of the pontifical definitions, which, it was claimed, could only have been acquired by them through the assent of the Church. This doctrine, rather political than theological, was a survival of the errors which had come into being after the Great Schism, and especially at the council of Constance; its object was to put the Church above its head, as the council of Constance had put the ecumenical council above the pope, as though the council could be ecumenical without its head. In reality it was Gallicanism alone which was condemned at the Vatican Council, and it is Gallicanism which is aimed at in the last phrase of the definition we have quoted.

(*d*) Infallibility is the guarantee against error, not in all matters, but only in the matter of dogma and morality; everything else is beyond its power, not only truths of another order, but even discipline and the ecclesiastical laws, government and administration, &c.

(*e*) Again, not all dogmatic teachings of the pope are under the guarantee of infallibility; neither his opinions as private instructor, nor his official allocutions, however authoritative they may be, are infallible; it is only his *ex cathedra* instruction which is guaranteed; this is admitted by everybody.

But when does the pope speak *ex cathedra*, and how is it to be distinguished when he is exercising his infallibility? As to this point there are two schools, or rather two tendencies, among Catholics: some extend the privilege of infallibility to all official exercise of the supreme *magisterium*, and declare infallible, *e.g.* the papal encyclicals.[1] Others, while recognizing the supreme authority of the papal *magisterium* in matters of doctrine, confine the infallibility to those cases alone in which the pope chooses to make use of it, and declares positively that he is imposing on all the faithful the obligation of belief in a certain definite proposition, under pain of heresy and exclusion from the Church; they do not insist on any special form, but only require that the pope should clearly manifest his will to the Church. This second point of view, as clearly expounded by Mgr Joseph Fessler (1813-1872), bishop of St Pölten, who was secretary to the Vatican Council, in his work *Die wahre und die falsche Unfehlbarkeit der Päpste* (French trans. *La vraie et la fausse infaillibilité*, Paris, 1873), and by Cardinal Newman in his "Letter to the Duke of Norfolk," is the correct one, and this is clear from the fact that it has never been blamed by the ecclesiastical authority. Those who hold the latter opinion have been able to assert that since the Vatican Council no infallible definition had yet been formulated by the popes, while recognizing the supreme authority of the encyclicals of Leo XIII.

It is remarkable that the definition of the infallibility of the pope did not appear among the projects (*schemata*) prepared for the deliberations of the Vatican Council (1869). It doubtless arose from the proposed forms for the definitions of the primacy and the pontifical *magisterium*. The chapter on the infallibility was only added at the request of the bishops and after long hesitation on the part of the cardinal presidents. The proposed form, first elaborated in the conciliary commission *de fide*, was the object of long public discussions from the 50th general congregation (May 13th, 1870) to the 85th (July 13th); the constitution as a whole was adopted at a public session, on the 18th, of the 535 bishops present, two only replied "*Non placet*"; but about 50 had preferred not to be present. The controversies occasioned by this question had started from the very beginning of the Council, and were carried on with great bitterness on both sides. The minority, among whom were prominent Cardinals Rauscher and Schwarzenberg, Hefele, bishop of Rotterdam (the historian of the councils) Cardinal Mathieu, Mgr Dupanloup, Mgr Maret, &c., &c., did not pretend to deny the papal infallibility; they pleaded the inopportuneness of the definition and brought forward difficulties mainly of an historical order, in particular the famous condemnation of Pope Honorius by the 6th ecumenical council of Constantinople in 680. The majority, in which Cardinal Manning played a very active part, took their stand on theological reasons of the strongest kind; they invoked the promises of Our Lord to St Peter: "Thou art Peter, and upon this rock will I build my Church, and the gates of hell shall not prevail against her"; and again, "I have prayed for thee, Peter, that thy faith fail not; and do thou in thy turn confirm thy brethren"; they showed the popes, in the course of the ages, acting as the guardians and judges of the faith, arousing or welcoming dogmatic controversies and authoritatively settling them, exercising the supreme direction in the councils and sanctioning their decisions; they explained that the few historical difficulties did not involve any dogmatic defect in the teaching of the popes; they insisted upon the necessity of a supreme tribunal giving judgment in the name of the whole of the scattered Church; and finally, they considered that the definition had become opportune for the very reason that under the pretext of its inopportuneness the doctrine itself was being attacked.

The definition once proclaimed, controversies rapidly ceased; the bishops who were among the minority one after the other formulated their loyal adhesion to the Catholic dogma. The last to do so in Germany was Hefele, who published the decrees of the 10th of April 1871, thus breaking a long friendship with Döllinger; in Austria, where the government had thought good to revive for the occasion the royal *placet*, Mgr Haynald and Mgr Strossmayer delayed the publication, the former till the 15th of September 1871, the latter till the 26th of December 1872. In France the adhesion was rapid, and the publication was only delayed by some bishops in consequence of the disastrous war with Prussia. Though no bishops abandoned it, a few priests, such as Father Hyacinthe Loyson, and a few scholars at the German universities refused their adhesion. The most distinguished among the latter was Döllinger, who resisted all the advances of Mgr Scherr, archbishop of Munich, was excommunicated on the 17th of April 1871, and died unreconciled, though without joining any separate group. After him must be mentioned Friedrich of Munich, several professors of Bonn, and Reinkens of Breslau, who was the first bishop of the "Old Catholics." These professors formed the "Committee of Bonn," which organized the new Church. It was recognized and protected first in Bavaria, thanks to the minister Freiherr Johann von Lutz, then in Saxony, Baden, Württemberg, Prussia, where it was the pretext for, if not the cause of, the Kulturkampf, and finally in Switzerland, especially at Geneva.

For the theological aspects of the dogma of infallibility, see, among many others, L. Billot, S.J., *De Ecclesia Christi* (3 vols., Rome, 1898-1900); or G. Wilmers, S.J., *De Christi Ecclesia* (Regensburg, 1897). The most accessible popular work is that of Mgr Fessler already mentioned. For the history of the definition see VATICAN COUNCIL; also PAPACY, GALLICANISM, FEBRONIANISM, OLD CATHOLICS, &c.

(A. Bo.*)

1 It was in this sense that it was understood by Döllinger, who pointed out that the definition of the dogma would commit the Church to all past official utterances of the popes, *e.g.* the Syllabus of 1864, and therefore to a war *à outrance* against modern civilization. This view was embodied in the circular note to the Powers, drawn up by Döllinger and issued by the Bavarian prime minister Prince Hohenlohe-Schillingsfürst on April 9, 1869. It was also the view universally taken by the German governments which supported the *Kulturkampf* in a greater or less degree.—ED.

INFAMY (Lat. *infamia*), public disgrace or loss of character. Infamy (*infamia*) occupied a prominent place in Roman law, and took the form of a censure on individuals pronounced by a competent authority in the state, which censure was

the result either of certain actions which they had committed or of certain modes of life which they had pursued. Such a censure involved disqualification for certain rights both in public and in private law (see A. H. J. Greenidge, *Infamia, its Place in Roman Public and Private Law*, 1894). In English law infamy attached to a person in consequence of conviction of some crime. The effect of infamy was to render a person incompetent to give evidence in any legal proceeding. Infamy as a cause of incompetency was abolished by an act of 1843 (6 & 7 Vict. c. 85).

The word “infamous” is used in a particular sense in the English Medical Act of 1858, which provides that if any registered medical practitioner is judged by the General Medical Council, after due inquiry, to have been guilty of infamous conduct in any professional respect, his name may be erased from the Medical Register. The General Medical Council are the sole judges of whether a practitioner has been guilty of conduct infamous in a professional respect, and they act in a judicial capacity, but an accused person is generally allowed to appear by counsel. Any action which is regarded as disgraceful or dishonourable by a man’s professional brethren—such, for example, as issuing advertisements in order to induce people to consult him in preference to other practitioners—may be found infamous.

INFANCY, in medical practice, the nursing age, or the period during which the child is at the breast. As a matter of convenience it is usual to include in it children up to the age of one year. The care of an infant begins with the preparations necessary for its birth and the endeavour to ensure that taking place under the best possible sanitary conditions. On being born the normal infant cries lustily, drawing air into its lungs. As soon as the umbilical cord which unites the child to the mother has ceased to pulsate, it is tied about 2 in. from the child’s navel and is divided above the ligature. The cord is wrapped in a sterilized gauze pad and the dressing is not removed until the seventh to the tenth day, when the umbilicus is healed.

The baby is now a separate entity, and the first event in its life is the first bath. The room ready to receive a new-born infant should be kept at a temperature of 70° F. The temperature of the first bath should be 100° F. The child should be well supported in the bath by the left hand of the nurse, and care should be taken to avoid wetting the gauze pad covering the cord. In some cases infants are covered with a white substance termed “vernix caseosa,” which may be carefully removed by a little olive oil. Sponges should never be used, as they tend to harbour bacteria. A soft pad of muslin or gauze which can be boiled should take its place. After the first ten days 94° F. is the most suitable temperature for a bath. When the baby has been well dried the skin may be dusted with pure starch powder to which a small quantity of boric acid has been added. The most important part of the toilet of a new-born infant is the care of the eyes, which should be carefully cleansed with gauze dipped in warm water and one drop of a 2% solution of nitrate of silver dropped into each eye. The clothes of a newly born child should consist exclusively of woollen undergarments, a soft flannel binder, which should be tied on, being placed next the skin, with a long-sleeved woven wool vest and over this a loose garment of flannel coming below the feet and long enough to tuck up. Diapers should be made of soft absorbent material such as well-washed linen and should be about two yards square and folded in a three-cornered shape. An infant should always sleep in a bed or cot by itself. In 1907, of 749 deaths from violence in England and Wales of children under one month, 445 were due to suffocation in bed with adults. A healthy infant should spend most of its time asleep and should be laid into its cot immediately after feeding.

The normal infant at birth weighs about 7 ℔. During the two or three days following birth a slight decrease in weight occurs, usually 5 to 6 oz. When nursing begins the child increases in weight up to the seventh day, when the infant will have regained its weight at birth. From the second to the fourth week after birth (according to Camerer) an infant should gain 1 oz. daily or 1½ to 2 ℔ monthly, from the fourth to the sixth month ½ to ⅔ of an oz. daily or 1 ℔ monthly, from the sixth to the twelfth month ½ oz. daily or less than 1 ℔ monthly. At the sixth month it should be twice the weight at birth. The average weight at the twelfth month is 20 to 21 ℔. The increase of weight in artificially fed is less regular than in breast-fed babies.

Food.—There is but one proper food for an infant, and that is its mother’s milk, unless when in exceptional circumstances the mother is not allowed to nurse her child. Artificially fed children are much more liable to epidemic diseases. The child should be applied to the breast the first day to induce the flow of milk. The first week the child should be fed at intervals of two hours, the second week eight to nine times, and the fourth week eight times at intervals of two and a half hours. At two months the child is being suckled six times daily at intervals of three hours, the last feed being at 11 P.M. Where a mother cannot nurse a child the child must be artificially fed. Cow’s milk must be largely diluted to suit the new-born infant. Armstrong gives the following table of dilution:—

1st week,	milk	1	tablespoonful,	water	2	tablespoonfuls	
at 3 months	”	3½	tablespoonfuls,	”	3	”	added
at 6 months,	”	9	”	”	3	”	with
at 9 months,	”	12	”	”	3	”	sugar.

Koplik has drawn out a table of the amounts to be given as follows:—

1st day	3	feeds of	10 cc	total	1 oz.	in 24 hours
2nd day	8	”	20 cc	”	5½	”
3rd day	8	”	30 cc (1 oz.)	”	8	”
7th day	9	”	50 cc	”	13½	”
4th week	8	”	60 cc (2 oz.)	”	16	”
3 months	7	”	4 oz.	”	28	”
6 months	6	”	7 oz.	”	42	”
9 months	6	”	8½ oz.	”	50	”

In cities it is advisable that milk should be either sterilized by boiling or pasteurized, *i.e.* subjected to a form of heating which, while destroying pathogenic bacteria, does not alter the taste. The milk in a suitable apparatus is subjected to a temperature of 65° C. (149° F.) for half an hour and is then rapidly cooled to 20° C. (68° F.). Children fed on pasteurized milk should be given a teaspoonful of fresh orange juice daily to supply the missing acid and salts.

Artificial feeding is given by means of a bottle. In France all bottles with rubber tubes have been made illegal. They are a fruitful source of infection, as it is impossible to keep them clean. The best bottle is the boat-shaped one, with a wide mouth at one end, to which is attached a rubber teat, while the other end has a screw stopper. This is readily cleansed and a stream of water can be made to flow through it. All bottle teats should be boiled at least once a day for ten minutes with soda and kept in a glass-covered jar until required. A feed should be given at the temperature of 100°

F.

At the ninth month a cereal may be added to the food. Before that the infant is unable to digest starchy foods. Much starch tends to constipation, and it is rarely wise to give starchy preparations in a proportion of more than 3% to children under a year old. A child who is carefully fed in a cleanly manner should not have diarrhoea, and its appearance indicates carelessness somewhere. The English registrar-general's returns for 1906 show that in the seventy-six largest towns in England and Wales 14,306 deaths of infants under one year from diarrhoea took place in July, August and September alone. These deaths are largely preventable; when Dr Budin of Paris established his "Consultations de Nourissons" the infant mortality of Paris amounted to 178 per 1000, but at the consultation the rate was 46 per 1000. At Varengeville-sur-mer a consultation for nurslings was instituted under Dr Poupalt of Dieppe in 1904. During the seven previous years the infant mortality had averaged 145 per 1000. In 1904-1905 not one infant at the consultation died, though it was a summer of extreme heat, and in 1898 when similar heat had prevailed the infant mortality was 285 per 1000. The deaths of infants under one year in England and Wales, taken from the registrar-general's returns for 1907, amounted to 117.62 per 1000 births, an alarming sacrifice of life. France has been turning her attention to the establishment of infant consultations on the lines of Dr Budin's, and similar dispensaries under the designation "Gouttes de lait" have been widely established in that country; gratifying results in the fall in infant mortality have followed. At the Fécamp dispensary the mortality from diarrhoea has fallen to 2.8, while that in neighbouring towns is from 50 to 76 per 1000 (Sir A. Simpson). It has been left to private enterprise in England to deal with this problem. The St Pancras "School for Mothers" was established in 1907 in north-west London. Though started by private persons it was in 1909 worked in connexion with the Health Department of the Borough Council, but was supported by charitable subscriptions and by a small contribution from the student mothers. There are classes for mothers on the care of their health during pregnancy, infant feeding, home nursing, cooking and needlework. Poor mothers unable to contribute get free dinners for three months previous to the birth of their child and for nine months after if the child is breast-fed. Two doctors are in attendance, and mothers are encouraged to bring their children fortnightly to be weighed, and receive advice. The average attendance is ninety. A baby is said to have "graduated" when it is a year old. An interesting development in connexion with the scheme is a class for fathers at which the medical officer of health for the district lectures on the duties of fatherhood. Similar schools for mothers are now established in Fulham and Stepney. Weighing centres have been established at Dundee, Sheffield, Nottingham, Birmingham, Aberdeen, Bolton, Belfast, and Newcastle-on-Tyne. An infants' milk depôt has been established at Finsbury, and effort is being made to establish milk laboratories where separate nursing portions of sterile milk could be supplied to poor mothers. The Walker-Gordon milk laboratories in the United States are a step in this direction.

The average length of a child at birth is 19½ in. and during the first year the average increase is 7⅞ in. A new-born infant is deaf (Koplik). This is supposed to be due to the blocking of the eustachian tubes with mucus. On the fourth day there is some evidence of hearing, and at the fifth week noises in the room disturb it. A healthy infant may be taken out of doors when a fortnight old in summer, after which it should have a daily outing, the eyes being protected from the direct rays of the sun. On the second day the eyes are sensitive to light, in the second month the infant notices colours, at the sixth month it knows its parents, and should be able to hold its head up. At the sixth month the baby begins to cut its temporary teeth. After their appearance they should be cleaned once a day by a piece of gauze moistened in boric acid solution. Attempts to stand are made about the tenth month, and walking begins about the fourteenth month. By this time the intelligence should be developed and memory is observed. A child a year old should be able to articulate a few small words. With the advent of walking and speech the period of infancy may be said to end.

See Pierre Budin, The Nursling (1907); Henry Koplik, *Disease of Infancy and Childhood* (1906); Eric Pritchard, *The Physiological Feeding of Infants* (1904); Eric Pritchard, *Infant Education* (1907); John Grimshaw, *Your Child's Health* (1908).

(H. L. H.)

INFANT (in early forms *enfaunt*, *enfant*, through the Fr. *enfant*, from Lat. *infans*, *in*, not, and *fans*, the present participle of *fari*, to speak), a child; in non-legal use, a very young child, a baby, or one of an age suitable to be taught in an "infant school"; in law, a person under full age, and therefore subject to disabilities not affecting persons who have attained full age.

This article deals with "infants" in the last sense; for the more general sense see Infancy and Child. The period of full age varies widely in different systems, as do also the disabilities attaching to nonage (non-age). In Roman law, the age of puberty, fixed at fourteen for males and twelve for females, was recognized as a dividing line. Under that age a child was under the guardianship of a tutor, but several degrees of infancy were recognized. The first was absolute infancy; after that, until the age of seven, a child was *infantiae proximus*; and from the eighth year to puberty he was *pubertati proximus*. An infant in the last stage could, with the assent of his tutor, act so as to bind himself by stipulations; in the earlier stages he could not, although binding stipulations could be made to him in the second stage. After puberty, until the age of twenty-five years, a modified infancy was recognized, during which the minor's acts were not void altogether, but voidable, and a curator was appointed to manage his affairs. The difference between the tutor and the curator in Roman law was marked by the saying that the former was appointed for the care of the person, the latter for the estate of the pupil. These principles apply only to children who are *sui juris*. The *patria potestas*, so long as it lasts, gives to the father the complete control of the son's actions. The right of the father to appoint tutors to his children by will (*testamentarii*) was recognized by the Twelve Tables, as was also the tutorship of the *agnati* (or legal as distinct from natural relations) in default of such an appointment. Tutors who held office in virtue of a general law were called *legitimi*. Besides and in default of these, tutors *dativi* were appointed by the magistrates. These terms are still used in much the same sense in modern systems founded on the Roman law, as may be seen in the case of Scotland, noticed below.

By the law of England full age is twenty-one, and all minors alike are subject to incapacities. The period of twenty-one years is regarded as complete at the beginning of the day before the birthday: for example, an infant born on the first day of January attains his majority at the first moment of the 31st of December. The incapacity of an infant is designed for his own protection, and its general effect is to prevent him from binding himself absolutely by obligations. Of the contracts of an infant which are binding *ab initio*, the most important are those relating to "necessaries." By the Sale of Goods Act 1893, an infant liable on a contract for necessaries can be sued only for a reasonable price, not necessarily the price he agreed to pay. The same statute declares "necessaries" to mean "goods suitable to the condition in life of the infant, and to his actual requirements at the time of the sale and delivery." In the case of goods having a market price, the market price is reasonable. In all other cases the question is one of fact for the jury. The protection of infants extends sometimes to transactions completed after full age; the relief of heirs who have been induced to barter away

their expectations is an example. “Catching bargains,” as they are called, throw on the persons claiming the benefit of them the burden of proving their substantial righteousness.

At common law a bargain made by an infant might be ratified by him after full age, and would then become binding. Lord Tenterden’s act required the ratification to be in writing. But now, by the Infants’ Relief Act 1874, “all contracts entered into by infants for the repayment of money lent or to be lent, or for goods supplied or to be supplied (other than contracts for necessaries), and all accounts stated, shall be absolutely void,” and “no action shall be brought whereby to charge any person upon any promise made after full age to pay any debt contracted during infancy, or upon any ratification made after full age of any promise or contract made during infancy, whether there shall or shall not be any new consideration for such promise or ratification after full age.” For some years after the passage of this statute highly conflicting views were held as to the meaning of the part of section 2 whereby it was enacted that “no action shall be brought whereby to charge any person ... upon any ratification made after full age of any promise or contract made during infancy.” Some authorities were of opinion that the section only applied to the three classes of contract made void by the previous section, viz. for goods supplied, money lent and on account stated. Others thought the effect to be that no contract, except for necessaries, made during infancy could be enforced after the infant came to full age. After several conflicting decisions it has been settled that both these views were wrong. Of the infant’s contracts voidable at common law there were two kinds. The first kind became void at full age, unless expressly ratified. The second kind were valid, unless repudiated within a reasonable time after full age was attained by the infant. The Infants’ Relief Act (section 2) strikes only at the first class and leaves the second untouched. Thus a promise of marriage made during infancy cannot be ratified so as to become actionable: but an infant’s marriage settlement, being of the second class, is valid, unless it is repudiated within a reasonable time after the infant attains full age. What is a reasonable time depends on all the circumstances of the case. In a case decided in 1893 a settlement made by a female infant was allowed to be repudiated thirty years after she attained full age, but the circumstances were exceptional. A contract of marriage may be lawfully made by persons under age. Marriageable age is fourteen in males and twelve in females. So, generally, an infant may bind himself by contract of apprenticeship or service. Since the passing of the Wills Act, an infant, except he be a soldier in actual military service or a seaman at sea, is unable to make a will. Infancy is in general a disqualification for public offices and professions, *e.g.* to be a member of parliament or an elector, a mayor or burgess, a priest or deacon, a barrister or solicitor, &c.

Before 1886 the custody of an infant belonged in the first place, and against all other persons, to the father, who was said to be “the guardian of his children by nature and nurture”; and the father might by deed or will dispose of the custody or tuition of his children until the age of twenty-one.

The Guardianship of Infants Act 1886 placed the mother almost on the same footing as the father as to guardianship of infants. On the death of the father the mother becomes guardian under the statute, either alone when no guardian has been appointed by the father, or jointly with any guardian appointed by him under 12 Chas. II. c. 24. A change of the law even more important is that whereby the mother may by deed or will appoint a guardian or guardians of her infant children to act after her death. If the father survives the mother, the mother’s guardian can only act if it be shown to the satisfaction of the court that the father is unfitted to be the sole guardian. On the death of the father, the guardian so appointed by the mother acts jointly with any guardian appointed by the father. The Guardianship of Infants Act 1886 also gives power to the high court and to county courts to make orders, upon the application of the mother, regarding the custody of an infant, and the right of access thereto of either parent. The court must take into consideration “the welfare of the infant, and ... the conduct of the parents, and ... the wishes as well of the mother as of the father.” The same statute also empowers the high court of justice, “on being satisfied that it is for the welfare of the infant,” to “remove from his office any testamentary guardian or any guardian appointed or acting by virtue of this act,” and also to appoint another in place of the guardian so removed.

The same statute gives power to a court sitting in divorce practically to take away from a parent guilty of a matrimonial offence all rights of guardianship. When a decree for judicial separation or divorce is pronounced, the court pronouncing it may at the same time declare the parent found guilty of misconduct to be unfit to have the custody of the children of the marriage. “In such case the parent so declared to be unfit shall not, upon the death of the other parent, be entitled as of right to the custody or guardianship of such children.” The court exercises this power very sparingly. When the declaration of unfitness is made, the practical effect is to give to the innocent parent the sole guardianship, as well as power to appoint a testamentary guardian to the exclusion of the guilty parent.

Another radical change has been made in the rights of parents as to guardianship of their children. In consequence of several cases where, after children had been rescued by philanthropic persons from squalid homes and improper surroundings, the courts had felt bound by law to redeliver them to their parents, the Custody of Children Act 1891 was passed. It provides that when the parent of a child applies to the court for a writ or order for the production of the child, and the court is of opinion that the parent has abandoned or deserted the child, or that he has otherwise so conducted himself that the court should refuse to enforce his right to the custody of the child, the court may, in its discretion, decline to issue the writ or make the order. If the child, in respect of whom the application is made, is being brought up by another person (“person” includes “school or institution”), or is being boarded out by poor-law guardians, the court may, if it orders the child to be given up to the parent, further order the parent to pay all or part of the cost incurred by such person or guardians in bringing up the child.

A parent who has abandoned or deserted his child is, prima facie, unfit to have the custody of the child. And before the court can make an order giving him the custody, the onus lies on him to prove that he is fit. The same rule applies where the child has been allowed by the parent “to be brought up by another person at that person’s expense, or by the guardians of a poor-law union, for such a length of time and under such circumstances as to satisfy the court that the parent was unmindful of his parental duties.”

The 4th section of the Custody of Children Act 1891 preserves the right of the parent to control the religious training of the infant. The father, however unfit he may be to have the custody of his child, has the legal right to require the child to be brought up in his own religion. If the father is dead, and has left no directions on the point, the mother may assert a similar right. But the court may consult the wishes of the child; and when an infant has been allowed by the father to grow up in a faith different from his own, the court will not, as a rule, order any change in the character of religious instruction. This is especially the case where the infant appears to be settled in his convictions.

In the same direction as the Custody of Children Act 1891 is the Children Act 1908, whereby considerable powers have been conferred on courts of summary jurisdiction (see Children, Law Relating to).

There is not at common law any corresponding obligation on the part of either parent to maintain or educate the children. The legal duties of parents in this respect are only those created by the poor laws, the Education Acts and the Children Act 1908.

An infant is liable to a civil action for torts and wrongful acts committed by him. But, as it is possible so to shape the pleadings as to make what is in substance a right arising out of contract take the form of a right arising from civil

injury, care is taken that an infant in such a case shall not be held liable. With respect to crime, mere infancy is not a defence, but a child under seven years of age is presumed to be incapable of committing a crime, and between seven and fourteen his capacity requires to be affirmatively proved. After fourteen an infant is *doli capax*.

The law of Scotland follows the leading principles of the Roman law. The period of minority (which ends at twenty-one) is divided into two stages, that of absolute incapacity (until the age of fourteen in males, and twelve in females), during which the minor is in pupilarity, and that of partial incapacity (between fourteen and twenty-one), during which he is under curators. The guardians (or tutors) of the pupil are either tutors-nominate (appointed by the father in his will); tutors-at-law (being the next male agnate of twenty-five years of age), in default of tutors-nominate; or tutors-dative, appointed by royal warrant in default of the other two. No act done by the pupil, or action raised in his name, has any effect without the interposition of a guardian. After fourteen, all acts done by a minor having curators are void without their concurrence. Every deed in nonage, whether during pupilarity or minority, and whether authorized or not by tutors or curators, is liable to reduction on proof of "lesion," *i.e.* of material injury, due to the fact of nonage, either through the weakness of the minor himself or the imprudence or negligence of his curators. Damage in fact arising on a contract in itself just and reasonable would not be lesion entitling to restitution. Deeds in nonage, other than those which are absolutely null *ab initio*, must be challenged within the *quadriennium utile*, or four years after majority.

The Guardianship of Infants Act 1886, the Custody of Children Act 1891 and the Children Act 1908, mentioned above, all apply to Scotland.

In the United States, the principles of the English common law as to infancy prevail, generally the most conspicuous variations being those affecting the age at which women attain majority. In many states this is fixed at eighteen. There is some diversity of practice as to the age at which a person can make a will of real or personal estate.

INFANTE (Spanish and Portuguese form of Lat. *infans*, young child), a title of the sons of the sovereign of Spain and Portugal, the corresponding *infanta* being given to the daughters. The title is not borne by the eldest son of the king of Spain, who is prince of Asturias, *Il principe de Asturias*. Until the severance of Brazil from the Portuguese monarchy, the eldest son was prince of Brazil. While a son or daughter of the sovereign of Spain is by right infante or infanta of Spain, the title, alone, is granted to other members of the blood royal by the sovereign.

INFANTICIDE, the killing of a newly-born child or of the matured foetus. When practised by civilized peoples the subject of infanticide concerns the criminologist and the jurist; but its importance in anthropology, as it involves a widespread practice among primitive or savage nations, requires more detailed attention. J. F. McLennan (*Studies in Ancient History*, pp. 75 et seq.) suggests that the practice of female infanticide was once universal, and that in it is to be found the origin of exogamy. Much evidence, however, has been adduced against this hypothesis by Herbert Spencer and Edward Westermarck. Infanticide, both of males and females, is far less widespread among savage races than McLennan supposed. It certainly is common in many lands, and more females are killed than males; but among many fierce and savage peoples it is almost unknown. Thus among the Tuski, Ahts, Western Eskimo and the Botocudos new-born children are killed now and then, if they are weak and deformed, or for some other reason (such as the superstition attaching to birth of twins) but without distinction of sex. Among the Dakota Indians and Crees female infanticide is rare. The Blackfoot Indians believe that a woman guilty of such an act will never reach "the Happy Mountain" after death, but will hover round the scene of her misdeed with branches of trees tied to her legs. The Aleutians hold that child-murder brings misfortune on the whole village. Among the Abipones it is common, but the boys are usually the victims, because it is customary to buy a wife for a son, whereas a grown daughter will always command a price. In Africa, where a warm climate and abundance of food simplify the problem of existence, the crime is not common. Herr Valdau relates that a Bakundu woman, accused of it, was condemned to death. In Samoa, in the Mitchell and Hervey Islands, and in parts of New Guinea, it was unheard of; while among the cannibals, the Solomon Islanders, it occurred rarely. A theory has been advanced by L. Fison (*Kamilaroi and Kurnai*, 1880) that female infanticide is far less common among the lower savages than among the more advanced tribes. Among some of the most degraded of human beings, such as the Yahgans of Tierra del Fuego, the crime was unknown, except when committed by the mother "from jealousy or hatred of her husband or because of desertion and wretchedness." It is said that certain Californian Indians were never guilty of child-murder before the arrival of the whites; while Wm. Ellis (*Polynesian Researches*, i. 249) thinks it most probable that the custom was less prevalent in earlier than later Polynesian history. The weight of evidence tends to support Darwin's theory that during the earliest period of human development man did not lose that strong instinct, the love of his young, and consequently did not practice infanticide; that, in short, the crime is not characteristic of primitive races.

Infanticide may be said to arise from four reasons. It may be (1) an act of callous brutality or to satisfy cannibalistic cravings. A Fuegian, Darwin relates, dashed his child's brains out for upsetting a basket of fish. An Australian, seeing his infant son ill, killed, roasted and ate him. In some parts of Africa the negroes bait lion-traps with their own children. Some South American Indians, such as the Moxos, abandon or kill them without reason; while African and Polynesian cannibals eat them without the excuse of the periodic famines which made the Tasmanians regard the birth of a child as a piece of good fortune.

2. Or infanticide may be the result of the struggle for existence. Thus in Polynesia, while the climate ensures food in plenty, the relative smallness of the islands imposed the custom on all families without distinction. In the Hawaiian Islands all children, after the third or fourth, were strangled or buried alive. At Tahiti fathers had the right (and used it) of killing their newly-born children by suffocation. The chiefs were obliged by custom to kill all their daughters. The society of the Areois, famous in the Society Islands, imposed infanticide upon the women members by oath. In other islands all girl-children were spared, but only two boys in each family were reared. The difficulties of suckling partly explain the custom of killing twins. For the same reason the Eskimo and Red Indians used to bury the infant with the mother who died in childbirth. Among warrior and hunter tribes, where women could not act as beasts of burden as in agricultural communities, and where a large number of girls were likely to attract the hostile attentions of neighbouring tribesmen, girl-babies were murdered. Arabs, in ancient times, buried alive the majority of female children. In many lands infanticide was regarded as a meritorious act on the part of a parent, done, as a precaution against famine, in the interests of the tribe. In other parts of the world, infanticide results from customs which impose heavy burdens on

child-rearing. Of these artificial hardships the best example is afforded by India. There the practice, though forbidden by both the Vedas and the Koran, prevailed among the Rajputs and certain aboriginal tribes. Among the aristocratic Rajputs, it was thought dishonourable that a girl should remain unmarried. Moreover, a girl may not marry below her caste; she ought to marry her superior, or at least her equal. This reasoning was most powerful with the highest castes, in which the disproportion of the sexes was painfully apparent. But, assuming marriage to be possible, it was ruinously expensive to the bride's father, the cost in the case of some rajahs having been known to exceed £100,000. To avoid all this, the Rajput killed a proportion of his daughters—sometimes in a very singular way. A pill of tobacco and bhang might be given to the new-born child; or it was drowned in milk;[1] or the mother's breast was smeared with opium or the juice of the poisonous *datura*. A common method was to cover the child's mouth with a plaster of cow-dung, before it drew breath. Infanticide was also practised to a small extent by some sects of the aboriginal Khonds and by the poorer hill-tribes of the Himalayas. Where infanticide occurs in India, though it really rests on the economic facts stated, there is usually some poetical tradition of its origin. Infanticide from motives of prudence was common among some American Indian tribes of the north-west, with whom the "potlatch" was an essential part of their daughter's marriage ceremonies.

3. Or infanticide may be in the nature of a religious observance. The gods must be appeased with blood, and it is believed that no sacrifice can be so pleasing to them as the child of the worshipper. Such were the motives impelling parents to the burning of children in the worship of Moloch. In India children were thrown into the sacred river Ganges, and adoration paid to the alligators who fed on them. Where the custom prevails as a sacrifice the male child is usually the victim.

4. Or, finally, infanticide may have a social or political reason. Thus at Sparta (and in other places in early Greek and Roman history) weakly or deformed children were killed by order of the state, a custom approved in the ideal systems of Aristotle and Plato, and still observed among the Eskimo and the Kamchadales.

AUTHORITIES.—Herbert Spencer, *Principles of Sociology*, i. 614-619; McLennan, *Studies in Ancient History*, pp. 75 et seq.; McLennan, "Exogamy and Endogamy" in the *Fortnightly Review*, xxi. 884 et seq.; Darwin, Descent of Man, ii. 400 et seq.; L. Fison, and A. W. Howitt, *Kamilaroi and Kurnai* (1880); Westermarck, *History of Human Marriage* (1894); Browne, *Infanticide: Its Origin, Progress and Suppression* (London, 1857); Lord Avebury, *Prehistoric Times* (1900), and *Origin of Civilization* (1902).

Law.—The crime of infanticide among civilized nations is still frequent. It is however due in most cases to abnormal causes, such as a sudden access of insanity, privation, unreasoning dislike to the child, &c. It is most closely connected with illegitimacy in the class of farm and domestic servants, the more common motive being the terror of the mother of incurring the disgrace with which society visits the more venial offence. Often, however, it is inspired by no better motive than the wish to escape the burden of the child's support. The granting of affiliation orders thus tends to save the lives of many children, though it provides a motive for the paramour sometimes to share in the crime. The laws of the European states differ widely on this subject—some of them treating infanticide as a special crime, others regarding it merely as a case of murder of unusually difficult proof. In the law of England infanticide is murder or manslaughter 517
according to the presence or absence of deliberation. The infant must be a human being in the legal sense; and "a child becomes a human being when it has completely proceeded in a living state from the body of its mother, whether it has breathed or not, and whether it has an independent circulation or not, and whether the navel-string is severed or not; and the killing of such a child is homicide when it dies after birth in consequence of injuries received before, during or after birth." À child in the womb or in the act of birth, though it may have breathed, is therefore not a human being, the killing of which amounts to homicide. The older law of child murder under a statute of James I. consisted of cruel presumptions against the mother, and it was not till 1803 that trials for that offence were placed under the ordinary rules of evidence. The crown now takes upon itself the onus of proving in every case that the child has been alive. This is often a matter of difficulty, and hence a frequent alternative charge is that of concealment of birth (see BIRTH), or concealment of pregnancy in Scotland. It is the opinion of the most eminent of British medical jurists that this presumption has tended to increase infanticide. Apart from this, the technical definition of human life has excited a good deal of comment and some indignation. The definition allows many wicked acts to go unpunished. The experience of assizes in England shows that many children are killed when it is impossible to prove that they were wholly born. The distinction taken by the law was probably comprehended by the minds of the class to which most of the unhappy mothers belong. Partly to meet this complaint it was suggested to the Royal Commission of 1866 that killing during birth, or within seven days thereafter, should be an offence punishable with penal servitude. The second complaint is of an opposite character—partly that infanticide by mothers is not a fit subject for capital punishment, and partly that, whatever be the intrinsic character of the act, juries will not convict or the executive will not carry out the sentence. Earl Russell gave expression to this feeling when he proposed that no capital sentence should be pronounced upon mothers for the killing of children within six months after birth. When there has been a verdict of murder, sentence of death must be passed, but the practice of the Home Office, as laid down in 1908, is invariably to commute the death sentence to penal servitude for life. The circumstances of the case and the disposition and general progress of the prisoners under discipline in a convict prison are then determining factors in the length of subsequent detention, which rarely exceeds three years. After release, the prisoner's further progress is carefully watched, and if it is seen to be to her advantage the conditions of her release are cancelled and she is restored to complete freedom.

In India measures against the practice were begun towards the end of the 18th century by Jonathan Duncan and Major Walker. They were continued by a series of able and earnest officers during the 19th century. One of its chief events, representing many minor occurrences, was the Amritsar durbar of 1853, which was arranged by Lord Lawrence. At that meeting the chiefs residing in the Punjab and the trans-Sutlej states signed an agreement engaging to expel from caste every one who committed infanticide, to adopt fixed and moderate rates of marriage expenses, and to exclude from these ceremonies the minstrels and beggars who had so greatly swollen the expense. According to the present law, if the female children fall below a certain percentage in any tract or among any tribe in northern India where infanticide formerly prevailed, the suspected village is placed under police supervision, the cost being charged to the locality. By these measures, together with a strictly enforced system of reporting births and deaths, infanticide has been almost trampled out; although some of the Rājput clans keep their female offspring suspiciously close to the lowest average which secures them from surveillance.

It is difficult to say to what extent infanticide prevails in the United Kingdom. At one time a large number of children were murdered in England for the purpose of obtaining the burial money from a benefit club,[2] but protection against this risk has been provided for by the Friendly Societies Act 1896, and the Collecting Societies Act 1896. The neglect or killing of nurse-children is treated under BABY-FARMING, and CHILDREN, LAW RELATING TO.

In the United States, the elements of this offence are practically the same as in England. The wilful killing of an unborn child is not manslaughter unless made so by statute. To constitute manslaughter under Laws N.Y. 1869, ch. 631, by attempts to produce miscarriage, the "quickening" of the child must be averred and proved (*Evans* v. *People*, 49 New York Rep. 86; see also *Wallace* v. *State*, 7 Texas app. 570).

1 In Baluchistan, where children are often drowned in milk, there is a euphemistic proverb: “The lady’s daughter died drinking milk.”

2 See *Report on the Sanitary Condition of the Labouring Classes*, “Supplementary Report on Interment in Towns,” by Edwin Chadwick (*Parl. Papers*, 1843, xii. 395); and *The Social Condition and Education of the People*, by Joseph Kay (1850).

INFANTRY, the collective name of soldiers who march and fight on foot and are armed with hand-weapons. The word is derived ultimately from Lat. *infans*, infant, but it is not clear how the word came to be used to mean soldiers. The suggestion that it comes from a guard or regiment of a Spanish infanta about the end of the 15th century cannot be maintained in view of the fact that Spanish foot-soldiers of the time were called *soldados* and contrasted with French *fantassins* and Italian *fanteria*. The *New English Dictionary* suggests that a foot-soldier, being in feudal and early modern times the varlet or follower of a mounted noble, was called a boy (cf. *Knabe*, *garçon*, footman, &c., and see Valet).

Historical Sketch

The importance of the infantry arm, both in history and at the present time, cannot be summed up better and more concisely than in the phrase used by a brilliant general of the Napoleonic era, General Morand—“*L’infanterie, c’est l’armée*.”

It may be confidently asserted that the original fighting man was a foot-soldier. But infantry was differentiated as an “arm” considerably later than cavalry; for when a new means of fighting (a chariot or a horse) presented itself, it was assimilated by relatively picked men, chiefs and noted warriors, who *ipso facto* separated themselves from the mass or reservoir of men. How this mass itself ceased to be a mere residue and developed special characteristics; how, instead of the cavalry being recruited from the best infantry, cavalry and infantry came to form two distinct services; and how the arm thus constituted organized itself, technically and tactically, for its own work—these are the main questions that constitute the historical side of the subject. It is obvious that as the “residue” was far the greatest part of the army, the history of the foot-soldier is practically identical with the history of soldiering.

It was only when a group of human beings became too large to be surprised and assassinated by a few lurking enemies, that proper fighting became the normal method of settling a quarrel or a rivalry. Two groups, neither of which had been able to surprise the other, had to meet face to face, and the instinct of self-preservation had to be reconciled with the necessity of victory. From this it was an easy step to the differentiation of the champion, the proved excellent fighting man, and to providing this man, on whom everything depended, with all assistance that better arms, armour, horse or chariot could give him. But suppose our champion slain, how are we to make head against the opposing champion? For long ages, we may suppose, the latter, as in the *Iliad*, slaughtered the sheep who had lost their shepherd, but in the end the “residue” began to organize itself, and to oppose a united front to the enemy’s champions —in which term we include all selected men, whether horsemen, charioteers or merely specially powerful axemen and swordsmen. But once the individual had lost his commanding position, the problem presented itself in a new form—how to ensure that every member of the group did his duty by the others—and the solution of this problem for the conditions of the ancient hand-to-hand struggle marks the historical beginning of infantry tactics.

Gallic warriors bound themselves together with chains. The Greeks organized the city state, which gave each small army solidarity and the sense of duty to an ideal, and the phalanx, in which the file-leaders were in a sense champions yet were made so chiefly by the unity of the mass. But the Romans went farther. Besides developing solidarity and a sense of duty, they improved on this conception of the battle to such a degree that as a nation they may be called the best tacticians who ever existed. Giving up the attempt to make all men fight equally well, they dislocated the mass of combatants into three bodies, of which the first, formed of the youngest and most impressionable men, was engaged at the outset, the rest, more experienced men, being kept out of the turmoil. This is the very opposite of the “champion” system. Those who would have fled after the fall of the champions are engaged and “fought out” before the champions enter the area of the contest, while the champions, who possess in themselves the greatest power of resisting and mastering the instinct of self-preservation, are kept back for the moment when ordinary men would lose heart.

The phalanx and the legion.

It might be said with perfect justice that without infantry there would never have been discipline, for cavalry began and continued as a crowd of champions. Discipline, which created and maintained the intrinsic superiority of the Roman legion, depended first on the ideal of patriotism. This was ingrained into every man from his earliest years and expressed in a system of rewards and punishments which took effect from the same ideal, in that rewards were in the main honorary in character (mural crowns, &c.), while no physical punishment was too severe for the man who betrayed, by default or selfishness, the cause of Rome. Secondly, though every man knew his duty, not every man was equal to doing it, and in recognition of this fact the Romans evolved the system of three-line tactics in which the strong parts of the machine neutralized the weak. The first of these principles, being psychological in character, rose, flourished and decayed with the *moral* of the nation. The second, deduced from the first, varied with it, but as it was objectively expressed in a system of tactics, which had to be modified to suit each case, it varied also in proportion as the combat took more or less abnormal forms. So closely knit were the parts of the system that not only did the decadence of patriotism sap the legionary organization, but also the unsuitability of that organization to new conditions of warfare reacted unfavourably, even disastrously, on the moral of the nation. Between them, the Roman infantry fell from its proud place, and whereas in the Republic it was familiarly called the “strength” (*robur*), by the 4th century A.D. it had become merely the background for a variety of other arms and corps. Luxury produced “egoists,” to whom the rewards meant nothing and the punishments were torture for the sake of torture. When therefore the Roman *imperium* extended far enough to bring in silks from China and ivory from the forests of central Africa, the citizen-army ceased to exist, and the mere necessity for garrisoning distant savage lands threw the burden of service upon the professional soldier.

The natural consequence of this last was the uniform training of every man. There were no longer any primary differences between one cohort and another, and though the value of the three-line system in itself ensured its continuance, any cohort, however constituted, might find itself serving in any one of the three lines, *i.e.* the *moral* of the last line was no better than that of the first. The best guarantee of success became *uniform* regimental excellence, and whereas Camillus or Scipio found useful employment in battle for every citizen, Caesar complained that a legion which had been sent him was too raw, though it had been embodied for nine years. The conditions which were so admirably met by the old system never

The Roman Imperial Army.

reappeared; for before armies resumed a “citizen” character the invention of firearms had subjected all ranks and lines alike to the same ordeal of facing unseen death, and the old soldiers were better employed in standing shoulder to shoulder with the young. In brief, the old Roman organization was based on patriotism and experience, and when patriotism gave place to “egoism,” and the experience of the citizen who spent every other summer in the field of war gave place to the formal training of the paid recruit, it died, unregretted either by the citizen or by the military chieftain. The latter knew how to make the army his devoted servant, while the former disliked military service and failed to prepare himself for the day when the military chief and the mercenary overrode his rights and set up a tyranny, and ultimately the inner provinces of the empire came to be called *inermes*—unarmed, defenceless—in contrast to the borderland where the all-powerful professional legions lay in garrison.

In these same frontier provinces the tactical disintegration of the legion slowly accomplished itself. Originally designed for the exigencies of the normal pitched battle on firm open fields, and even after its professionalization retaining its character as a large battle unit, it was soon fragmented through the exigencies of border warfare into numerous detachments of greater or less size, and when the military frontier of the empire was established, the legion became an almost sedentary corps, finding the garrisons for the blockhouses on its own section of the line of defence. Further, the old heavy arms and armour which had given it the advantage in wars of conquest—in which the barbarians, gathering to defend their homes, offered a target for the blow of an army—were a great disadvantage when it became necessary to police the conquered territory, to pounce upon swiftly moving bodies of raiders before they could do any great harm. Thus gradually cavalry became more numerous, and light infantry of all sorts more useful, than the old-fashioned linesman. To these corps went the best recruits and the smartest officers, the opportunities for good service and the rewards for it. The legion became once more the “residue.” Thus when the “champion” reappeared on the battlefield the solidarity that neutralized his power had ceased to exist.

The battle of Adrianople, the “last fight of the legion,” illustrates this. The frontal battle was engaged in the ordinary way, and the cohorts of the first line of the imperial army were fighting man to man with the front ranks of the Gothic infantry (which had indeed a solidarity of its own, unlike the barbarians of the early empire, and was further guaranteed against moral over-pressure by a wagon laager), when suddenly the armoured heavy cavalry of the Goths burst upon their flank and rear. There were no longer *Principes* and *Triarii* of the old Republican calibre, but only average troops, in the second and third lines, and they were broken at once. The first line felt the battle in rear as well as in front and gave way. Thereafter the victors, horse and foot, slaughtered unresisting herds of men, not desperate soldiers, and on this day the infantry arm, as an arm, ceased to exist.

Of course, not every soldier became a horseman, and still fewer could provide themselves with armour. Regular infantry, too, was still maintained for siege, mountain and forest warfare. But the *robur*, the kernel of the line of battle, was gone, and though a few of the peoples that fought their way into the area of civilization in the dark ages brought with them the natural and primitive method of fighting on foot, it was practically always a combination of mighty champions and “residue,” even though the latter bound themselves together by locked shields, as the Gauls had bound themselves long before with chains, to prevent “skulking.” These infantry nations, without any infantry system comparable to that of the Greeks and Romans, succumbed in turn to the crowd of mounted warriors—not like the Greeks and Romans for want of good military qualities, but for want of an organization which would have distributed their fighting powers to the best advantage. One has only to study the battle of Hastings to realize how completely the infantry masses of the English slipped from the control of their leaders directly the front ranks became seriously engaged. For many generations after Hastings there was no attempt to use infantry as the kernel of armies, still less to organize it as such beforehand. Indeed, except in the Crusades, where men of high and of low degree alike fought for their common faith, and in sieges, where cavalry was powerless and the services of archers and labourers were at a premium, it became quite unusual for infantry to appear on the field at all.

The Dark Ages.

Bouvines.

The tactics of feudal infantry at its best were conspicuously illustrated in the battle of Bouvines, where besides the barons, knights and sergeants, the Brabançon mercenaries (heavy foot) and the French communal militia opposed one another. On the French right wing, the opportune arrival of a well-closed mass of cavalry and infantry in the flank of a loose crowd of men-at-arms which had already been thoroughly engaged, decided the fight. In the centre, the respective infantries were in first line, the nobles and knights, with their sovereigns, in second, yet it was a mixed mass of both that, after a period of confused fighting, focussed the battle in the persons of the emperor and the king of France, and if the personal encounters of the two bodies of knights gave the crowded German infantry a momentary chance to strike down the king, the latter was soon rescued by a half-dozen of heavy cavalrymen. On the left wing, the count of Boulogne made a living castle of his Brabançon pikes, whence with his men-at-arms he sallied forth from time to time and played the champion. Lastly, the Constable Montmorency brought over what was still manageable of the corps that had defeated the cavalry on the right (nearly all mounted men) and gave the final push to the allied centre and right in succession. Then the imperial army fled and was slaughtered without offering much resistance. Of infantry in this battle there was enough and to spare, but its only opportunities for decisive action were those afforded by the exhaustion of the armoured men or by the latter becoming absorbed in their own single combats to the exclusion of their proper work in the line of battle. As usual the infantry suffered nine-tenths of the casualties. For all their numbers and apparent tactical distribution on this field, they were “residue,” destitute of special organization, training or utility; and the only suggestion of “combined tactics” is the expedient adopted by the count of Boulogne, rings of spearmen to serve as pavilions served in the tournament—to secure a decorous setting for a display of knightly prowess.

In those days in truth the infantry was no more the army than to-day the shareholders of a limited company are the board of directors. They were deeply, sometimes vitally, interested in the result, but they contributed little or nothing to bringing it about, except when the opposing cavalries were in a state of moral equilibrium, and in these cases anything suffices—the appearance of camp followers on a “Gillies Hill,” as at Bannockburn or the sound of half-a-dozen trumpets—to turn the scale. Once it turned, the infantry of the beaten side was cut down unresistingly, while the more valuable prisoners were admitted to ransom. Thereafter, feudal tactics were based principally on the ideas of personal glory—won in single combat, champion against champion, and of personal profit—won by the knight in holding a wealthy and well-armed baron to ransom and by the foot-soldier in plundering while his masters were fighting. In the French army, the term *bidaux*, applied in the days of Bouvines to all the infantry other than archers and arblasters, came by a quite natural process to mean the laggards, malingerers and skulkers of the army.

Revival of infantry.

But even this infantry contained within itself two half-smothered sparks of regeneration, the idea of *archery* and the idea of *communal militia*. Archery, in whatever form practised, was the one special form of military activity with which the heavy *gendarme* (whether he fought on horseback or dismounted) had no concern. Here therefore infantry had a special function, and in so far ceased to be “residue.” The communal militia was an early and inadequate expression of the town-spirit that was soon to produce the solid burgher-militia of Flanders and Germany and after that the trained bands of the English cities and towns. It therefore represented the principles of solidarity, of combination, of duty to one’s comrade and to the common cause—principles which had disappeared from feudal warfare.[1] It was under the influence of these two ideas or forces that infantry as an arm began once again, though slowly and painfully, to differentiate itself from the mass of *bidaux* until in

the end the latter practically contained only the worthless elements.

Courtrai.

The first true infantry battle since Hastings was fought at Courtrai in 1302, between the burghers of Bruges and a feudal army under Count Robert of Artois. The citizens, arrayed in heavy masses, and still armed with miscellaneous weapons, were careful to place themselves on ground difficult of access—dikes, pools and marshes—and to fasten themselves together, like the Gauls of old. Their van was driven back by the French communal infantry and professional crossbowmen, whereupon Robert of Artois, true feudal leader as he was, ordered his infantry to clear the way for the cavalry and without even giving them time to do so pushed through their ranks with a formless mass of gendarmerie. This, in attempting to close with the enemy, plunged into the canals and swamped lands, and was soon immovably fastened in the mud. The citizens swarmed all round it and with spear, cleaver and flail destroyed it. Robert himself with a party of his gendarmerie strove to break through the solid wall of spears, but in vain. He was killed and his army perished with him, for the citizens did not regard war as a game and ransom as the loser's forfeit. As for the communal infantry which had won the first success, it had long since disappeared from the field, for when count Robert ordered his heavy cavalry forward, they had thought themselves attacked in rear by a rush of hostile cavalry—as indeed they were, for the gendarmerie rode them down—and melted away.

Crécy (*q.v.*) was fought forty-four years after Courtrai. Here the knights had open ground to fight on, and many boasted that they would revenge themselves. But they encountered not merely infantry, but infantry tactics, and were for the second, and not the last, time destroyed. The English army included a large feudal element, but the spirit of indiscipline had been crushed by a series of iron-handed kings, and for more than a century the nobles, in so far as they had been bad subjects, had been good Englishmen. The English yeomen had reached a level of self-discipline and self-respect which few even of the great continental cities had attained. They had, lastly, made the powerful long-bow (see Archery) their own, and Edward I. had *combined* the shock of the heavy cavalry with the slow searching preparatory rain of arrows (see Falkirk). That is, infantry tactics and cavalry tactics were co-ordinated by a *general*, and the special point of this for the present purpose is that instead of being, as in France, the unstable base of the so-called "feudal pyramid," infantry has become an *arm*, capable of offence and defence and having its own special organization, function in the line of battle and tactical method. This last, indeed, like every other tactical method, rested ultimately on the *moral* of the men who had to put it into execution. Archer tactics did not serve against the disciplined rush of Joan of Arc's gendarmerie, for the solidarity of the archer companies that tried to stop it had long been undermined.

The English archer.

Yet we cannot overrate the importance of the archer in this period of military history. In the city militias solidarity had been obtained through the close personal relationship of the trade gilds and by the elimination of the champion. Therefore, as every offensive in war rests upon boldness, these militias were essentially defensive, for they could only hope to ward off the feudal champion, not to outfight him (Battle of Legnano, 1176. See Oman, p. 442). England, however, had evolved a weapon which no armour could resist, and a race of men as fully trained to use it as the gendarme was to use the lance.[2] This weapon gave them the power of killing without being killed, which the citizens' spears and maces and voulges did not. But like all missiles, arrows were a poor stand-by in the last resort if determined cavalry crossed the "beaten zone" and closed in, and besides pavises and pointed stakes the English archers were given the support of the knights, nobles and sergeants—the armoured champions—whose steady lances guaranteed their safety. Here was the real forward stride in infantry tactics. Archery had existed from time immemorial, and a mere technical improvement in its weapon could hardly account for its suddenly becoming the queen of the battlefield. The defensive power of the "dark impenetrable wood" of spears had been demonstrated again and again, but when the cavalry had few or no preliminary difficulties to face, the chances of the infantry mass resisting long-continued pressure was small. It was the combination of the two elements that made possible a Crécy and a Poitiers, and this combination was the result of the English social system which produced the *camaraderie* of knight and yeoman, champion and plain soldier. Fortified by the knight's unshakeable steadiness, the yeoman handled his bow and arrows with cool certainty and rapidity, and shot down every rush of the opposing champions. This was *camaraderie de combat* indeed, and in such conditions the offensive was possible and even easy. The English conquered whole countries while the Flemish and German spearmen and vougiers merely held their own. For them, decisive victories were only possible when the enemy played into their hands, but for the English the guarantee of such victories was the specific character of their army itself and the tactical methods resulting from and expressing that character.

The Hundred Years' War.

But the war of conquest embodied in these decisive victories dwindled in its later stages to a war of raids. The feudal lord, like the feudal vassal, returned home and gave place to the professional man-at-arms and the professional captain. Ransom became again the chief object, and except where a great leader, such as Bertrand Du Guesclin, compelled the mercenaries to follow him to death or victory, a battle usually became a mêlée of irregular duels between men-at-arms, with all the selfishness and little of the chivalry of the purely feudal encounter. The war went on and on, the gendarmes thickened their armour, and the archers found more difficulty in penetrating it. Moreover, in raids for devastation and booty, the slow-moving infantryman was often a source of danger to his comrades. In this *guerrilla* the archer, though he kept his place, soon ceased to be the mainstay of battle. It had become customary since Crécy (where the English knights and sergeants were dismounted to protect the archers) for all mounted men to send away their horses before engaging. Here and there cavalry masses were used by such energetic leaders as the Black Prince and Du Guesclin, and more often a few men remained mounted for work requiring exceptional speed and courage,[3] but as a general rule the man-at-arms was practically a mounted infantryman, and when he dismounted he stood still. Thus two masses of dismounted lances, mixed with archers, would meet and engage, but the archers, the offensive element, were now far too few in proportion to the lances, the purely defensive element, and battles became indecisive skirmishes instead of overwhelming victories.

Cavalry therefore became, in a very loose sense of the word, infantry. But we are tracing the history not of all troops that stood on their feet to fight, but of infantry and the special tactics of infantry, and the period before and after 1370, when the moral foundations of the new English tactics had disappeared, and the personality of Du Guesclin gave even the bandits of the "free companies" an intrinsic, if slight, superiority over the invaders, is a period of deadlock. Solidarity, such as it was, had gone over to the side of the heavy cavalry. But the latter had deliberately forfeited their power of forcing the decision by fighting on foot, and the English archer, the cadre of the English tactical system, though diminished in numbers, prestige and importance, held to existence and survived the deadlock. Infantry of that type indeed could never return to the "residue" state, and it only needed a fresh moral impetus, a Henry V., to set the old machinery to work again for a third great triumph. But again, after Agincourt, the long war lapsed into the hands of the soldiers of fortune, the basis of Edward's and Henry's tactics crumbled, and, led by a greater than Du Guesclin, the knights and the nobles of France, and the mercenary captains and men-at-arms as well, *rode down* the stationary masses of the English, lances and bowmen alike.

The net result of the Hundred Years' War therefore was to re-establish the two arms, cavalry and infantry, side by side, the one acting by shock, and the other by fire. The lesson of Crécy was "prepare your charge before delivering it," and for that purpose great bodies of infantry armed with bows, arblasts and handguns were brought into existence in France. When the French king in 1448 put into force the "lessons of the war" and organized a permanent army, it

consisted in the main of heavy cavalry (knights and squires in the "ordonnance" companies, soldiers of fortune in the paid companies) and archers and arblasters (*francs-archers* recruited nationally, arblasters as a rule mercenaries, though largely recruited in Gascony). To these *armes de jet* were added, in ever-increasing numbers, hand firearms. Thus the "fire" principle of attack was established, and the defensive principle of "mass" relegated to the background. In such circumstances cavalry was of course the decisive arm, and the reputation of the French gendarmerie was such as to justify this bold elimination of the means of passive defence.[4]

Burgher militias.

The foot-soldier of Germany and the Low Countries had followed a very different line of development. Here the rich commercial cities scarcely concerned themselves with the quarrels or revolts of neighbouring nobles, but they resolutely defended their own rights against feudal interference, and enforced them by an organized militia, opposing the strict solidarity of their own institutions to the prowess of the champion who threatened them. The struggle was between "you shall" on the part of the baron and "we will not" on the part of the citizens, the offensive *versus* the defensive in the simplest and plainest form. The latter was a policy of unbreakable squares, and wherever possible, strong positions as well. Sometimes the citizens, sometimes the nobles gained the day, but the general result was that steady infantry in proper formation could not be ridden down, and as yeomen-archers of the English type to "prepare" the charge were not obtainable from amongst the serf populations of the countryside, the problem of the attack was, for Central Europe, insoluble.

The Wagenburg.

The unbreakable square took two forms, the *wagenburg* with artillery, and the infantry mass with pikes. The first was no more, in the beginning, than an expedient for the safe and rapid crossing of wider stretches of open country than would have been possible for dismounted men, whom the cavalry headed off as soon as they ventured far enough from the shelter of walls. The men rode not on horses but on carriages, and the carriages moved over the plains in laager formation, the infantrymen standing ready with halbert and voulge or short stabbing spear, and the gunners crouching around the long barrelled two-pounders and the "ribaudequins"—the early machine guns—which were mounted on the wagons. These *wagenburgen* combined in themselves the due proportions of mobility and passive defence, and in the skilled hands of Ziska they were capable of the boldest offensive. But such a tactical system depended first of all on drill, for the armoured cavalry would have crowded through the least gap in the wagon line, and the necessary degree of drill in those days could only be attained by an army which had both a permanent existence and some bond of solidarity more powerful than the incentive to plunder—that is, in practice, it was only attained in full by the Hussite insurgents. The cavalry, too, learned its lesson, and pitted mobile three-pounders against the foot-soldiers' one- and two-pounders, and the *wagenburg* became no more than a helpless target. Thus when, not many years after the end of the Hussite wars, the Wars of the Roses eliminated the English model and the English tactics from the military world of Europe, the French system of fire tactics—masses of archers, arblasters and handgun-men, with some spearmen and halberdiers to stiffen them—was left face to face with that of the Swiss and Landsknechts, the system of the "long pike."

The Swiss.

A series of victories ranging from Morgarten (1315) to Nancy (1477) had made the Swiss the most renowned infantry in Europe. Originally their struggles with would-be oppressors had taken the form, often seen elsewhere, of arraying solid masses of men, united in purpose and fidelity to one another rather than by any material or tactical cohesion. Like the men of Bruges at Courtrai, the Swiss had the advantage of broken ground, and the still greater advantage of being opposed by reckless feudal cavalry. Their armament at this stage was not peculiar—voulges, gisarmes, halberts and spears—though they were specially adept in the use of the two-handed sword. But as time went on the long pike (said to have originated in Savoy or the Milanese about 1330) became more and more popular until at last on the verge of their brief ascendancy (about 1475-1515) the Swiss armed as much as one quarter of their troops with it. The use of firearms made little or no progress amongst them, and the Swiss mercenaries of 1480, like their forerunners of Morgarten and Sempach, fought with the *arme blanche* alone. But in a very few years after the Swiss nation had become soldiers of fortune *en masse*, the more open lands of Swabia entered into serious and bitter competition with them. From these lands came the Landsknechts, whose order was as strong as, and far less unwieldy than, that of the Swiss, whose armament included a far greater proportion of firearms, and who established a regimental system that left a permanent mark on army organization. The Landsknecht was the prototype of the infantryman of the 16th and 17th centuries, but his right to indicate the line of evolution had to be wrung from many rivals.

The long pike.

The year 1480 indeed was a turning-point in military history. Within the three years preceding it the battles of Nancy and Guinegate had destroyed both the old feudalism of Charles the Bold and the new cavalry tactics of the French gendarmerie. The former was an anachronism, while the latter, when the great wars came to an end and there was no longer either a national impulse or a national leader, had lapsed into the old vices of ransom and plunder. With these, on the same fields, the *franc-archer* system of infantry tactics perished ignominiously. It rested, as we know, on the principle that the fire of the infantry was to be combined with and completed by the shock of the gendarmerie, and when the latter were found wanting as at Guinegate, the masses of archers and arblasters, which were only feebly supported by a few handfuls of pikemen and halberdiers, were swept away by the charge of some heavy battalions of Swabian and Flemish pikes. Guinegate was the *début* of the Landsknecht infantry as Nancy was that of the Swiss, and the lesson could not be misread. Louis XI. indeed hanged some of his *franc-archers* and dismissed the rest, and in their place raised "bands" of regular infantry, one of which bore for the first time the historic name of *Picardie*. But these "bands" were not self-contained. Armed for the most part with *armes de jet* they centred on the 6000 Swiss pikemen whom Louis XI., in 1480, took into his service, and for nearly fifty years thereafter the French foot armies are always composed of two elements, the huge battalions of Swiss or Landsknechts,[5] armed exclusively with the long pike (except for an ever-decreasing proportion of halberts, and a few arquebuses), and for their support and assistance, French and mercenary "bands."

The Italian wars of 1494-1544, in which the principles of fire and shock were readjusted to meet the conditions created by firearms, were the nursery of modern infantry. The combinations of Swiss, Landsknechts, Spanish "tercios" and French "bands" that figured on the battlefields of the early 16th century were infinitely various. But it is not difficult to find a thread that runs through the whole.

The Italian Wars, 1494-1525.

The essence of the Swiss system was solidity. They arrayed themselves in huge oblongs of 5000 men and more, at the corners of which, like the tower bastions of a 16th-century fortress, stood small groups of arquebusiers. The Landsknechts and the Romagnols of Italy, imitated and rivalled them, though as a rule developing more front and less depth. At this stage solidity was everything and fire-power nothing. At Fornuovo (1495) the mass of arquebusiers and arblasters in the French army did little or nothing; it was the Swiss who were *l'espérance de l'ost*. At Agnadello or Vailá in 1509 the ground and the "encounter-battle" character of the engagement gave special chances of effective employment to the arquebusiers on either side. Along the front the Venetian marksmen, secure behind a bank, picked off the leaders of the enemy as they came near. On the outer flank of the battle the bands of Gascon arquebusiers, which would otherwise have been relegated to an unimportant place in the general line of battle, lapped round the enemy's flank in broken ground and produced great and almost decisive effect. But this was only an afterthought of the king of France and Bayard. In the rest of the battle the huge masses of Swiss pikes were thrown upon the enemy much as the old feudal cavalry had been,

regardless of ditches, orchards and vineyards.

Then for a moment the problem was solved, or partially solved, by the artillery. From Germany the material, though not—at least to the same extent—the principle, of the *wagenburg* penetrated, in the first years of the 16th century, to Italy and thence to France. Thus by degrees a very numerous and exceedingly handy light artillery—"carts with gonnes," as they were called in England—came into play on the Italian battlefields, and took over from the dying *franc-archer* system the work of preparing the assault by fire. For mere skirmishing the Swiss and Landsknechts had arquebusiers enough, without needing to call on the masses of Gascons, &c., and *pari passu* with the development of this artillery, the "bands," other than Swiss and Landsknechts, began to improve themselves into pikemen and halberdiers. At Ravenna (1512) the bands of Gascony and Picardy, as well as the French *aventuriers* (the "bands of Piedmont," afterwards the second senior regiment of the French line) fought in the line of battle shoulder to shoulder with the Landsknechts. On this day the fire action of the new artillery was extraordinarily murderous, ploughing lanes in the immobile masses of infantry. At Marignan the French gendarmerie and artillery, closely and skilfully combined, practically destroyed the huge masses of the Swiss, and so completely had "infantry" and "fire" become separate ideas that on the third day of this tremendous battle we find even the "bands of Piedmont" cutting their way into the Swiss masses.

The Spanish infantry and the arquebus.

But from this point the lead fell into the hands of the Spaniards. These were originally swift and handy light infantry, capable—like the Scottish Highlanders at Prestonpans and Falkirk long afterwards—of sliding under the forest of pikes and breaking into the close-locked ranks with buckler and stabbing sword. For troops of this sort the arquebus was an ideal weapon, and the problem of self-contained infantry was solved by Gonsalvo de Cordoba, Pescara and the great Spanish captains of the day by intercalating small closed bodies of arquebusiers with rather larger, but not inordinately large, bodies of pikes. These arquebusiers formed separate, fully organized sections of the infantry regiment. In close defence they fought on the front and flanks of the pikes, but more usually they were pushed well to the front independently, their speed and excellent fire discipline enabling them to do what was wholly beyond the power of the older type of firing infantry—to take advantage of ground, to run out and reopen fire during a momentary pause in the battle of lance and pike, and to run back to the shelter of their own closed masses when threatened by an oncoming charge. When this system of tactics was consecrated by the glorious success of Pavia (1525), the "cart with gonnes" vanished and the system of fighting everywhere and always "at push of pike" fell into the background.

16th Century-tactics.

The lessons of Pavia can be read in Francis I.'s instructions to his newly formed Provincial (militia) Legions in 1534 and in the battle of Cerisoles ten years later. The "legion" was ordered to be composed of six "bands"—battalions we should call them now, but in those days the term "battalion" was consecrated to a gigantic square of the Swiss type—each of 800 pikes (including a few halberts) and 200 arquebusiers. The pikes, 4800 strong, of each legion were grouped in one large battalion, and covered on the front and flanks by the 1200 arquebuses, the latter working in small and handy squads. These "legions" did not of course count as good troops, but their organization and equipment, designed deliberately in peace time, and not affected by the coming and going of soldiers of fortune, represent therefore the theoretically perfect type for the 16th century. Cerisoles represents the system in practice, with veteran regular troops. On the side of the French most of the arquebuses were grouped on the right wing, in a long irregular line of companies or strong squads, supported at a moderate distance by companies or small battalions of "corselets" (pikes of the French bands of Picardy and Piedmont); the rest of the line of battle was composed of Landsknechts, &c., similarly arrayed, except that the arquebusiers were on the flanks and immediate front of the "corselets" and behind the arquebuses and corselets of the right wing came a Swiss monster of the old type. On the imperial side of the Landsknechts, Spanish and Italian infantry were drawn up in seven or eight battalions, each with its due proportion of pikes and "shot." The course of the battle demonstrated both the active tactical power of the new form of fire-action and the solidity of the pike nucleus, the former in the attack and defence of hills, woods and localities, the latter in an episode in which a Spanish battalion, after being ridden through from corner to corner by the French gendarmes, continued on its way almost unchecked and quite unbroken. This combination of arquebusiers supported by corselets in first line and corselets with a few arquebusiers in second, reappeared at Renty (1554), and St Quentin (1557), and was in fact the typical disposition of infantry from about 1530 to 1600.

By 1550, then, infantry had entirely ceased to be an auxiliary arm. It contained within itself, and (what is more important) within its regimental units, the power of fighting effectively and decisively both at close quarters and at a distance—the principal characteristic of the arm to-day. It had, further, developed a permanent regimental existence, both in Spain and in France, and in the former country it had progressed so far from the "residue" state that young nobles preferred to trail a pike in the ranks of the foot to service in the gendarmerie or light horse. The service battalions were kept up to war strength by the establishment of depots and the preliminary training there of recruits. In France, apart from Picardie and the other old regiments, every temporary regiment, on disbandment, threw off a depot company of the best soldiers, on which nucleus the regiment was reconstituted for the next campaign. Moreover, the permanent establishment was augmented from time to time by the colonel-general of the foot "giving his white flag" to temporary regiments.

The French infantry in 1570.

The organization of the French infantry in 1570 presents some points of interest. The former broad classification of *au delà* and *en deça des monts* or "Picardie" and "Piedmont," representing the home and Italian armies, had disappeared, and instead the whole of the infantry, under one colonel-general, was divided into the regiments of Picardie, Piedmont and French Guards, each of which had its own colonel and its own colours. Besides these, three newer corps were *entretenus par le Roy*—"Champagne," practically belonging to the Guise[6] family, and two others formed out of the once enormous regiment of Marshal de Cossé-Brissac. At the end of a campaign all temporary regiments were disbanded, but in imitation of the Spanish depot system, each, on disbandment, threw off a depot company of picked men who formed the nucleus for the next year's augmentation. The regiment consisted of 10-16 "ensigns" or companies, each of about 150 pikemen and 50 arquebusiers. Each company had a proprietary captain, the owners of the first two companies being the colonel-general and the colonel (*mestre de camp*). The senior captain was called the sergeant-major, and performed the duties of a second in command and an adjutant or brigade-major. Unlike the regimental commander, the sergeant-major was always mounted, and it is recorded that one officer newly appointed to the post incurred the ridicule of the army by dismounting to speak to the king. "Some veteran officers," wrote a contemporary, "are inclined to think that the regimental commander should be mounted as well as the sergeant-major." The regiment was as a rule formed for parade and battle either in line 10 deep or in "battalion" (*i.e.* mass), Swiss fashion. The captain occupied the front, the ensigns with the company colours the centre, and the lieutenants the rear place in the file. The sergeants, armed with the halbert, marched on each side of the battalion or company. Though the musket was gradually being introduced, and had powerful advocates in Marshal Strozzi and the duke of Guise, the bulk of the "shot" still carried the arquebus, the calibre of which had been, thanks to Strozzi's efforts, standardized (see Caliver) so that all the arms took the same sizes of ball. The pikeman had half-armour and a 14-ft. pike, the arquebusier beside the firearm a sword which he was trained to use in the manner of the former Spanish light infantry. The arquebusiers were arrayed in 3 ranks in front of the pikes or in 10 deep files on either flank.

The wars in which this system was evolved were wars for prestige and aggrandizement. They were waged, therefore, by mercenary soldiers, whose main object was to live, and who were officered either by men of their own stamp, or by nobles eager to win military glory. But the Wars of Religion raised questions of life and death for the Frenchmen of either faith, and such public opinion as there was influenced the method of operations so far that a decision and not a prolongation of the struggle began to be the desired end of operations. Hence in those wars the relatively immobile "battalion" of pikes diminishes in importance and the arquebusiers and musketeers grow more and more efficient. Armies, too, became smaller, and marched more rapidly. Encounter-battles became more frequent than "pitched" battles, and in these the musketeer was at a great advantage. Thus by 1600 the proportions between pikes and musketeers in the French army had come to be 6 pikes to 4 muskets or arquebuses, and the *bataillon de combat* or brigade was normally no more than 1200 strong. In the Netherlands, however, the war of consciences was fought out between the best regular army in the world and burgher militias. Even the French *fantassins* were second in importance to the Spanish *soldados*. The latter continued to hold the pre-eminent position they had gained at Pavia.[7] They improved the arquebus into the musket, a heavier and much more powerful weapon (fired from a rest) which could disable a horse at 500 paces.

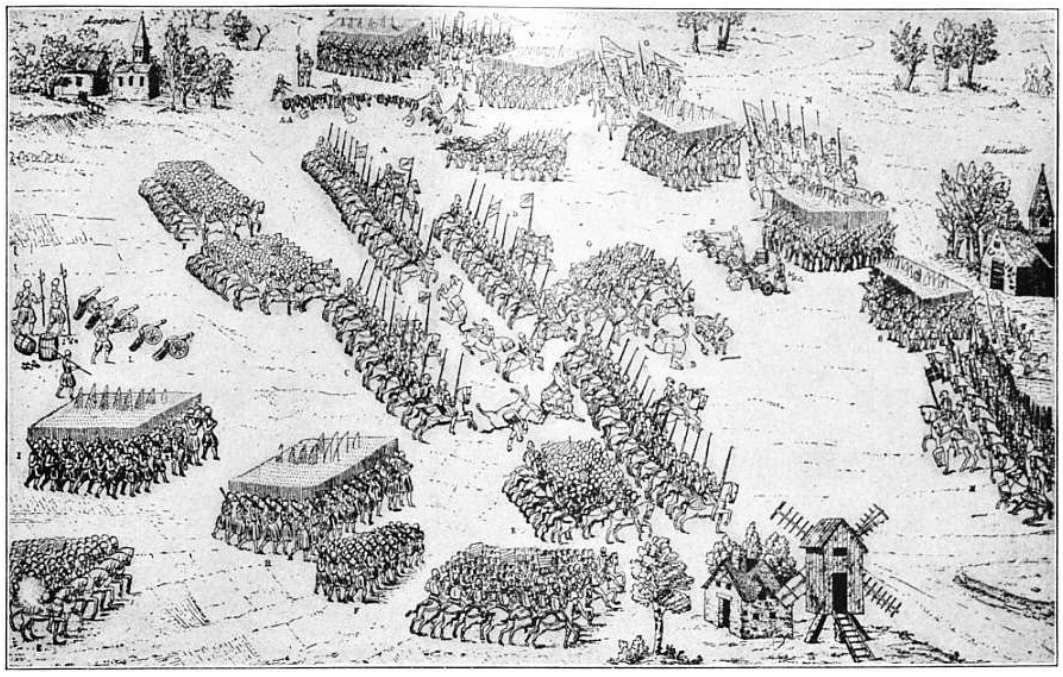
Alva.

At this moment the professional soldier was at the high-water mark of his supremacy. The musket was too complicated to be rapidly and efficiently used by any but a highly trained man; the pike, probably because it had now to protect two or three ranks of "shot" in front of the leading rank of pikemen, as well as the pikemen themselves, had grown longer (up to 18 ft.); and drill and manœuvre had become more important than ever, for in the meantime cavalry had mostly abandoned the massive armour and the long lance in favour of half-armour and the pistol, and their new tactics made them both swifter to charge groups of musketeers and more deadly to the solid masses of pikemen. This superiority of the regular over the irregular was most conspicuously shown in Alva's war against the Netherlands patriots. Desperately as the latter fought, Spanish captains did not hesitate to attack patriot armies ten times their own strength. If once or twice this contempt led them to disaster, as at Heiligerlee in 1568 (though here, after all, Louis of Nassau's army was chiefly composed of trained mercenaries), the normal battle was of the Jemmingen type—seven *soldados* dead and seven thousand rebels.

As regards battles in the open field, such results as these naturally confirmed the "Spanish system" of tactics. The Dutch themselves, when they evolved reliable field armies, copied it with few modifications, and by degrees it was spread over Europe by the professional soldiers on both sides. There was plenty of discussion and readjustment of details. For example, the French, with their smaller battalions and more rapid movements, were inclined to disparage both the cuirass and the pike, and only unwillingly hampered themselves with the long heavy Spanish musket, which had to be fired from a rest. In 1600, nearly fifty years after the introduction of the musket, this most progressive army still deliberately preferred the old light arquebus, and only armed a few selected men with the larger weapons. On the other hand, the Spaniards, though supreme in the open, had for the most part to deal with desperate men behind fortifications. Fighting, therefore, chiefly at close quarters with a fierce enemy, and not disposing either of the space or of the opportunity for "manœuvre-battles," they sacrificed all their former lightness and speed, and clung to armour, the long pike and the heavy 2½ oz. bullet. But the principles first put into practice by Gonsalvo de Cordoba, the combination, in the proportions required in each case, of *fire* and *shock* elements in every body of organized infantry however small, were maintained in full vigour, and by now the superiority of the infantry arm in method, discipline and technique, which had long before made the Spanish nobles proud to trail a pike in the ranks, began to impress itself on other nations. The relative value of horse and foot became a subject for expert discussion instead of an axiom of class pride. The question of cavalry *versus* infantry, hotly disputed in all ages, is a matter affecting general tactics, and does not come within the scope of the present article (see further Cavalry). Expert opinion indeed was still on the side of the horsemen. It was on their cavalry, with its speed, its swords and its pistols that the armies of the 16th century relied in the main to produce the decision in battle. Sir Francis Vane, speaking of the battle of Nieupoort in 1600, says, "Whereas most commonly in battles the success of the foot dependeth on that of the horse, here it was clean contrary, for so long as the foot held good the horse could not be beaten out of the field." The "success" of the foot in Vane's eyes is clearly resistance to disintegration rather than ability to strike a decisive blow.

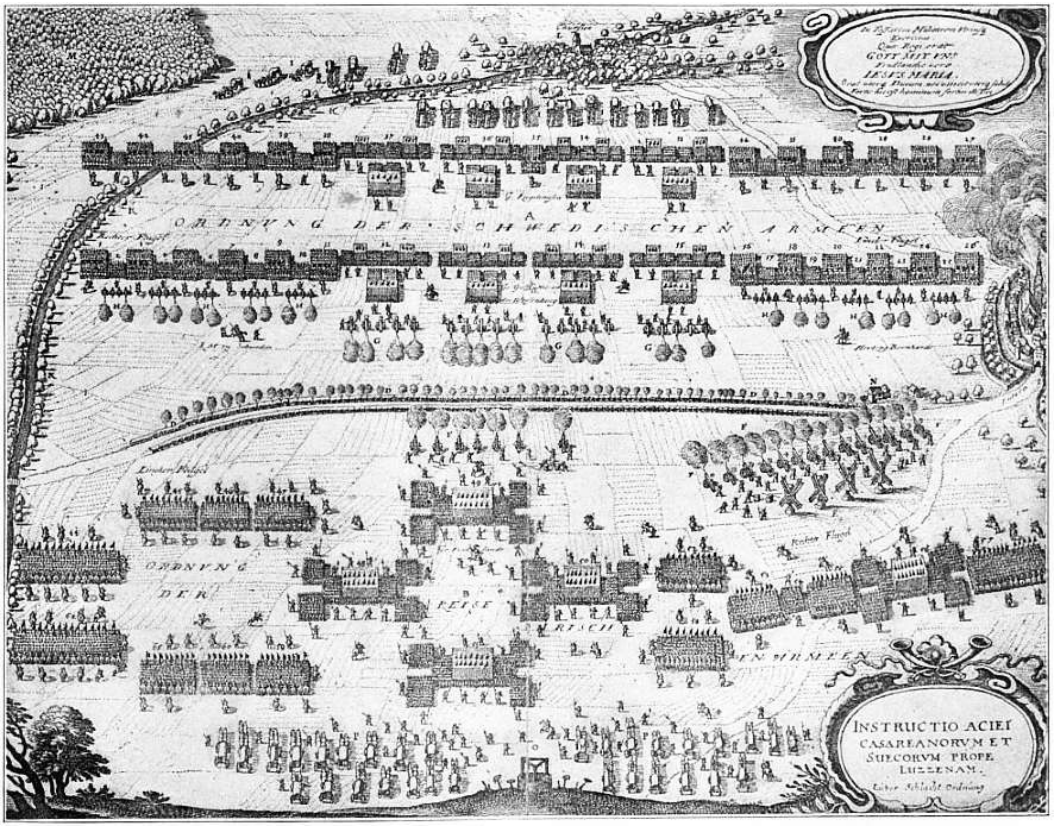
Infantry in 1600.

Plate I.



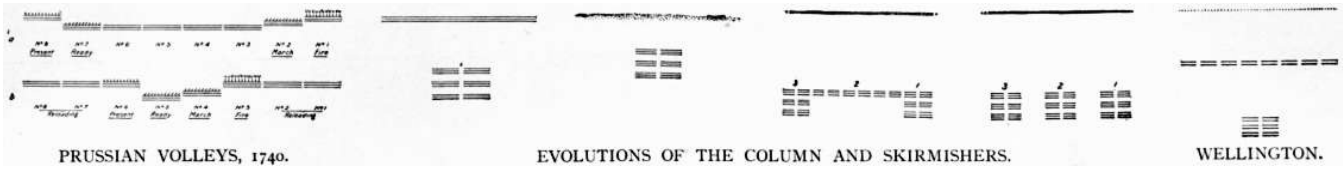
(*From Hardÿ de Périni's Batailles Françaises, by permission.*)

DREUX—1562.

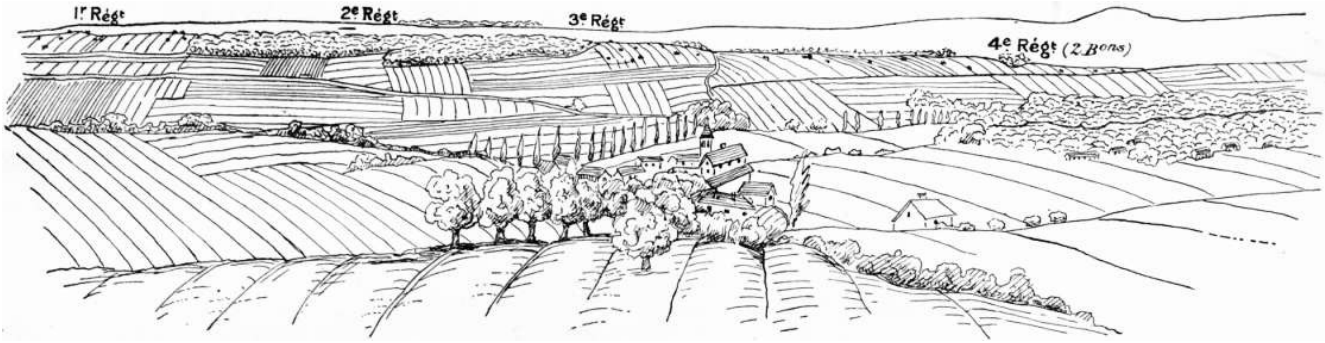


LÜTZEN—1632.

PLATE II.



PRUSSIAN VOLLEYS, 1740. EVOLUTIONS OF THE COLUMN AND SKIRMISHERS. WELLINGTON.



VIONVILLE DE CISSEY'S COUNTER-ATTACK (SEEN FROM REAR OF PRUSSIAN 38th BRIGADE).

(*From Revue d'Infanterie*, 19

APPROACH-MARCH UNDER ARTILLERY FIRE, FRENCH PRINCIPLES (FROM ENEMY'S ARTILLERY POSITION).

It must be remembered, however, that Vane is speaking of the Low Countries, and that in France at any rate the solidity which saved the day at Nieupoort was less appreciated than the *élan* which had won so many smart engagements in the Wars of Religion. Moreover, it was the *offensive*, the decision-compelling faculty of the foot that

steadily developed during the 17th century. To this, little by little, the powers of passive resistance to which Vane did homage, valuable as they were, were sacrificed, until at last the long pike disappeared altogether and the firearm, provided with a bayonet, was the uniform weapon of the foot-soldier. This stage of infantry history covers almost exactly a century. As far as France was concerned, it was a natural evolution. But the acceptance of the principle by the rest of the military world, imposed by the genius of Gustavus Adolphus, was rather revolution than evolution.

Gustavus Adolphus.

In the army which Louis XIII. led against his revolted barons of Anjou in 1620, the old regiments (*les vieux*—Picardie, Piedmont, &c.) seem to have marched in an open chequer-wise formation of companies which is interesting not only as a deliberate imitation of the Roman legion (all soldiers of that time, in the prevailing confusion of tactical ideas, sought guidance in the works of Xenophon, Aelian and Vegetius), but as showing that flexibility and handiness was not the monopoly of the Swedish system that was soon to captivate military Europe. The formations themselves are indeed found in the Spanish and Dutch armies, but the equipment of the men, and the general character of the operations in which they were engaged, probably failed to show off the advantages of this articulation, for the generals of the Thirty Years' War, trained in this school, formed their infantry into large battalions (generally a single line of masses). Experience certainly gave the troops that used these unwieldy formations a relatively high manœuvring capacity, for Tilly's army at Breitenfeld (1631) "changed front half-left" in the course of the battle itself. But the manœuvring power of the Swedes was higher still. Each party represented one side of the classical revival, the Swedes the Roman three-line manipular tactics, the Imperialists and Leaguers those of the Greek line of phalanxes. The former, depending as it did on high *moral* in the individual foot-soldier, was hardly suitable to such a congeries of mercenaries as those that Wallenstein commanded, and later in the Thirty Years' War, when the old native Swedish and Scottish brigades had been annihilated, the Swedish infantry was little if at all better than the rest.

But its tactical system, sanctified by victory, was eagerly caught up by military Europe. The musket, though it had finally driven out the arquebus, had been lightened by Gustavus Adolphus so far that it could be fired without a rest. Rapidity in loading had so far improved that a company could safely be formed six deep instead of ten, as in the Spanish and Dutch systems. Its fire power was further augmented by the addition of two very light field-guns to each battalion; these could inflict loss at twice the effective range of the shortened musket. Above all, Gustavus introduced into the military systems of Europe a new discipline based on the idea of exact performance of duty, which made itself felt in every part of the service, and was a welcome substitute for the former easy-going methods of regimental existence.[8] The adoption of Swedish methods indeed was facilitated by the disrepute into which the older systems had fallen. Men were beginning to see that armies raised by contract for a few months' work possessed inherent vices that made it impossible to rely upon them in small things. Courage the mercenary certainly possessed, but his individual sense of honour, code of soldierly morals, and sometimes devotion to a particular leader did not compensate for the absence of a strong motive for victory and for his general refractoriness in matters of detail, such as march-discipline and punctuality, which had become essential since the great Swedish king had reintroduced order, method and definiteness of purpose into the conduct of military operations. In the old-fashioned masses, moreover, individual weaknesses, both moral and physical, counted for little or were suppressed in the general soldierly feeling of the whole body. But the six-deep line used by Gustavus demanded more devotion and exact obedience in the individual and a more uniform method of drill and handling arms. So shallow an order was not strong enough, under any other conditions, to resist the shock of cavalry or even of pikemen. Indeed, had not the cavalry (who, after Gustavus's death, were uninspired mercenaries like the rest) ceased to charge home in the fashion that Gustavus exacted of them, it is possible that the new-fashioned line would not have stood the test, and that infantry would have reverted to the early 16th-century type.

The Great Rebellion.

The problem of combining the maximum of fire power with the maximum of control over the individual firer was not fully solved until 1740, but the necessity of attempting the problem was realised from the first. In the Swedish army, before it was corrupted by the atmosphere of the Thirty Years' War, duty to God and to country were the springs of the punctual discipline, in small things and in great, which made it the most formidable army, unit for unit, in the world. In the English Civil War (in which the adherents of the "Swedish system" from the first ousted those of the "Dutch") the difficulty was more acute, for although the mainsprings of action were similar, the technical side of the soldier's business—the regimental organization, drill and handling of arms—had all to be improvised. Now in the beginning the Royalist cavalry was recruited from "gentlemen that have honour and courage and resolution"; later, Cromwell raised a cavalry force that was even more thoroughly imbued with the spirit of duty, "men who made some conscience of what they did," and throughout the Civil War, consequently, the mounted arm was the queen of the battlefield.

The Parliamentary foot too "made some conscience of what it did," more especially in the first years of the war. But its best elements—the drilled townsmen—were rather of a defensive than of an offensive character, and towards the close of the struggle, when the foot on both sides came to be formed of professional soldiers, the defensive element decreased, as it had decreased in France and elsewhere. The war was like Gustavus's German campaign, one of rapid and far-ranging marches, and the armoured pikeman had either to shorten his pike and to cast off his armour or to be left at home with the heavy artillery (see Firth's *Cromwell's Army,* ch. iv.). Fights "at push of pike" were rare enough to be specially mentioned in reports of battles. Sir James Turner says that in 1657, when he was commissioned with others to raise regiments for the king of Denmark, "those of the Privy Council would not suffer one word to be mentioned of a pike in our Commissions." It was the same with armour. In 1658 Lockhart, the commander of the English contingent in France, specially asked for a supply of cuirasses and headpieces for his pikemen in order to impress his allies. In 1671 Sir James Turner says, "When we see battalions of pikes, we see them everywhere naked unless it be in the Netherlands." But a small proportion of pikes was still held to be necessary by experienced soldiers, for as yet the socket bayonet had not been invented, and there was still cavalry in Europe that could be trusted to ride home.

Disuse of the pike.

While such cavalry existed, the development of fire power was everywhere hindered by the necessity of self-defence. On the other hand the hitherto accepted defensive means militated against efficiency in many ways, and about 1670, when Louis XIV. and Louvois were fashioning the new standing army that was for fifty years the model for Europe, the problem was how to improve the drill and efficiency of the musketeers so far that the pikes could be reduced to a minimum. In 1680 the firelock was issued instead of the matchlock to all grenadiers and to the four best shots in each French Company. The bayonet—in its primitive form merely a dagger that was fixed into the muzzle of the musket—was also introduced, and the pike was shortened. The proportion of pikes to muskets in Henry IV.'s day, 2 to 1 or 3 to 2, and in Gustavus's 2 to 3, had now fallen to 1 to 3.

The day of great causes that could inspire the average man with the resolution to conquer or die was, however, past, and the "shallow order" (*l'ordre mince*), with all its demands on the individual's sense of duty, had become an integral part of the military system. How then was the sense of duty to be created? Louis and Louvois and their contemporaries sought to create it by taking raw recruits in batches, giving them a consistent training, quartering them in barracks and uniforming them. Henceforward the soldier was not a unit, self-taught and free to enter the service of any master. He had no existence as a soldier apart from his regiment, and within it he was taught that the regiment was everything and the individual nothing. Thus by degrees the idea of implicit obedience to orders and of *esprit de corps* was absorbed.

But the self-respecting Englishman or the quick ardent Frenchman was not the best raw material for quasi-automatic regiments, and it was not until an infinitely more rigorous system of discipline was applied to an unimaginative army that the full possibilities of this enforced sense of duty were realized.

Methods of fire before 1740.

The method of delivering fire originally used by the Spaniards, in which each man in succession fired and fell back to the rear of the file to reload, required for its continued and exact performance a degree of coolness and individual smartness which was probably rarely attained in practice. This was not of serious moment when the "shot" were simple auxiliaries, but when under Gustavus the offensive idea came to the front, and the bullets of the infantry were expected to do something more than merely annoy the hostile pikemen, a more effective method had to be devised. First, the handiness of the musket was so far improved that one man could reload while five, instead of as formerly ten, fired. Then, as the enhanced rate of fire made the file-firing still more disorderly than before, two ranks and three were set to fire "volews" or "salvees" together, and before 1640 it had become the general custom for the musketeers to fire one or two volleys and then, along with the pikemen, to "fall on." It was of course no mean task to charge even a disordered mass of pikes with a short sword or a clubbed musket, and usually after a few minutes the combatants would drift apart and the musketeers on either side would keep up an irregular fire until the officers urged the whole forward for a second attempt.

The bayonet.

With the general disuse of the lance, the disappearance of the personal motives that formerly made the cavalryman charge home, the adoption of the flintlock musket and the invention of the socket bayonet (the fixing of which did not prevent fire being delivered), all reason for retaining the pike vanished, and from about 1700 to the present day, therefore, the invariable armament of infantry has been the musket (or rifle) and bayonet. The manner of employing the weapons, however, changed but slowly. In the French army in 1688, for instance (15 years before the abolition of the pike), the old file-fire was still officially recognized, though rarely employed, the more usual method being for the musketeers in groups of 12 to 30 men to advance to the front and deliver their volleys in turn, these groups corresponding in size to one of the musketeer wings (*manches*) of a company or double company. But the fire and shock action of infantry were still distinct, the idea of "push of pike" remained, the bayonet (as at Marsaglia) taking the place of the pike, and musketry methods were still and throughout the War of the Spanish Succession somewhat half-hearted and tentative. Two generals so entirely different in genius and temperament as Saxe and Catinat could agree on this point, that attacking infantry ought to close with the enemy, bayonets fixed, without firing a shot. Catinat's orders to his army in 1690, indeed, seem rather to indicate that he expected his troops to endure the enemy's first fire without replying in order that their own volley, when it was at last delivered at a few paces distance, should be as murderous as possible, while Saxe, who was a dreamer as well as a practical commander of troops, advocated the pure bayonet charge. But the fact that is common to both is the relative ineffectiveness of musketry before the Prussian era, whether this musketry was delivered by groups of men running forward and returning in line or even by companies in a long line of battle.

This ineffectiveness was due chiefly to the fact that *fire* and *movement* were separate matters. The enemy's volley, that Catinat and others ordered their troops to endure without flinching, was sometimes (as at Fontenoy) absolutely crushing. But as a rule it inflicted an amount of loss that was not sufficient to put the advancing troops out of action, and experienced officers were aware that to halt to reply gave the enemy time to reload, and that once the fight became an interchange of partial and occasional volleys or a general *tiraillerie*, there was an end to the attack.

Linear tactics.

Meanwhile, the tactics of armies had been steadily crystallizing into the so-called "linear" form, which, as far as concerns the infantry, is simply two long lines of battalions (three, four or five deep) and gave the utmost possible development to fire-power. The object of the "line" was to break or beat down the opposing line in the shortest possible time, whether by fire action or shock action, but fire action was only decisive at so short a range that the principal volley could be followed immediately by a charge over a few score paces at most and the crossing of bayonets. Fire was, however, effective at ranges outside charging distance, especially from the battalion guns, and however the decision was achieved in the end, it was necessary to cross the zone between about 300 yds. and 50 yds. range as quickly as possible. It was therefore the business of the regimental officer to force his men across this zone before fire was opened. If, as Catinat recommended, decisive range was reached with every musket loaded and the troops well in hand, their fire when finally it was delivered might well be decisive. But in practice this rarely happened, and though here and there such expedients as a skirmishing line were employed to assist the advance by disturbing the enemy's fire the most that was hoped by the average colonel or captain was that in the advance fire should be opened as late as possible and that the officers should strive to keep in their hands the power of breaking off the fire-fight and pushing the troops forward again. Theorists were already proposing column formations for shock action, and initiating the long controversy between *l'ordre mince* and *l'ordre profonde*, but this was for the time being pure speculation. The linear system rested on the principle that the maximum weight of controlled fire at short range was decisive, and the practical problem of infantry tactics was how to obtain this. The question of *fire versus shock* had been answered in favour of the former, and henceforward for many years the question of *fire versus movement* held the first place. The purpose was settled, and it remained to discover the means.

This means was Prussian fire-discipline, which was elaborated by Leopold of Dessau and Frederick William I., and practically applied by Frederick the Great. It consisted first in the combination, instead of the alternation, of fire and movement, and secondly in the thorough efficiency of the fire in itself. But both these demanded a more stringent and technically more perfect drill than had ever before been imagined, or, for that matter, has ever since been attained. A hundred years before the steady drill of the Spanish veterans at Rocroi, who at the word of command opened their ranks to let the cannon fire from the rear and again closed them, impressed every soldier in Europe. But such drill as this was child's play compared with the Old Dessauer's.

Prussian fire discipline, 1740.

On approaching the enemy the marching columns of the Prussians, which were generally open columns of companies 4 deep, wheeled, in succession to the right or left (almost always to the right) and thus passed along the front of the enemy at a distance of 800-1200 yds. until the rear company had wheeled. Then the whole together (or in the case of a deployment to the left, in succession) wheeled into line facing the enemy. These movements, if intervals and distances were preserved with proper precision, brought the infantry into two long well-closed lines, and parade-ground precision was actually attained, thanks to remorseless drilling and to the reintroduction of the march in step to music. Of course such movements were best executed on a firm plain, and as far as possible the attack and defence of woods and villages was left to light infantry and grenadiers. But even in marshes and scrub, the line managed to manœuvre with some approach to the precision of the barrack square.[9] Now, this precision allowed Frederick to take risks that no former commander would have dared to take. At Hohenfriedberg the infantry columns crossed a marshy stream almost within cannon shot of the enemy; at Kolin (though there this insolence was punished) the army filed past the Imperialist skirmishers within less than musket shot, and the climax of this daring was the "oblique order" attack of Leuthen. With this was bound up a fire discipline that was more extraordinary than any perfection of manœuvre. Before Hohenfriedberg the king gave orders that "pelotonfeuer" was to be opened at 200 paces from the enemy and continued up to 30 paces, when the line was to fall on with the bayonet. The possibility of this combination of fire and movement was the work of Leopold, who gave the Prussian infantry iron ramrods, and by sheer drill made the soldier a machine capable of delivering (with the flintlock muzzle-loading muskets, be it observed) five volleys a minute. This *pelotonfeuer* or company volleys replaced the old fire by ranks practised in other armies. Fire began from the flanks of the battalion, which consisted of eight companies (for

firing, 3 deep). When the right company commander gave “fire,” the commander of No. 2 gave “ready,” followed in turn by other companies up to the centre. The same process having been gone through on the left flank, by the time the two centre companies had fired the two flank companies were ready to recommence, and thus a continuous series of rolling volleys was delivered, at one or two seconds’ interval only between companies. In attack this fire was combined with movement, each company in turn advancing a few paces after “making ready.” In square, old-fashioned methods of fire were employed. Square was an indecisive and defensive formation, rarely used, and in the advance of the deployed line, the offensive and decision-seeking formation *par excellence*, the special Prussian fire-discipline gave Frederick an advantage of five shots to two against all opponents. The bayonet-attack, if the rolling volleys had done their work, was merely “presenting the cheque for payment” as a modern German writer puts it. The cheque had been drawn, the decision given, in the fire-fight.

Leuthen.

For some years this method of infantry training gave the Prussians a decisive superiority in whatever order they fought. But their enemies improved and also grew in numbers, while the Prussian army’s resources were strictly limited. Thus in the Seven Years’ War, after the two costly battles of Prague and Kolin (1757) especially, it became necessary to manœuvre with the object of bringing the Prussian infantry into contact with an equal or if possible smaller portion of the enemy’s line. If this could be achieved, victory was as certain as ever, but the difficulties of bringing about a successful manœuvre were such that the classical “oblique order” attack was only once completely executed. This was at Leuthen, December 5th, 1757, perhaps the greatest day in the history of the Prussian army. Here, in a rolling plain country occasionally broken by marshes and villages, the “oblique order” was executed at high speed and with clockwork precision. Frederick’s object was to destroy the left of the Austrian army (which far outnumbered his own) before the rest of their deployed line of battle could change front to intervene. His method was to place his own line, by a concealed flank march, opposite the point where he desired to strike, and then to advance, not in two long lines but in échelon of battalions from the right (see Leuthen). The échelon was not so deep but that each battalion was properly supported by the following one on its left (100 paces distance), and each, as it came within 200 yds. of the Austrian battalion facing it, opened its “rolling volleys” while continuing to advance; thus long before the left and most backward battalions were committed to the fight, the right battalions were crumbling the Austrian infantry units one by one from left to right. It was the same, without parade manœuvres, when at last the Austrians managed to organize a line of defence about Leuthen village. Unable to make an elaborate change of front with the whole centre and right wing for want of time, they could do no more than crowd troops about Leuthen, on a short fighting front, and this crumbled in turn before the Prussian volleys.

One lesson of Leuthen that contemporary soldiers took to heart was that even a two-to-one superiority in numbers could not remedy want of manoeuvring capacity. It might be hoped that with training and drill an Austrian battalion could be made equal to a Prussian one in the front-to-front fight, and in fact, as losses told more and more heavily on Frederick’s army as years went on, the specific superiority of his infantry disappeared. From 1758 therefore, to the end of the war, there were no more Rossbachs and Leuthens. Superiority in efficiency through previous training having exhausted its influence, superiority in force through manœuvre began to be the general’s ideal, and as it was a more familiar notion to the average Prussian general, trained to manœuvre, than to his opponent, whose idea of “manœuvre” was to sidle carefully from one *position* to another, Prussian generalship maintained its superiority, in spite of many reverses, to the end. The last campaigns were indeed a war of positions, because Frederick had no longer the men available for forcing the Austrians out of them, and on many occasions he was so weak that the most passive defensive and the most elaborate entrenchments barely sufficed to save him. But whenever opportunity offered itself, the king sought a decisive success by bringing the whole of his infantry against part of the enemy’s—the principle of Leuthen put in practice over a wider area and with more elastic manœuvre methods. The long échelon of battalions directed against a part of the hostile line developed quite naturally into an irregular échelon of brigade columns directed against a part of the enemy’s position. But the history of the “cordon system” which followed this development belongs rather to the subject of tactics in general than to that of infantry fighting methods. Within the unit the tactical method scarcely varied. In a battle each battalion or brigade fought as a unit in line, using company volleys and seeking the decision by fire.

Controversies and developments, 1760-1790.

In this, and in even the most minute details of drill and uniform, military Europe slavishly copied Prussia for twenty years after the Seven Years’ War. The services of ex-Prussian officers were at a premium just as those of Gustavus’s officers had been 150 years before. Military missions from all countries went to Potsdam or to the “Reviews” to study Prussian methods, with as simple a faith in their adequacy as that shown to-day by small states and half-civilized kingdoms who send military representatives to serve in the great European armies. And withal, the period 1763-1792 is full of tactical and strategical controversies. The principal of these, as regards infantry, was that between “fire” and “shock” revived about 1710 by Folard, and about 1780 the American War of Independence complicated it by introducing a fresh controversy between *skirmishing* and *close order*. As to the first, in Folard’s day as in Frederick’s, fire action at close range was the deciding factor in battle, but in Frederick’s later campaigns, wherein he no longer disposed of the old Prussian infantry and its swift mechanical fire-discipline, there sprang up a tendency to trust to the bayonet for the decision. If the (so-called) Prussian infantry of 1762 could be in any way brought to close with the enemy, it had a fair chance of victory owing to its leaders’ previous dispositions, and then the advocates of “shock,” who had temporarily been silenced by Mollwitz and Hohenfriedberg, again took courage. The ordinary line was primarily a formation for fire, and only secondarily or by the accident of circumstances for shock, and, chiefly perhaps under Saxe’s influence, the French army had for many years been accustomed to differentiate between “linear” formations for fire and “columnar” for attack—thus reverting to 16th-century practice. While, therefore, the theoreticians pleaded for battalion columns and the bayonet or for line and the bullet, the practical soldier used both. Many forms of combined line and column were tried, but in France, where the question was most assiduously studied, no agreement had been arrived at when the advent of the skirmisher further complicated the issues.

In the early Silesian wars, when armies fought in open country in linear order, the outpost service scarcely concerned the line troops sufficiently to cause them to get under arms at the sound of firing on the sentry line. It was performed by irregular light troops, recruited from wild characters of all nations, who were also charged with the preliminary skirmishing necessary to clear up the situation before the deployment of the battle-army, but once the line opened fire their work was done and they cleared away to the flanks (generally in search of plunder). Later, however, as the preliminary manœuvring before the battle grew in importance and the ground taken into the manœuvring zone was more varied and extended than formerly, light infantry was more and more in demand—in a “cordon” defensive for patrolling the intervals between the various detachments of line troops, in an attack for clearing the way for the deployment of each column. Yet in all this there was no suggestion that light troops or skirmishers were capable of bringing about the decision in an armed conflict. When Frederick gained a durable peace in 1763 he dismissed his “free battalions” without mercy, and by 1764 not more than one Prussian soldier in eleven was an “irregular,” either of horse or foot.[10]

But in the American War of Independence the line was pitted against light infantry in difficult country, and the British and French officers who served in it returned to Europe full of enthusiasm for the latter. Nevertheless, their light infantry was, unlike Frederick’s, *selected line infantry*. The light infantry duties—skirmishing, reconnaissance, outposts

Light Infantry.

—were grafted on to a thorough close-order training. At first these duties fell to the grenadiers and light companies of each battalion, but during the struggle in the colonies, the light companies of a brigade were so frequently massed in one battalion that in the end whole regiments were converted into light infantry. This combination of "line" steadiness and "skirmisher" freedom was the keynote of Sir John Moore's training system fifteen years later, and Moore's regiments, above all the 52nd, 43rd (now combined as the Oxfordshire Light Infantry) and 95th Rifles (Rifle Brigade), were the backbone of the British Army throughout the Peninsular War. At Waterloo the 52nd, changing front in line at the double, flung itself on the head and flank of the Old Guard infantry, and with the "rolling volleys" inherited from the Seven Years' War, shattered it in a few minutes. Such an exploit would have been absolutely inconceivable in the case of one of the old "free battalions." But the light infantry had not merely been levelled up to the line, it had surpassed it, and in 1815 there were no troops in Europe, whether trained to fight in line or column or skirmishers, who could rival the three regiments named, the "Light Division" of Peninsular annals. For meantime the infantry organization and tactics of the old régime, elsewhere than in England, had been disintegrated by the flames of the French Revolution, and from their ashes a new system had arisen, which forms the real starting-point of the infantry tactics of to-day.

The French Revolution.

The controversialists of Louis XVI.'s time, foremost of whom were Guibert, Joly de Maizeroy and Menil Durand (see Max Jähns, *Gesch. d. Kriegswissenschaften*, vol. iii.), were agreed that shock action should be the work of troops formed in column, but as to the results to be expected from shock action, the extent to which it should be facilitated by a previous fire preparation, and the formations In which fire should be delivered (line, line with skirmishers or "swarms") discussion was so warm that it sometimes led to wrangles in ladies' drawing-rooms and meetings in the duelling field. The drill-book for the French infantry issued shortly before the Revolution was a common-sense compromise, which in the main adhered to the Frederician system as modified by Guibert, but gave an important place in infantry tactics to the battalion "columns of attack," that had hitherto appeared only spasmodically on the battlefields of the French army and never elsewhere. This, however, and the quick march (100 paces to the minute instead of the Frederician 75) were the only prescriptions in the drill-book that survived the test of a "national" war, to which within a few years it was subjected (see French Revolutionary Wars). The rest, like the "linear system" of organization and manœuvre to which it belonged (see Army, §§ 30-33; Conscription, &c.) was ignored, and circumstances and the practical troop-leaders evolved by circumstances fashioned the combination of *close-order columns and loose-order skirmishers* which constituted essentially the new tactics of the Revolutionary and Napoleonic infantry.

Tactical evolution in France 1792-1807.

The process of evolution cannot be stated in exact terms, more especially as the officers, as they grew in wisdom through experience, learned to apply each form in accordance with ground and circumstances, and to reject, when unsuitable, not only the forms of the drill-book, but the forms proposed by themselves to replace those of the drill-book. But certain tendencies are easily discernible. The first tendency was towards the dissolution of all tactical links. The earlier battles were fought partly in line for fire action, partly in columns for the bayonet attack. Now the linear tactics depended on exact preservation of dressing, intervals and distances, and what required in the case of the Prussians years of steady drill at 76 paces to the minute was hardly attainable with the newly levied ardent Frenchmen marching at 100 to 120. Once, therefore, the line moved, it broke up into an irregular swarm of excited firers, and experience soon proved that only the troops kept out of the turmoil, whether in line or in column, were susceptible of manœuvre and united action. Thus from about 1795 onwards the forms of the old régime, with half the troops in front in line of battle (practically in dense hordes of firers) and the other half in rear in line or line of columns, give way to new ones in which the skirmishers are fewer and the closed troops more numerous, and the decision rests no longer with the fire of the leading units (which of course could not compare in effectiveness with the rolling volleys of the drilled line) but with the bayonets of the second and third lines—the latter being sometimes in line but more often, owing to the want of preliminary drill, in columns. The skirmishers tended again to become pure light infantry, whose rôle was to prepare, not to give, the decision, and who fought in a thin line, taking every advantage of cover and marksmanship. In the Consulate and early Empire, indeed, we commonly find, in the closed troops destined for the attack, mixed line and column formations combining in themselves shock and controlled close-order fire—absolutely regardless of the skirmishers in front.

In sum, then, from 1792 to 1795 the fighting methods of the French infantry, of which so much has been written and said, are, as they have aptly been called, "horde-tactics." From 1796 onwards to the first campaigns of the Empire, on the other hand, there is an ever-growing tendency to combine skirmishers, properly so called, with controlled and well-closed bodies in rear, the first to prepare the attack to the best of their ability by individual courage and skill at arms, the second to deliver it at the right moment (thanks to their retention of manœuvre formations), and with all possible energy (thanks to the cohesion, moral and material, which carried forward even the laggards). Even when in the long wars of the Empire the quality of the troops progressively deteriorated, infantry tactics within the regiment or brigade underwent no radical alteration. The actual formations were most varied, but they always contained two of the three elements, column, line and skirmishers. Column (generally two lines of battalions in columns of double-companies) was for shock or attack, line for fire-effect, and skirmishers to screen the advance, to scout the ground and to disturb the enemy's aim. Of these, except on the defensive (which was rare in a Napoleonic battle), the "column" of attack was by far the most important. The line formations for fire, with which it was often combined, rarely accounted for more than one-quarter of the brigade or division, while the skirmishers were still less numerous. Withal, these formations in themselves were merely fresh shapes for old ideas. The armament of Napoleon's troops was almost identical with that of Frederick's or Saxe's. Line, column and combinations of the two were as old as Fontenoy and were, moreover, destined to live for many years after Napoleon had fallen. "Horde-tactics" did not survive the earlier Revolutionary campaigns. Wherein then lies the change which makes 1792 rather than 1740 the starting-point of modern tactics?

Napoleon's infantry and artillery tactics, 1807-1815.

The answer, in so far as so comprehensive a question can be answered from a purely infantry standpoint, is that whereas Frederick, disposing of a small and highly finished instrument, used its manœuvre power and regimental efficiency to destroy one part of his enemy so swiftly that the other had no time to intervene, Napoleon, who had numbers rather than training on his side, only delivered his decisive blow after he had "fixed" all bodies of the enemy which would interfere with his preparations—*i.e.* had set up a physical barrier against the threatened intervention. This new idea manifested itself in various forms. In strategy (*q.v.*) and combined tactics it is generally for convenience called "economy of force." In the domain of artillery (see Artillery) it marked a distinction, that has revived in the last twenty years, between slow disintegrating fire and sudden and overpowering "fire-preparation." As regards infantry the effect of it was revolutionary. Regiments and brigades were launched to the attack to compel the enemy to defend himself, and fought until completely dissolved to force him to use up his reserves. "On s'engage partout et puis l'on voit" is Napoleon's own description of his *holding attack*, which in no way resembled the "feints" of previous generations. The self-sacrifice of the men thus engaged enabled their commander to "see," and to mass his reserves opposite a selected point, while little by little the enemy was hypnotized by the fighting. Lastly, when "the battle was ripe" a hundred and more guns galloped into close range and practically annihilated a part of the defender's line. They were followed up by masses of reserve infantry, often more solidly formed at the outset than the old Swiss masses of the 16th century.[11] If

the moment was rightly chosen these masses, dissolved though they soon were into dense formless crowds, penetrated the gap made by the guns (with their arms at the slope) and were quickly followed by cavalry divisions to complete the enemy's defeat. Here, too, it is to be observed there is no true shock. The infantry masses merely "present the cheque for payment," and apart from surprises, ambushes and fights in woods and villages there are few recorded cases of bayonets being crossed in these wars. Napoleon himself said "Le feu est tout, le reste peu de chose," and though a mere plan of his dispositions suggests that he was the disciple of Folard and Menil Durand, in reality he simply applied "fire-power" in the new and grander form which his own genius imagined.

The problem, then, was not what it had been one hundred and fifty years before. The business of the attack was not to break down the passive resistance of the defence, but to destroy or to evade its fire-power. No attack with the bayonet could succeed if this remained effective and unbroken, and no resistance (in the open field at least) availed when it had been mastered or evaded. In Napoleon's army, the circumstance that the infantry was (after 1807) incapable of carrying out its own fire-preparation forced the task into the hands of the field artillery. In other armies the 18th-century system had been discredited by repeated disasters, and the infantry, as it became "nationalized," was passing slowly through the successive phases of irregular lines, "swarms," skirmishers and line-and-column formations that the French Revolutionary armies had traversed before them—none of them methods that in themselves had given decisive results.

The British Peninsular infantry.

In all Europe the only infantry that represented the Frederician tradition and prepared its own charge by its own fire was the British. Eye-witnesses who served in the ranks of the French have described the sensation of powerlessness that they felt as their attacking column approached the line and watched it load and come to the present. The column stopped short, a few men cheered, others opened a ragged individual fire, and then came the volleys and the counter-attack that swept away the column. Sometimes this counterstroke was made, as in the famous case of Busaco, from an apparently unoccupied ridge, for the British line, under Moore's guidance, had shaken off the Prussian stiffness, fought 2 deep instead of 3 and was able to take advantage of cover. The "blankness of the battlefield" noted by so many observers to-day in the South African and Manchurian Wars was fully as characteristic of Wellington's battles from Vimeiro to Waterloo, in spite of close order and red uniforms. But these battles were of the offensive-defensive type in the main, and for various reasons this type could not be accepted as normal by the rest of Europe. Nonchalance was not characteristic of the eager national levies of 1813 and 1814, and the Wellington method of infantry tactics, though it had brought about the failure of Napoleon's last effort, was still generally regarded as an illustration of the already recognized fact that on the defensive the fire-power of the line, unless partly or wholly evaded by rapidity in the advance and manœuvring power or mastered and extinguished by the fire-power of the attack, made the front of the defence impregnable. There was indeed nothing in the English tactics at Waterloo that, standing out from the incidents of the battle, offered a new principle of winning battles.

Infantry methods, 1815-1870.

Nor indeed did Europe at large desire a fresh era of warfare. Only the French, and a few unofficial students of war elsewhere, realized the significance of the rejuvenated "line." For every one else, the later Napoleonic battle was the model, and as the great wars had ended before the "national" spirit had been exhausted or misused in wars of aggrandizement, infantry tactics retained, in Germany, Austria and Russia, the characteristic Napoleonic formations, lines of battalion or regimental columns, sometimes combined with linear formations for fire, and always covered by skirmishers. That these columns must in action dissolve sooner or later into dense irregular swarms was of course foreseen, but Napoleon had accustomed the world to long and costly fire-fighting as the preliminary to the attack of the massed reserves, and for the short remainder of the period of smooth-bore muskets, troops were always launched to the attack in columns covered by a thin line of picked shots as skirmishers. The moral power of the offensive "will to conquer" and the rapidity of the attack itself were relied upon to evade and disconcert the fire-power of the defence. If the attack failed to do so, the ranges at which infantry fire was really destructive were so small that it was easy for the columns to deploy or disperse and open a fire-fight to prepare the way for the next line of columns. And after a careful study of the battle of the Alma, in which the British line won its last great victory in the open field, Moltke himself only proposed such modifications in the accepted tactical system as would admit of the troops being deployed for *defence* instead of meeting attack, as the Russians met it, in solid and almost stationary columns. Fire in the attack, in fact, had come to be considered as chiefly the work of artillery, and as artillery, being an expensive arm, had been reduced during the period of military stagnation following Waterloo, and was no longer capable of Napoleonic feats, the attack was generally a bayonet attack pure and simple. Waterloo and the Alma were credited, not to fire-power, but to English solidity, and as Ardant du Picq observes, "All the peoples of Europe say 'no one can resist our bayonet attack if it is made resolutely'—and *all are right*.... Bayonet fixed or in the scabbard, it is all the same." Since the disappearance of the "dark impenetrable wood" of spears, the question has always turned on the word "resolute." If the defence cannot by any means succeed in mastering the resolution of the assailant, it is doomed. But the means (moral and material) at the disposal of the defence for the purpose of mastering this resolution were, within a few years of the Crimean War, revolutionized by the general adoption of the rifle, the introduction of the breech-loader and the revival of the "nation in arms."

Thirty years before the Crimea the flint-lock had given way to the percussion lock (see Gun), which was more certain in its action and could be used in all weathers. But fitting a copper cap on the nipple was not so simple a matter for nervous fingers as priming with a pinch of powder, and the usual rate of fire had fallen from the five rounds a minute of Frederick's day to two or three at the most. "Fire-power" therefore was at a low level until the general introduction[12] of the rifled barrel, which while further diminishing the rate of fire, at any rate greatly increased the range at which volleys were thoroughly effective. Artillery (see Artillery, § 13), the fire-weapon of the attack, made no corresponding progress, and even as early as the Alma and Inkerman (where the British troops used the Minie rifle) the dense columns had suffered heavily without being able to retaliate by "crossing bayonets." Fire power, therefore, though still the special prerogative of the defence, began to reassert its influence, and for a brief period the defensive was regarded as the best form of tactics. But the low rate of fire was still a serious objection. Many incidents in the American Civil War showed this, notably Fredericksburg, where the key of the Confederate position was held—against a simple frontal attack unsupported by effective artillery fire—by three brigades in line one behind the other, *i.e.* by a *six-deep* firing line. No less force could guarantee the "inviolability of the front," and even when, in this unnatural and uneconomical fashion, the rate of fire was augmented as well as the effective range, a properly massed and well-led attack in column (or in a rapid succession of deployed lines) generally reached the defender's position, though often in such disorder that a resolute counterstroke drove it back again. The American fought over more difficult country and with less previous drill-training than the armies of the Old World. The fire-power of the defence, therefore, that even in America did not always prevail over the resolution of the attack, entirely failed in the Italian war of 1859 to stop the swiftly moving, well-drilled columns of the French professional army, in which the national *élan* had not as yet been suppressed, as it was a few years later, by the doctrine that "the new arms found their greatest scope in the defence." The Austrians, who had pinned their faith to this doctrine, deserted their false gods, forbade any mention of the defensive in their drill-books, and brought back into honour the bayonet tactics of the old wars.

The need of artillery support for the attack was indeed felt (though the gunners had not as yet evolved any substitute

for the case-shot preparation of Napoleon's time), but men remembered that artillery was used by the great captain, not so much to enable good troops to close with the enemy, as to win battles with masses of troops of an inferior stamp, and contemporary experience seemed to show that (if losses were accepted as inevitable) good and resolute troops could overpower the defence, even in face of the rifle and without the aid of case shot. But a revolution was at hand.

The breech-loading rifle.

In 1861 Moltke, discussing the war in Italy, wrote, "General Niel attributes his victory (at Solferino) to the bayonet. But that does not imply that the attack was often followed by a hand-to-hand fight. In principle, when one makes a bayonet charge, it is because one supposes that the enemy will not await it.... *To approach the enemy closely, pouring an efficacious fire into him*—as Frederick the Great's infantry did—*is also a method of the offensive*." This method was applicable at that time for the Prussians alone, for they alone possessed a breech-loading firearm. The needle-gun was a rudimentary weapon in many respects, but it allowed of maintaining more than twice the rate of fire that the muzzle-loader could give, and, moreover, it permitted the full use of cover, because the firer could lie down to fire without having to rise between every round to load. Further, he could load while actually running forward, whereas with the old arms loading not only required complete exposure but also checked movement. The advantages of the Prussian weapon were further enhanced, in the war against Austria, by the revulsion of feeling in the Imperial army in favour of the pure bayonet charge in masses that had followed upon Magenta and Solferino.

With the stiffly drilled professional soldier of England, Austria and Russia the handiness of the new weapon could hardly have been exploited, for (in Russia at any rate) even skirmishers had to march in step. The Prussians were drilled nominally in accordance with regulations dating from 1812, and therefore suitable, if not to the new weapon, at least to the "swarm" fighting of an enthusiastic national army, but upon these regulations a mass of peace-time amendments had been superposed, and in theory their drill was as stiff as that of the Russians. But, as in France in 1793-1796, the composition of their army—a true "nation in arms"—and the character of the officers evolved by the universal service system saved them from their regulations. The offensive spirit was inculcated as thoroughly as elsewhere, and in a much more practical form. Dietrich von Bülow's predictions of the future battle of "skirmishers" (meaning thereby a dense but irregular firing line) had captivated the younger school of officers, while King William and the veterans of Napoleon's wars were careful to maintain small columns (sometimes company[13] columns of 240 rifles, but quite as often half-battalion and battalion columns) as a solid background to the firing line. Thus in 1866 (see Seven Weeks' War), as Moltke had foreseen, the attacking infantry fought its way to close quarters by means of its own fire, and the bayonet charge again became, in his own words, "not the first, but the last, phase of the combat," immediately succeeding a last burst of rapid fire at short range and carried out by the company and battalion reserves in close order. Against the Austrians, whose tactics alternated between unprepared bayonet rushes by whole brigades and a passive slow-firing defensive, victory was easily achieved.

Infantry in the war of 1870.

But immediately after Königgrätz the French army was served out with a breech-loading rifle greatly superior in every respect to the needle-gun, and after four years' tension France pitted breech-loader against breech-loader. In the first battles (see Wörth, and Metz: *Battles*) the decision-seeking spirit of the "armed nation," the inferior range of the needle-gun as compared with that of the chassepot, and the recollections of easy triumphs in 1864 and 1866, all combined to drive the German infantry forward to within easy range before they began to make use of their weapons. Their powerful artillery would have sufficed of itself to enable them to do this (see Sedan), had they but waited for its fire to take effect. But they did not, and they suffered accordingly, for, owing to the ineffectiveness of their rifle between 1000 and 400 yds. range, they had to advance, as the Austrians and Russians had done in previous wars, without firing a shot. In these circumstances their formations, whether line or column, broke up, and the whole attacking force dissolved into long irregular swarms. These swarms were practically composed only of the brave men, while the rest huddled together in woods and valleys. When, therefore, at last the firing line came within 400 or 500 yds. of the French, it was both severely tried and numerically weak, but the fact that it was composed of the best men only enabled it to open and to maintain an effective fire. Even then the French, highly disciplined professional soldiers that they were, repeatedly swept them back by counterstrokes, but these counterstrokes were subjected to the fire of the German guns and were never more than locally and momentarily effective. More and more German infantry was pushed forward to support the firing line, and, like its predecessors, each reinforcement, losing most of its unwilling men as it advanced over the shot-swept ground, consisted on arrival of really determined men, and closing on the firing line pushed it forward, sometimes 20 yds., sometimes 100, until at last rapid fire at the closest ranges dislodged the stubborn defenders. Bayonets (as usual) were never actually used, save in sudden encounters in woods and villages. The decisive factors were, first the superiority of the Prussian guns, secondly, heavy and effective fire delivered at short range, and above all the high moral of a proportion of resolute soldiers who, after being subjected for hours to the most demoralizing influences, had still courage left for the final dash. These three factors, in spite of changes in armament, rule the infantry attack of to-day.

Infantry Tactics Since 1870

The net result of the Franco-German War on infantry tactics, as far as it can be summed up in a single phrase, was to transfer the fire-fight to the line of skirmishers. Henceforward the old and correct sense of the word "skirmishers" is lost. They have nothing to do with a "skirmish," but are the actual organ of battle, and their old duties of feeling the way for the battle-formations have been taken over by "scouts." The last-named were not, however, fully recognized in Great Britain[14] till long after the war—not in fact until the war in South Africa had shown that the "skirmisher" or firing line was too powerful an engine to be employed in mere "feeling." In most European armies "combat patrols," which work more freely, are preferred to scouts, but the idea is the same.

Lessons of 1870.

The fire-fight on the line of skirmishers, now styled the *firing line*, is the centre of gravity of the modern battle. In 1870, owing to the peculiar circumstances of unequal armament, the "fire-fight" was insufficiently developed and uneconomically used, and after the war tacticians turned their attention to the evolution of better methods than those of Wörth and Gravelotte, Europe in general following the lead of Prussia. Controversy, in the early stages, took the form of a contest between "drill" and "individualism," irrespective of formations and technical details, for until about 1890 the material efficiency of the gun and the rifle remained very much what it had been in 1870, and the only new factor bearing on infantry tactics was the general adoption of a "national army" system similar to Prussia's and of rifles equal, and in some ways superior, to the chassepot. All European armies, therefore, had to consider equality in artillery power, equality in the ballistics of rifles, and equal intensity of fighting spirit as the normal conditions of the next battle of nations. Here, in fact, was an equilibrium, and in such conditions how was the attacking infantry to force its way forward, whether by fire or movement or by both? France sought the answer in the domain of artillery. Under the guidance of General Langlois, she re-created the Napoleonic hurricane of case-shot (represented in modern conditions by time shrapnel), while from the doctrine formed by Generals Maillard and Bonnal there came a system of infantry tactics derived fundamentally from the tactics of the Napoleonic era. This, however, came later; for the moment (viz. from 1871 to about 1890) the lead in infantry training was admittedly in the hands of the Prussians.

German officers who had fought through the war had seen the operations, generally speaking, either from the staff officer's or from the regimental officer's point of view. To the former and to many of the latter the most indelible impression of the battlefield was what they called *Massen-Drückebergertum* or "wholesale skulking." The rest, who had perhaps in most cases led the brave remnant of their companies in the final assaults, believed that battles were won by the individual soldier and his rifle. The difference between the two may be said to lie in this, that the first sought a remedy, the second a method. The remedy was *drill*, the method *extended order*.

The extreme statement of the case in favour of drill pure and simple is to be found in the famous anonymous pamphlet *A Summer Night's Dream*, in which a return to the "old Prussian fire-discipline" of Frederick's day was offered as the solution of the problem, how to give "fire" its maximum efficacity. Volleys and absolutely mechanical obedience to word of command represent, of course, the most complete application of fire-power that can be conceived. But the proposals of the extreme close-order school were nevertheless merely pious aspirations, not so much because of the introduction of the breech-loader as because the short-service "national" army can never be "drilled" in the Frederician sense. The proposals of the other school were, however, even more impracticable, in that they rested on the hypothesis that all men were brave, and that, consequently, all that was necessary was to teach the recruit how to shoot and to work with other individuals in the squad or company. Disorder of the firing line was accepted, not as an unavoidable evil, but as a condition in which individuality had full play, and as dense swarm formations were quite as vulnerable as an ordinary line, it was an easy step from a thick line of "individuals" to a thin one. The step was, in fact, made in the middle of the war of 1870, though it was hardly noticed that extension only became practicable in proportion as the quality of the enemy decreased and the Germans became acclimatized to fire.

Between these extremes, a moderate school, with the emperor William (who had more experience of the human being in battle than any of his officers) at its head, spent a few years in groping for close-order formations which admitted of control without vulnerability, then laid down the principle and studied the method of developing the greatest fire-power of which short-service infantry was supposed capable, ultimately combined the "drill" and teaching ideas in the German infantry regulations of 1888, which at last abolished those of 1812 with their multitudinous amendments.

Conditions of the modern battle.

The necessity for "teaching" arose partly out of the new conditions of service and the relative rarity of wars. The soldier could no longer learn the ordinary rules of safety in action and comfort in bivouac by experience, and had to be taught. But it was still more the new conditions of fighting that demanded careful individual training. Of old, the professional soldier (other than the man belonging to light troops or the ground scout) was, roughly speaking, either so far out of immediate danger as to preserve his reasoning faculties, or so deep in battle that he became the unconscious agent of his inborn or acquired instincts. But the increased range of modern arms prolonged the time of danger, and although (judged by casualty returns) the losses to-day are far less than those which any regiment of Frederick's day was expected to face without flinching, and actual fighting is apparently spasmodic, the period in which the individual soldier is subjected to the fear of bullets is greatly increased. Zorndorf, the most severe of Frederick's battles, lasted seven hours, Vionville twelve and Wörth eleven. The battle of the future in Europe, without being as prolonged as Liao-Yang, Shaho and Mukden, will still be undecided twenty-four hours after the advanced guards have taken contact. Now, for a great part of this time, the "old Prussian fire-discipline," which above all aims at a rapid decision, will be not only unnecessary, but actually hurtful to the progress of the battle as a whole. As in Napoleon's day (for reasons presently to be mentioned) the battle must resolve itself into a preparative and a decisive phase.[15] In the last no commander could desire a better instrument (if such were attainable with the armies of to-day) than Frederick's forged steel machine, in which every company was human mitrailleuse. But the preparatory combat not only will be long, but also must be graduated in intensity at different times and places in accordance with the commander's will, and the Frederician battalion only attained its mechanical perfection by the absolute and permanent submergence of the individual qualities of each soldier, with the result that, although it furnished the maximum effort in the minimum time, it was useless once it fell apart into ragged groups. The individual spirit of earnestness and intelligence in the use of ground by small fractions, which in Napoleon's day made the *combat d'usure* possible, was necessarily unknown in Frederick's. On the other hand, graduation implies control on the part of the leaders, and this the method of irregular swarms of individual fighters imagined by the German progressives merely abdicates. At most such swarms—however close or extended—can only be tolerated as an evil that no human power can avert when the battle has reached a certain stage of intensity. Even the latest *German Infantry Training* (1906) is explicit on this point. "It must never be forgotten that the obligation of abandoning close order is an evil which can often be avoided when" &c. &c. (par. 342). The consequences of this evil, further, are actually less serious in proportion as the troops are well drilled—not to an unnecessary and unattainable ideal of mechanical perfection, but to a state of instinctive self-control in danger. Drill, therefore, carried to such a point that it has eliminated the bad habits of the recruit without detriment to his good habits, is still the true basis of all military training, whether training be required for the swift controlled movements of bodies of infantry in close order, for the cool and steady fire of scattered groups of skirmishers, or for the final act of the resolute will embodied in the "decisive attack." Unfortunately for the solution of infantry problems "drill" and "close order" are often confused, owing chiefly to the fact that in the 1870 battles the dissolution of close order formations practically meant the end of control as control was then understood. Both the material and objective, and the inward and spiritual significances of "drill" are, however, independent of "close order." In fact, in modern history, when a resolute general has made a true decisive attack with half-drilled troops, he has generally arrayed them in the closest possible formations.

Drill.

Drill is the military form of education by repetition and association (see G. le Bon, *Psychologie de l'éducation*). Materially it consists in exercises frequently repeated by bodies of soldiers with a view to ensuring the harmonious action of each individual in the work to be performed by the mass—in a word, rehearsals. Physical "drill" is based on physiology and gymnastics, and aims at the development of the physique and the individual will power.[16] But the psychological or moral is incomparably the most important side of drill. It is the method or art of discipline. Neither self-control nor devotion in the face of imminent danger can as a rule come from individual reasoning. A commander-in-chief keeps himself free from the contact with the turmoil of battle so long as he has to calculate, to study reports or to manœuvre, and commanders of lower grades, in proportion as their duty brings them into the midst of danger, are subjected to greater or less disturbing influences. The man in the fighting line where the danger is greatest is altogether the slave of the unconscious. Overtaxed infantry, whether defeated or successful, have been observed to present an appearance of absolute insanity. It is true that in the special case of great war experience reason resumes part of its dominion in proportion as the fight becomes the soldier's habitual *milieu*. Thus towards the end of a long war men become skilful and cunning individual fighters; sometimes, too, feelings of respect for the enemy arise and lead to interchange of courtesies at the outposts, and it has also been noticed that in the last stage of a long war men are less inclined to sacrifice themselves. All this is "reason" as against inborn or inbred "instinct." But in the modern world, which is normally at peace, some method must be found of ensuring that the peace-trained soldier will carry out his duties when his reason is submerged. Now we know that the constant repetition of a certain act, whether on a given impulse or of the individual's own volition, will eventually make the performance of that act a reflex action. For this reason peace-drilled troops have often defeated a war-trained enemy, even when the motives for fighting were equally powerful on each side. The mechanical performance of movements, and loading and firing at the enemy, under the most disturbing conditions can be ensured by bringing the

required self-control from the domain of reason into that of instinct. "*L'éducation*," says le Bon, "*est l'art de faire passer le conscient dans l'inconscient*." Lastly, the instincts of the recruit being those special to his race or nation, which are the more powerful because they are operative through many generations, it is the drill sergeant's business to bring about, by disuse, atrophy of the instincts which militate against soldierly efficiency, and to develop, by constant repetition and special preparation, other useful instincts which the Englishman or Frenchman or German does not as such possess. In short, as regards infantry training, there is no real distinction between drill and education, save in so far as the latter term covers instruction in small details of field service which demand alertness, shrewdness and technical knowledge (as distinct from technical training). As understood by the controversialists of the last generation, drill was the antithesis of education. To-day, however, the principle of education having prevailed against the old-fashioned notion of drill, it has been discovered that after all drill is merely an intensive form of education. This discovery (or rather definition and justification of an existing empirical rule) is attributable chiefly to a certain school of French officers, who seized more rapidly than civilians the significance of modern psycho-physiology. In their eyes, a military body possesses in a more marked degree than another, the primary requisite of the "psychological crowd," studied by Gustave le Bon, viz. the orientation of the wills of each and all members of the crowd in a determined direction. Such a crowd generates a collective will that dominates the wills of the individuals composing it. It coheres and acts on the common property of all the instincts and habits in which each shares. Further it tends to extremes of baseness and heroism—this being particularly marked in the military crowd—and lastly it reacts to a stimulus. The last is the keynote of the whole subject of infantry training as also, to a lesser degree, of that of the other arms. The officer can be regarded practically as a hypnotist playing upon the unconscious activities of his subject. In the lower grades, it is immaterial whether reason, caprice or a fresh set of instincts stimulated by an outside authority, set in motion the "suggestion." The true leader, whatever the provenance of his "suggestion," makes it effective by dominating the "psychological crowd" that he leads. On the other hand, if he fails to do so, he is himself dominated by the uncontrolled will of the crowd, and although leaderless mobs have at times shown extreme heroism, it is far more usual to find them reverting to the primitive instinct of brutality or panic fear. A mob, therefore, or a raw regiment, requires greater powers of suggestion in its leader, whereas a thorough course of drill tunes the "crowd" to respond to the stimulus that average officers can apply.

So far from diminishing, drill has increased in importance under modern conditions of recruiting. It has merely changed in form, and instead of being repressive it has become educative. The force of modern short-service troops, as *troops*, is far sooner spent than that of the old-fashioned automatic regiments, while the reserve force of its component parts, remaining after the dissolution, is far higher than of old. But this uncontrolled, force is liable to panic as well as amenable to an impulse of self-sacrifice. In so far, then, it is necessary to adopt the catchword of the Bülow school and to "organize disorder," and the only known method of doing so is drill. "Individualism" pure and simple had certainly a brief reign during and after the South African War, especially in Great Britain, and both France and Germany coquetted with "Boer tactics," until the Russo-Japanese war brought military Europe back to the old principles.

The South African War.

But the South African War came precisely at the point of time when the controversies of 1870 had crystallized into a form of tactics that was not suitable to the conditions of that war, while about the same time the relations of infantry and artillery underwent a profound change. As regards the South African War, the clear atmosphere, the trained sight of the Boers, and the alternation of level plain and high concave kopjes which constituted the usual battlefield, made the front to front infantry attacks not merely difficult but almost impossible. For years, indeed ever since the Peninsular War, the tendency of the British army to deploy early had afforded a handle to European critics of its tactical methods. It was a tendency that survived with the rest of the "linear" tradition. But in South Africa, owing to the special advantages of the defenders, which denied to the assailant all reliable indications of the enemy's strength and positions, this early deployment had to take a non-committal form—viz. many successive lines of skirmishers. The application of this form was, indeed, made easy by the openness of the ground, but like all "schematic" formations, open or close, it could not be maintained under fire, with the special disadvantage that the extensions were so wide as to make any manœuvring after the fight had cleared up a situation a practical impossibility. Hence some *preconceived idea* of an objective was an essential preliminary, and as the Boer mounted infantry hardly ever stood to defend any particular position to the last (as they could always renew the fight at some other point in their vast territory), the preconceived idea was always, after the early battles, an envelopment in which the troops told off to the frontal holding attack were required, not to force their advance to its logical conclusion, but to keep the fight alive until the flank attack made itself felt. The principal tendency of British infantry tactics after the Boer War was therefore quite naturally, under European as well as colonial conditions, to deploy at the outset in great depth, *i.e.* in many lines of skirmishers, each line, when within about 1400 yds. of the enemy's position, extending to intervals of 10 to 20 paces between individuals. The reserves were strong and their importance was well marked in the 1902 training manual, but their functions were rather to extend or feed the firing line, to serve as a rallying point in case of defeat and to take up the pursuit (par. 220, *Infantry Training*, 1902), than to form the engine of a decisive attack framed by the commander-in-chief after "engaging everywhere and then seeing" as Napoleon did. The 1905 regulations adhered to this theory of the attack in the main, only modifying a number of tactical prescriptions which had not proved satisfactory after their transplantation from South Africa to Europe, but after the Russo-Japanese War a series of important amendments was issued which gave greater force and still greater elasticity to the attack procedure, and in 1909 the tactical "doctrine" of the British army was definitively formulated in *Field Service Regulations*, paragraph 102, of which after enumerating the advantages and disadvantages of the "preconceived idea" system, laid it down, as the normal procedure of the British Army, that the general should "obtain the decision by *manœuvre on the battlefield* with a large general reserve maintained in his own hand" and "*strike with his reserve at the right place and time*."

Formulation of the British "Doctrine."

The rehabilitation of the Napoleonic attack idea thus frankly accepted in Great Britain had taken place in France several years before the South African War, and neither this war nor that in Manchuria effectively shook the faith of the French army in the principle, while on the other hand Germany remains faithful to the "preconceived idea," both in strategy and tactics.[17] This essential difference in the two rival "doctrines" is intimately connected with the revival of the Napoleonic artillery attack, in the form of concentrated time shrapnel.

The Napoleonic artillery preparation, it will be remembered, was a fire of overwhelming intensity delivered against the selected point of the enemy's position, at the moment of the massed and decisive assault of the reserves. In Napoleon's time the artillery went in to within 300 or 400 yds. range for this act, *i.e.* in front of the infantry, whereas now the guns fire over the heads of the infantry and concentrate shells instead of guns on the vital point. The principle is, however, the same. A model infantry attack in the Napoleonic manner was that of Okasaki's brigade on the Terayama hill at the battle of Shaho, described by Sir Ian Hamilton in his *Staff Officer's Scrap-Book*. The Japanese, methodical and cautious as they were, only sanctioned a pure open force assault as a last resort. Then the brigadier Okasaki, a peculiarly resolute leader, arrayed his brigade in a "schematic" attack formation of four lines, the first two in single rank, the third in line and the fourth in company columns. Covered by a powerful converging shrapnel fire, the brigade covered the first 900 yds. of open plain without firing a shot. Then, however, it disappeared from sight amongst the houses of a village, and the spectators watched the thousands of flashes fringing the further edge that indicated a fire-fight at decisive range (the Terayama was about 600 yds. beyond the houses). Forty minutes passed, and the army

commander Kuroki said, “He cannot go forward. We are in check to-day all along the line.” But at that moment Okasaki’s men, no longer in a “schematic” formation but in many irregularly disposed groups—some of a dozen men and some of seventy, some widely extended and some practically in close order—rushed forward at full speed over 600 yds. of open ground, and stormed the Terayama with the bayonet.

The decisive attack.

Such an attack as that at the battle of Shaho is rare, but so it has always been with masterpieces of the art of war. We have only to multiply the front of attack by two and the forces engaged by five—and to find the resolute general to lead them—to obtain the ideal decisive attack of a future European war. Instead of the bare open plain over which the advance to decisive range was made, a European general would in most cases dispose of an area of spinneys, farm-houses and undulating fields. The schematic approach-march would be replaced in France and England by a forward movement of bodies in close order, handy enough to utilize the smallest covered ways. Then the fire of both infantry and artillery would be augmented to its maximum intensity, overpowering that of the defence, and the whole of the troops opposite the point to be stormed would be thrown forward for the bayonet charge. The formation for this scarcely matters. What is important is speed and the will to conquer, and for this purpose small bodies (sections, half-companies or companies), not in the close order of the drill book but grouped closely about the leader who inspires and controls them, are as potent an instrument as a Frederician line or a Napoleonic column.

Controversy, in fact, does not turn altogether on the method of the assault, or even on the method of obtaining the fire-superiority of guns and rifles that justifies it. Although one nation may rely on its guns more than on the rifles, or vice versa, all are agreed that at decisive range the firing line should contain as many men as can use their rifles effectually. Perhaps the most disputed point is the form of the “approach-march,” viz. the dispositions and movements of the attacking infantry between about 1400 and about 600 yds. from the position of the enemy.

The approach-march.

The condition of the assailant’s infantry when it reaches decisive ranges is largely governed by the efforts it has expended and the losses it has suffered in its progress. Sometimes even after a firing line of some strength has been established at decisive range, it may prove too difficult or too costly for the supports (sent up from the rear to replace casualties and to augment fire-power) to make their way to the front. Often, again, it may be within the commander’s intentions that his troops at some particular point in the line should not be committed to decisive action before a given time—perhaps not at all. It is obvious then that no “normal” attack procedure which can be laid down in a drill book (though from time to time the attempt has been made, as in the French regulations of 1875) can meet all cases. But here again, though all armies formally and explicitly condemn the normal attack, each has its own well-marked tendencies.

Current views on the infantry attack.

The German regulations of 1906 define the offensive as “transporting fire towards the enemy, if necessary to his immediate proximity”; the bayonet attack “confirms” the victory. Every attack begins with deployment into extended order, and the leading line advances as close to the enemy as possible before opening fire. In ground offering cover, the firing line has practically its maximum density at the outset. In open ground, however, half-sections, groups and individuals, widely spaced out, advance stealthily one after the other till all are *in position*. It is on this position, called the “first fire position” and usually about 1000 yds. from the enemy, that the full force of the attack is deployed, and from this position, as simultaneously as possible, it opens the fight for fire-superiority. Then, each unit covering the advance of its neighbours, the whole line fights its way by open force to within charging distance. If at any point a decision is not desired, it is deliberately made impossible by employing there such small forces as possess no offensive power. Where the attack is intended to be pushed home, the infantry units employed act as far as possible simultaneously, resolutely and in great force (see the German *Infantry Regulations*, 1906, §§ 324 et seq.).

While in Germany movement “transports the fire,” in France fire is regarded as the way to make movement possible. It is considered (see Grandmaison, *Dressage de l’infanterie*) that a premature and excessive deployment enervates the attack, that the ground (*i.e.* covered ways of approach for small columns, not for troops showing a fire front) should be used as long as possible to march “en troupe” and that a firing line should only be formed when it is impossible to progress without acting upon the enemy’s means of resistance. Thereafter each unit, in such order as its chief can keep, should fight its way forward, and help others to do so—like Okasaki’s brigade in the last stage of its attack—utilizing bursts of fire or patches of wood or depressions in the ground, as each is profitable or available to assist the advance. “From the moment when a fighting unit is ‘uncoupled,’ its action must be ruled by two conditions, and by those only: the one material, an object to be reached; the other moral, the will to reach the object.”

The British *Field Service Regulations* of 1909 are in spirit more closely allied to the French than to the German. “The climax of the infantry attack is the assault, which is made possible by superiority of fire” is the principle (emphasized in the book itself by the use of conspicuous type), and a “gradual *building up of the firing line within close range* of the position,” coupled with the closest artillery support, and the final blow of the reserves delivered “unexpectedly and in the greatest possible strength” are indicated as the means.[18]

Defence.

The *defence*, as it used to be understood, needs no description. To-day in all armies the defence is looked upon not as a means of winning a battle, but as a means of temporizing and avoiding the decision until the commander of the defending party is enabled, by the general military situation or by the course and results of the defensive battle itself, to take the offensive. In the British *Field Service Regulations* it is laid down that when an army acts on the defensive no less than half of it should if possible be earmarked, suitably posted and placed under a single commander, for the purpose of delivering a decisive counter-attack. The object of the purely defensive portion, too, is not merely to hold the enemy’s firing line in check, but to drive it back so that the enemy may be forced to use up his local reserve resources to keep the fight alive. A firing line covered and steadied by entrenchments, and restless local reserves ever on the look-out for opportunities of partial counterstrokes, are the instruments of this policy.

Entrenchments.

A word must be added on the use of entrenchments by infantry, a subject the technical aspect of which is fully dealt with and illustrated in Fortification and Siegecraft: *Field Defences*. Entrenchments of greater or less strength by themselves have always been used by infantry on the defensive, especially in the wars of position of the 17th and 18th centuries. In the Napoleonic and modern “wars of movement,” they are regarded, not as a passive defence—they have long ceased to present a physical barrier to assault—but as fire positions so prepared as to be defensible by relatively few men. Their purpose is, by economizing force elsewhere, to give the maximum strength to the troops told off for the counter-offensive. In the later stages of the American Civil War, and also in the Russo-Japanese War of 1904-1905—each in its way an example of a “war of positions”—the assailant has also made use of the methods of fortification to secure every successive step of progress in the attack. The usefulness and limitations of this procedure are defined in generally similar terms in the most recent training manuals of nearly every European army. Section 136, § 7 of the British *Infantry Training* (1905, amended 1907) says: “During the process of establishing a superiority of fire, successive fire positions will be occupied by the firing line. As a rule those affording natural cover will be chosen, but if none exist and the intensity of the hostile fire preclude any immediate further advance, it may be expedient for the firing line to create some. This hastily constructed protection will enable the attack

to cope with the defender's fire and thus prepare the way for a farther advance. The construction of cover during an attack, however, will entail delay and a temporary loss of fire effect *and should therefore be resorted to only when absolutely necessary*.... As soon as possible the advance should be resumed, &c." The German regulations are as follows (*Infantry Training*, 1906, § 313): "In the offensive the entrenching tool may be used where it is desired, for the moment, to content one's self with maintaining the ground gained.... The entrenching tool is only to be used with the greatest circumspection, because of the great difficulty of getting an extended line to go forward under fire when it has expended much effort in digging cover for itself. The construction of trenches must never paralyze the desire for the irresistible advance, *and above all must not kill the spirit of the offensive*."

Organization and Equipment

The organization of infantry varies rather more than that of other arms in different countries. Taking the British system first, the battalion (and not as elsewhere the regiment of two, three or more battalions) is the administrative and manœuvre unit. It is about 1000 strong, and is commanded by a lieutenant-colonel, who has a major and an adjutant (captain or lieutenant) to assist him, and an officer of lieutenant's or captain's rank (almost invariably promoted from the ranks), styled the quartermaster, to deal with supplies, clothing, &c. There are eight companies of a nominal strength of about 120 each. These are commanded by captains (or by junior majors), and each captain has or should have two lieutenants or second lieutenants to assist him. Machine guns are in Great Britain distributed to the battalions and not massed in permanent batteries. In addition there are various regimental details, such as orderly-room staff, cooks, cyclists, signallers, band and ambulance men. The company is divided into four sections of thirty men each and commanded by sergeants. A half-company of two sections is under the control of a subaltern officer. A minor subdivision of the section into two "squads" is made unless the numbers are insufficient to warrant it. In administrative duties the captain's principal assistant is the colour-sergeant or pay-sergeant, who is not assigned to a section command. The lieutenant-colonel, the senior major and the adjutant are mounted. The commanding officer is assisted by a battalion staff, at the head of which is the adjutant. The sergeant-major holds a "warrant" from the secretary of state for war, as does the bandmaster. Other members of the battalion staff are non-commissioned officers, appointed by the commanding officer. The most important of these is the quartermaster-sergeant, who is the assistant of the quartermaster. The two colours ("king's" and "regimental") are in Great Britain carried by subalterns and escorted by colour-sergeants (see Colours).

The "tactical" unit of infantry is now the *company*, which varies very greatly in strength in the different armies. Elsewhere the company of 250 rifles is almost universal, but in Great Britain the company has about 110 men in the ranks, forming four sections. These sections, each of about 28 rifles, are the normal "fire-units," that is to say, the unit which delivers its fire at the orders of and with the elevation and direction given by its commander. This, it will be observed, gives little actual executive work for the junior officers. But a more serious objection than this (which is modified in practice by arrangement and circumstances) is the fact that a small unit is more affected by detachments than a large one. In the home battalions of the Regular Army such detachments are very large, what with finding drafts for the foreign service battalions and for instructional courses, while in the Territorial Force, where it is so rarely possible to assemble all the men at once, the company as organized is often too small to drill as such. On the other hand, the full war-strength company is an admirable unit for control and manœuvre in the field, owing to its rapidity of movement, handiness in using accidents of ground and cover, and susceptibility to the word of command of one man. But as soon as its strength falls below about 80 the advantages cease to counterbalance the defects. The sections become too small as fire-units to effect really useful results, and the battalion commander has to coordinate and to direct 8 comparatively ineffective units instead of 4 powerful ones. The British regular army, therefore, has since the South African War, adopted the *double company* as the unit of training. This gives at all times a substantial unit for fire and manœuvre training, but the disadvantage of having a good many officers only half employed is accentuated. As to the tactical value of the large or double company, opinions differ. Some hold that as the small company is a survival from the days when the battalion was the tactical unit and the company was the unit of volley-fire, it is unsuited to the modern exigencies that have broken up the old rigid line into several independent and co-operating fractions. Others reply that the strong continental company of 250 rifles came into existence in Prussia in the years after Waterloo, not from tactical reasons, but because the state was too poor to maintain a large establishment of officers, and that in 1870, at any rate, there were many instances of its tactical unwieldiness. The point that is common to both organizations is the fact that there is theoretically one subaltern to every 50 or 60 rifles, and this reveals an essential difference between the British and the Continental systems, irrespective of the sizes or groupings of companies. The French or German subaltern effectively commands his 50 men as a unit, whereas the British subaltern supervises two groups of 25 to 30 men under responsible non-commissioned officers. That is to say, a British sergeant may find himself in such a position that he has to be as expert in controlling and obtaining good results from collective fire as a German lieutenant. For reasons mentioned in Army, § 40, non-commissioned officers, of the type called by Kipling the "backbone of the army," are almost unobtainable with the universal service system, and the lowest unit that possesses any independence is the lowest unit commanded by an officer. But apart from the rank of the fire-unit commander, it is questionable whether the section, as understood in England, is not too small a fire-unit, for European warfare at any rate. The regulations of the various European armies, framed for these conditions, practically agree that the fire-unit should be commanded by an officer and should be large enough to ensure good results from collective fire. The number of rifles meeting this second condition is 50 to 80 and their organization a "section" (corresponding to the British half-company) under a subaltern officer. The British army has, of course, to be organized and trained for an infinitely wider range of activity, and no one would suggest the abolition of the small section as a fire-unit. But in a great European battle it would be almost certainly better to group the two sections into a real unit for fire effect. (For questions of infantry fire tactics see Rifle: § *Musketry*.)

On the continent of Europe the "regiment," which is a unit, acting in peace and war as such, consists normally of three battalions, and each battalion of four companies or 1000 rifles. The company of 250 rifles is commanded by a captain, who is mounted. In France the company has four sections, commanded in war by the three subalterns and the "adjudant" (company sergeant-major); the sections are further grouped in pairs to constitute *pelotons* (platoons) or half-companies under the senior of the two section leaders. In peace there are two subalterns only, and the *peloton* is the normal junior officer's command. The battalion is commanded by a major (*commandant* or strictly *chef de bataillon*), the regiment (three or four battalions) by a colonel with a lieutenant-colonel as second. An organization of 3-battalion regiments and 3-company battalions was proposed in 1910.

In Germany, where what we have called the continental company originated, the regiment is of three battalions under majors, and the battalion of four companies commanded by captains. The company is divided into three *Züge* (sections), each under a subaltern, who has as his second a sergeant-major, a "vice-sergeant-major" or a "sword-knot ensign" (aspirant officer). In war there is one additional officer for company. The *Zug* at war-strength has therefore about 80 rifles in the ranks, as compared with the French "section" of 50, and the British section of 30.

The system prevailing in the United States since the reorganization of 1901 is somewhat remarkable. The regiment, which is a tactical as well as an administrative unit, consists of three battalions. Each battalion has four companies of (at war-strength) 3 officers and 150 rifles each. The regiment in war therefore consists of about 1800 rifles in three small and handy battalions of 600 each. The circumstances in which this army serves, and in particular the maintenance of small frontier posts, have always imposed upon subalterns the responsibilities of small independent commands, and it

is fair to assume that the 75 rifles at a subaltern's disposal are regarded as a tactical unit.

In sum, then, the infantry battalion is in almost every country about 1000 rifles strong in four companies. In the United States it is 600 strong in four companies, and in Great Britain it is 1000 strong in eight. The captain's command is usually 200 to 250 men, in the United States 150, and in Great Britain 120. The lieutenant or second lieutenant commands in Germany 80 rifles, in France 50, in the United States 75, as a unit of fire and manœuvre. In Great Britain he commands, with relatively restricted powers, 60.

A short account of the infantry equipments—knapsack or valise, belt, haversack, &c.—in use in various countries will be found in Uniforms, Naval and Military. The armament of infantry is, in all countries, the magazine rifle (see Rifle) and bayonet (*q.v.*), for officers and for certain under-officers sword (*q.v.*) and pistol (*q.v.*). Ammunition (*q.v.*) in the British service is carried (*a*) by the individual soldier, (*b*) by the reserves (mules and carts) in regimental charge, some of which in action are assembled from the battalions of a brigade to form a brigade reserve, and (*c*) by the ammunition columns.

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(C. F. A.)

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1 At Bouvines, it is recorded with special emphasis that Guillaume des Barres, when in the act of felling the emperor, heard the call to rescue King Philip Augustus and, forfeiting his rich prize, made his way back to help his own sovereign.

2 Crossbows indeed were powerful, and also handled by professional soldiers (*e.g.* the Genoese at Crécy), but they were slow in action, six times as slow as the long bow, and the impatient gendarmerie generally became tired of the delay and crowded out or rode over the crossbowmen.

3 As for instance when thirty men-at-arms "cut out" the Captal de Buch from the midst of his army at Cocherel.

4 This tendency of the French military temperament reappears at almost every stage in the history of armies.

5 The term *landsknecht*, it appears, was not confined to the right bank of the Rhine. The French "lansquenets" came largely from Alsace, according to General Hardy de Périni. In the Italian wars Francis I. had in his service a famous corps called the "black bands" which was recruited, in the lower Rhine countries.

6 This practice of "maintenance" on a large scale continued to exist in France long afterwards. As late as the battle of Lens (1648) we find figuring in the king of France's army three "regiments of the House of Condé."

7 Even as late as 1645 a battalion of infantry in England was called a "tercio" or "tertia" (see Army; *Spanish army*).

8 In France it is recorded that the *Gardes françaises*, when warned for duty at the Louvre, used to stroll thither in twos and threes.

9 About this time there was introduced, for resisting cavalry, the well-known hollow battalion square, which, replacing the former masses of pikes, represented up to the most modern times the defensive, as the line or column represented the offensive formation of infantry.

10 The Prussian Grenadier battalions in the Silesian and Seven Years' Wars were more and more confined strictly to line-of-battle duties as the irregular light infantry developed in numbers.

11 Even when the hostile artillery was still capable of fire these masses were used, for in no other formation could the heterogeneous and ill-trained infantry of Napoleon's vassal states (which constituted half of his army) be brought up at all.

12 Rifles had, of course, been used by corps of light troops (both infantry and mounted) for many years. The British Rifle Brigade was formed in 1800, but even in the Seven Years' War there were rifle-corps or companies in the armies of Prussia and Austria. These older rifles could not compare in rapidity or volume of fire with the ordinary firelock.

13 The Prussian company was about 250 strong (see below under "Organization"). This strength was adopted after 1870 by practically all nations which adopted universal service. The battalion had 4 companies.

14 The 1902 edition of *Infantry Training* indeed treated the new scouts as a thin advanced firing line, but in 1907, at which date important modifications began to be made in the "doctrine" of the British Army, the scouts were expressly restricted to the old-fashioned "skirmishing" duties.

15 This is no new thing, but belongs, irrespective of armament, to the "War of masses." The king of Prussia's fighting instructions of the 10th of August 1813 lay down the principle as clearly as any modern work.

16 In the British Service, men whose nerves betray them on the shooting range are ordered more gymnastics (*Musketry Regulations*, 1910).

17 In 1870 the "preconceived idea" was practically confined to strategy, and the tactical improvisations of the Germans themselves deranged the execution of the plan quite as often as the act of the enemy. Of late years, therefore, the "preconceived idea" has been imposed on tactics also in that country. Special care and study is given to the once despised "early deployments" in cases where a fight is part of the "idea," and to the difficult problem of breaking off the action, when it takes a form that is incompatible with the development of the main scheme.

18 In February 1910 a new *Infantry Training* was said to be in preparation. The *I.T.* of 1905 is in some degree incompatible with the later and ruling doctrine of the *F.S. Regulations*, and in the winter of 1909 the Army Council issued a memorandum drawing attention to the different conceptions of the decisive attack as embodied in the latter and as revealed in manœuvre procedure.

INFANT SCHOOLS. The provision in modern times of systematized training for children below the age when elementary education normally begins may be dated from the village school at Waldbach founded by Jean Frédéric Oberlin in 1774. Robert Owen started an infant school at New Lanark in 1800, and great interest in the question was taken in Great Britain during the early years of the 19th century, leading to the foundation in 1836 of the Home and Colonial School Society for the training of teachers in infant schools; this in turn reacted upon other countries, especially Germany. Further impetus and a new direction were given to the movement by Friedrich W. A. Froebel, and the methods of training adopted for children between the ages of three and six have in most countries been influenced by, if not based on, that system of directed activities which was the foundation of the type of "play-school" called by him the *Kinder Garten*, or "children's garden." The growing tendency in England to lay stress on the mental training of very young children, and to use the "infant school" as preparatory to the elementary school, has led to a considerable reaction; medical officers of health have pointed out the dangers of infection to which children up to the age of five are specially liable when congregated together—also the physical effects of badly ventilated class-rooms, and there is a consensus of opinion that formal mental teaching is directly injurious before the age of six or even seven years. At the same time the increase in the industrial employment of married women, with the consequent difficulty of proper care of young children by the mother in the home, has somewhat shifted the ground from a purely educational to a social and physical aspect. While it is agreed that the ideal place for a young child is the home under the supervision of its mother, the present industrial conditions often compel a mother to go out to work, and leave her children either shut up alone, or free to play about the streets, or in the care of a neighbour or professional "minder." In each case the children must suffer. The provision by a public authority of opportunities for suitable training for such children seems therefore a necessity. The moral advantages gained by freeing the child from the streets, by the superintendence of a trained teacher over the games, by the early inculcation of habits of discipline and obedience; the physical advantages of cleanliness and tidiness, and the opportunity of disclosing incipient diseases and weaknesses, outweigh the disadvantages which the opponents of infant training adduce. It remains to give a brief account of what is done in Great Britain, the United States of America, and certain other countries. A valuable report was issued for the English Board of Education by a Consultative Committee upon the school attendance of children below the age of five (vol. 22 of the *Special Reports*, 1909), which also gives some account of the provision of day nurseries or *crèches* for babies.

United Kingdom.—Up to 1905 it was the general English practice since the Education Act of 1870 for educational authorities to provide facilities for the teaching of children between three and five years old whose parents desired it. In 1905, of an estimated 1,467,709 children between those ages, 583,268 were thus provided for in England and Wales. In 1905 the objections, medical and educational, already stated, coupled with the increasing financial strain on the local educational authorities, led to the insertion in the code of that year of Article 53, as follows: "Where the local education authority have so determined in the case of any school maintained by them, children who are under five years may be refused admission to that school." In consequence in 1907 the numbers were found to have fallen to 459,034 out of an estimated 1,480,550 children, from 39.74% in 1905 to 31%. In the older type of infant school stress was laid on the mental preparation of children for the elementary teaching which was to come later. This forcing on of young children was encouraged by the system under which the government grant was allotted; children in the infant division earned an annual grant of 17s. per head, on promotion to the upper school this would be increased to 22s. In 1909 the system was altered; a rate of 21s. 4d. was fixed as the grant for all children above five, and the grant for those below the age was reduced to 13s. 4d. Different methods of training the teachers in these schools as well as the children themselves have been now generally adopted. These methods are largely based on the Froebelian plan, and greater attention is being paid to physical development. In one respect England is perhaps behind the more progressive of other European countries, viz. in providing facilities for washing and attending to the personal needs of the younger children. There is no *femme de service* as in Belgium on the staff of English schools. While in Ireland the children below the age of five attend the elementary schools in much the same proportion as in England and Wales, in Scotland it has never been the general custom for such children to attend school.

United States of America.—In no country has the kindergarten system taken such firm root, and the provision made for children below the compulsory age is based upon it. In 1873 there were 42 kindergartens with 1252 pupils; in 1898 the numbers had risen to 2884 with 143,720 pupils; more than half these were private schools, managed by charitable institutions or by individuals for profit. In 1904-1905 there were 3176 public kindergartens with 205,118 pupils.

Austria Hungary.—Provision in Austria is made for children under six by two types of institution, the Day Nursery (*Kinderbewahranstalten*) and the Kindergarten. In 1872 as the result of a State Commission the Kindergarten was established in the state system of education. Its aim is to "confirm and complete the home education of children under school age, so that through regulated exercise of body and mind they may be prepared for institution in the primary school." No regular teaching in ordinary school subjects is allowed; games, singing and handwork, and training of speech and observation by objects, tales and gardening are the means adopted. The training for teachers in these schools is regulated by law. No children are to be received in a kindergarten til! the beginning of the fourth and must leave at the end of the sixth year. In 1902-1903 there were 77,002 children in kindergartens and 74,110 in the day nurseries. In Hungary a law was passed in 1891 providing for the education and care of children between three and six, either by asyle or nurseries open all the year round in communes which contribute from £830 to £1250 in state taxation, or during the summer in those whose contribution is less. Communes above the higher sum must provide kindergartens. In 1904 there were over 233,000 children in such institutions.

Belgium.—For children between three and six education and training are provided by *Écoles gardiennes* or *Jardins d'enfants*. They are free but not compulsory, are provided and managed by the communes, receive a state grant, and are under government inspection. Schools provided by private individuals or institutions must conform to the conditions of the communal schools. There is a large amount of voluntary assistance especially in the provision of clothes and food for the poorer children. The state first recognized these schools in 1833. In 1881 there were 708 schools with accommodation for over 56,000 children; in 1907 there were 2837 and 264,845 children, approximately one-half of the total number of children in the country between the ages of three and six. In 1890 the minister of Public Instruction issued a code of rules on which is based the organization of the *Écoles gardiennes* throughout Belgium, but some of the communes have regulations of their own. A special examination for teachers in the *Écoles gardiennes* was started in 1898. All candidates must pass this examination before a *certificat de capacité* is granted. The training includes a course in Froebelian methods. While Froebel's system underlies the training in these schools, the teaching is directed very much towards the practical education of the child, special stress being laid on manual dexterity. Reading, writing and arithmetic are also allowed in the classes for the older children. A marked feature of the Belgian schools is the close attention paid to health and personal cleanliness. In all schools there is a *femme de service*, not a teacher, but an attendant, whose duty it is to see to the tidiness and cleanliness of the children, and to their physical requirements.

France.—The first regular infant school was established in Paris at the beginning of the 19th century and styled a *Salle d'essai*. In 1828 a model school, called a *Salle d'asile*, was started, followed shortly by similar institutions all over France. State recognition and inspection were granted, and by 1836 there were over 800 in Paris and the provinces. In 1848 they became establishments of public instruction, and the name *École maternelle* which they have since borne was given them. Every commune with 2000 inhabitants must have one of these schools or a *Classe enfantine*. Admission is free, but not compulsory, for children between two and six. Food and clothes are provided in exceptional cases. Formal

mental instruction is still given to a large extent, and the older children are taught reading, writing and arithmetic. Though the staffs of the school include *femmes de service*, not so much attention is paid to cleanliness as in Belgium, nor is so much stress laid on hygiene. In 1906-1907 there were 4111 public and private *Écoles maternelles* in France, with over 650,000 pupils. The closing of the clerical schools has led to some diminution in the numbers.

Germany.—There are two classes of institution in Germany for children between the ages of 2½ or 3 and 6. These are the *Kleinkinderbewahranstalten* and *Kindergarten*. The first are primarily social in purpose, and afford a place for the children of mothers who have to leave their homes for work. These institutions, principally conducted by religious or charitable societies, remain open all day and meals are provided. Many of them have a kindergarten attached, and others provide some training on Froebelian principles. The kindergartens proper are also principally in private hands, though most municipalities grant financial assistance. They are conducted on advanced Froebelian methods, and formal teaching in reading, writing and arithmetic is excluded. In Cologne, Düsseldorf, Frankfort and Munich there are municipal schools. The state gives no recognition to these institutions and they form no part of the public system of education.

Switzerland.—In the German speaking cantons the smaller towns and villages provide for the younger children by *Bewahranstalten*, generally under private management with public financial help. The larger towns provide kindergartens where the training is free but not compulsory for children from four to six. These are generally conducted on Froebel's system and there is no formal instruction. In the French speaking cantons the *Écoles enfantines* are recognized as the first stage of elementary education. They are free and not compulsory for children from three to six years of age.

(C. We.)

INFINITE (from Lat. *in*, not, *finis*, end or limit; cf. *findere*, to cleave), a term applied in common usage to anything of vast size. Strictly, however, the epithet implies the absence of all limitation. As such it is used specially in (1) theology and metaphysics, (2) mathematics.

1. Tracing the history of the world to the earliest date for which there is any kind of evidence, we are faced with the problem that for everything there is a prior something: the mind is unable to conceive an absolute beginning ("ex nihilo nihil"). Mundane distances become trivial when compared with the distance from the earth of the sun and still more of other heavenly bodies: hence we infer infinite space. Similarly by continual subdivision we reach the idea of the infinitely small. For these inferences there is indeed no actual physical evidence: infinity is a mental concept. As such the term has played an important part in the philosophical and theological speculation. In early Greek philosophy the attempt to arrive at a physical explanation of existence led the Ionian thinkers to postulate various primal elements (*e.g.* water, fire, air) or simply the infinite τὸ ἄπειρον (see Ionian School). Both Plato and Aristotle devoted much thought to the discussion as to which is most truly real, the finite objects of sense, or the universal idea of each thing laid up in the mind of God; what is the nature of that unity which lies behind the multiplicity and difference of perceived objects? The same problem, variously expressed, has engaged the attention of philosophers throughout the ages. In Christian theology God is conceived as infinite in power, knowledge and goodness, uncreated and immortal: in some Oriental systems the end of man is absorption into the infinite, his perfection the breaking down of his human limitations. The metaphysical and theological conception is open to the agnostic objection that the finite mind of man is by hypothesis unable to cognize or apprehend not only an infinite object, but even the very conception of infinity itself; from this standpoint the Infinite is regarded as merely a postulate, as it were an unknown quantity (cf. $\sqrt{-1}$ in mathematics). The same difficulty may be expressed in another way if we regard the infinite as unconditioned (cf. Sir William Hamilton's "philosophy of the unconditioned," and Herbert Spencer's doctrine of the infinite "unknowable"); if it is argued that knowledge of a thing arises only from the recognition of its differences from other things (*i.e.* from its limitations), it follows that knowledge of the infinite is impossible, for the infinite is by hypothesis unrelated.

With this conception of *the* infinite as absolutely unconditioned should be compared what may be described roughly as lesser infinities which can be philosophically conceived and mathematically demonstrated. Thus a point, which is by definition infinitely small, is as compared with a line a unit: the line is infinite, made up of an infinite number of points, any pair of which have an infinite number of points between them. The line itself, again, in relation to the plane is a unit, while the plane is infinite, *i.e.* made up of an infinite number of lines; hence the plane is described as doubly infinite in relation to the point, and a solid as trebly infinite. This is Spinoza's theory of the "infinitely infinite," the limiting notion of infinity being of a numerical, quantitative series, each term of which is a qualitative determination itself quantitatively little, *e.g.* a line which is quantitatively unlimited (*i.e.* in length) is qualitatively limited when regarded as an infinitely small unit of a plane. A similar relation exists in thought between the various grades of species and genera; the highest genus is the "infinitely infinite," each subordinated genus being infinite in relation to the particulars which it denotes, and finite when regarded as a unit in a higher genus.

2. In mathematics, the term "infinite" denotes the result of increasing a variable without limit; similarly, the term "infinitesimal," meaning indefinitely small, denotes the result of diminishing the value of a variable without limit, with the reservation that it never becomes actually zero. The application of these conceptions distinguishes ancient from modern mathematics. Analytical investigations revealed the existence of series or sequences which had no limit to the number of terms, as for example the fraction $1/(1-x)$ which on division gives the series. $1 + x + x^2 + \ldots$; the discussion of these so-called infinite sequences is given in the articles Series and Function. The doctrine of geometrical continuity (*q.v.*) and the application of algebra to geometry, developed in the 16th and 17th centuries mainly by Kepler and Descartes, led to the discovery of many properties which gave to the notion of infinity, as a localized space conception, a predominant importance. A line became continuous, returning into itself by way of infinity; two parallel lines intersect in a point at infinity; all circles pass through two fixed points at infinity (the circular points); two spheres intersect in a fixed circle at infinity; an asymptote became a tangent at infinity; the foci of a conic became the intersections of the tangents from the circular points at infinity; the centre of a conic the pole of the line at infinity, &c. In analytical geometry the line at infinity plays an important part in trilinear coordinates. These subjects are treated in Geometry. A notion related to that of infinitesimals is presented in the Greek "method of exhaustion"; the more perfect conception, however, only dates from the 17th century, when it led to the infinitesimal calculus. A curve came to be treated as a sequence of infinitesimal straight lines; a tangent as the extension of an infinitesimal chord; a surface or area as a sequence of infinitesimally narrow strips, and a solid as a collection of infinitesimally small cubes (see Infinitesimal Calculus).

INFINITESIMAL CALCULUS. 1. The infinitesimal calculus is the body of rules and processes by means of which continuously varying magnitudes are dealt with in mathematical analysis. The name "infinitesimal" has been applied to the calculus because most of the leading results were first obtained by means of arguments about "infinitely small" quantities; the "infinitely small" or "infinitesimal" quantities were vaguely conceived as being neither zero nor finite but in some intermediate, nascent or evanescent, state. There was no necessity for this confused conception, and it came to be understood that it can be dispensed with; but the calculus was not developed by its first founders in accordance with logical principles from precisely defined notions, and it gained adherents rather through the impressiveness and variety of the results that could be obtained by using it than through the cogency of the arguments by which it was established. A similar statement might be made in regard to other theories included in mathematical analysis, such, for instance, as the theory of infinite series. Many, perhaps all, of the mathematical and physical theories which have survived have had a similar history—a history which may be divided roughly into two periods: a period of construction, in which results are obtained from partially formed notions, and a period of criticism, in which the fundamental notions become progressively more and more precise, and are shown to be adequate bases for the constructions previously built upon them. These periods usually overlap. Critics of new theories are never lacking. On the other hand, as E. W. Hobson has well said, "pertinent criticism of fundamentals almost invariably gives rise to new construction." In the history of the infinitesimal calculus the 17th and 18th centuries were mainly a period of construction, the 19th century mainly a period of criticism.

I. *Nature of the Calculus.*

Geometrical representation of Variable Quantities.

2. The guise in which variable quantities presented themselves to the mathematicians of the 17th century was that of the lengths of variable lines. This method of representing variable quantities dates from the 14th century, when it was employed by Nicole Oresme, who studied and afterwards taught at the Collège de Navarre in Paris from 1348 to 1361. He represented one of two variable quantities, *e.g.* the time that has elapsed since some epoch, by a length, called the "longitude," measured along a particular line; and he represented the other of the two quantities, *e.g.* the temperature at the instant, by a length, called the "latitude," measured at right angles to this line. He recognized that the variation of the temperature with the time was represented by the line, straight or curved, which joined the ends of all the lines of "latitude." Oresme's longitude and latitude were what we should now call the abscissa and ordinate. The same method was used later by many writers, among whom Johannes Kepler and Galileo Galilei may be mentioned. In Galileo's investigation of the motion of falling bodies (1638) the abscissa OA represents the time during which a body has been falling, and the ordinate AB represents the velocity acquired during that time (see fig. 1). The velocity being proportional to the time, the "curve" obtained is a straight line OB, and Galileo showed that the distance through which the body has fallen is represented by the area of the triangle OAB.

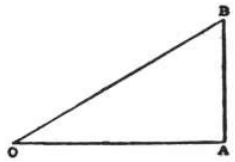

FIG. 1.

The problems of Maxima and Minima, Tangents, and Quadratures.

The most prominent problems in regard to a curve were the problem of finding the points at which the ordinate is a maximum or a minimum, the problem of drawing a tangent to the curve at an assigned point, and the problem of determining the area of the curve. The relation of the problem of maxima and minima to the problem of tangents was understood in the sense that maxima or minima arise when a certain equation has equal roots, and, when this is the case, the curves by which the problem is to be solved touch each other. The reduction of problems of maxima and minima to problems of contact was known to Pappus. The problem of finding the area of a curve was usually presented in a particular form in which it is called the "problem of quadratures." It was sought to determine the area contained between the curve, the axis of abscissae and two ordinates, of which one was regarded as fixed and the other as variable. Galileo's investigation may serve as an example. In that example the fixed ordinate vanishes. From this investigation it may be seen that before the invention of the infinitesimal calculus the introduction of a curve into discussions of the course of any phenomenon, and the problem of quadratures for that curve, were not exclusively of geometrical import; the purpose for which the area of a curve was sought was often to find something which is not an area—for instance, a length, or a volume or a centre of gravity.

Greek methods.

3. The Greek geometers made little progress with the problem of tangents, but they devised methods for investigating the problem of quadratures. One of these methods was afterwards called the "method of exhaustions," and the principle on which it is based was laid down in the lemma prefixed to the 12th book of Euclid's *Elements* as follows: "If from the greater of two magnitudes there be taken more than its half, and from the remainder more than its half, and so on, there will at length remain a magnitude less than the smaller of the proposed magnitudes." The method adopted by Archimedes was more general. It may be described as the enclosure of the magnitude to be evaluated between two others which can be brought by a definite process to differ from each other by less than any assigned magnitude. A simple example of its application is the 6th 536
proposition of Archimedes' treatise On the *Sphere and Cylinder*, in which it is proved that the area contained between a regular polygon inscribed in a circle and a similar polygon circumscribed to the same circle can be made less than any assigned area by increasing the number of sides of the polygon. The methods of Euclid and Archimedes were specimens of rigorous limiting processes (see FUNCTION). The new problems presented by the analytical geometry and natural philosophy of the 17th century led to new limiting processes.

Differentiation.

4. In the *problem of tangents* the new process may be described as follows. Let P, P′ be two points of a curve (see fig. 2). Let x, y be the coordinates of P, and x + Δx, y + Δy those of P′. The symbol Δx means "the difference of two x's" and there is a like meaning for the symbol Δy. The fraction Δy/Δx is the trigonometrical tangent of the angle which the secant PP′ makes with the axis of x. Now let Δx be continually diminished towards zero, so that P′ continually approaches P. If the curve has a tangent at P the secant PP′ approaches a limiting position (see § 33 below). When this is the case the fraction Δy/Δx tends to a limit, and this limit is the trigonometrical tangent of the angle which the tangent at P to the curve makes with the axis of x. The limit is denoted by

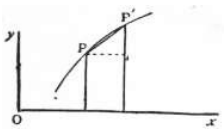

FIG. 2.

$$\frac{dy}{dx}.$$

If the equation of the curve is of the form $y = f(x)$ where f is a functional symbol (see FUNCTION), then

$$\frac{\Delta y}{\Delta x} = \frac{f(x + \Delta x) - f(x)}{\Delta x},$$

and

$$\frac{dy}{} \qquad f(x + \Delta x) - f(x)$$

$$\frac{dy}{dx} = \lim_{\Delta x = 0} \frac{\Delta y}{\Delta x}.$$

The limit expressed by the right-hand member of this defining equation is often written

$$f'(x),$$

and is called the "derived function" of $f(x)$, sometimes the "derivative" or "derivate" of $f(x)$. When the function $f(x)$ is a rational integral function, the division by Δx can be performed, and the limit is found by substituting zero for Δx in the quotient. For example, if $f(x) = x^2$, we have

$$\frac{f(x + \Delta x) - f(x)}{\Delta x} = \frac{(x + \Delta x)^2 - x^2}{\Delta x} = \frac{2x\Delta x + (\Delta x)^2}{\Delta x},$$

and

$$f'(x) = 2x.$$

The process of forming the derived function of a given function is called *differentiation*. The fraction $\Delta y/\Delta x$ is called the "quotient of differences," and its limit *dy/dx* is called the "differential coefficient of y with respect to x." The rules for forming differential coefficients constitute the *differential calculus*.

The problem of tangents is solved at one stroke by the formation of the differential coefficient; and the problem of maxima and minima is solved, apart from the discrimination of maxima from minima and some further refinements, by equating the differential coefficient to zero (see MAXIMA AND MINIMA).

Integration.

5. The *problem of quadratures* leads to a type of limiting process which may be described as follows: Let $y = f(x)$ be the equation of a curve, and let AC and BD be the ordinates of the points C and D (see fig. 3). Let a, b be the abscissae of these points. Let the segment AB be divided into a number of segments by means of intermediate points such as M, and let MN be one such segment. Let PM and QN be those ordinates of the curve which have M and N as their feet. On MN as base describe two rectangles, of which the heights are the greatest and least values of y which correspond to points on the arc PQ of the curve. In fig. 3 these are the rectangles RM, SN. Let the sum of the areas of such rectangles as RM be formed, and likewise the sum of the areas of such rectangles as SN. When the number of the points such as M is increased without limit, and the lengths of all the segments such as MN are diminished without limit, these two sums of areas tend to limits. When they tend to the same limit the curvilinear figure ACDB has an area, and the limit is the measure of this area (see § 33 below). The limit in question is the same whatever law may be adopted for inserting the points such as M between A and B, and for diminishing the lengths of the segments such as MN. Further, if P′ is any point on the arc PQ, and P′M′ is the ordinate of P′, we may construct a rectangle of which the height is P′M′ and the base is MN, and the limit of the sum of the areas of all such rectangles is the area of the figure as before. If x is the abscissa of P, $x + \Delta x$ that of Q, x′ that of P′, the limit in question might be written

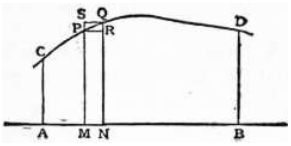

FIG. 3.

$$\lim. \sum_a^b f(x')\,\Delta x,$$

where the letters a, b written below and above the sign of summation Σ indicate the extreme values of x. This limit is called "the definite integral of $f(x)$ between the limits a and b," and the notation for it is

$$\int_a^b f(x)\,dx.$$

The germs of this method of formulating the problem of quadratures are found in the writings of Archimedes. The method leads to a definition of a definite integral, but the direct application of it to the evaluation of integrals is in general difficult. Any process for evaluating a definite integral is a process of integration, and the rules for evaluating integrals constitute the *integral calculus*.

Theorem of Inversion.

6. The chief of these rules is obtained by regarding the extreme ordinate BD as variable. Let ξ now denote the abscissa of B. The area A of the figure ACDB is represented by the integral $\int_a^\xi f(x)dx$, and it is a function of ξ. Let BD be displaced to B′D′ so that ξ becomes $\xi + \delta\xi$ (see fig. 4). The area of the figure ACD′B′ is represented by the integral $\int_a^{\xi+\Delta\xi} f(x)dx$, and the increment ΔA of the area is given by the formula

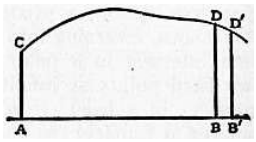

FIG. 4.

$$\Delta A = \int_\xi^{\xi+\Delta\xi} f(x)\,dx,$$

which represents the area BDD′B′. This area is intermediate between those of two rectangles, having as a common base the segment BB′, and as heights the greatest and least ordinates of points on the arc DD′ of the curve. Let these heights be H and h. Then ΔA is intermediate between $H\Delta\xi$ and $h\Delta\xi$, and the quotient of differences $\Delta A/\Delta\xi$ is intermediate between H and h. If the function $f(x)$ is continuous at B (see Function), then, as $\Delta\xi$ is diminished without limit, H and h tend to BD, or $f(\xi)$, as a limit, and we have

$$\frac{dA}{d\xi} = f(\xi).$$

The introduction of the process of differentiation, together with the theorem here proved, placed the solution of the problem of quadratures on a new basis. It appears that we can always find the area A if we know a function F(x) which has $f(x)$ as its differential coefficient. If $f(x)$ is continuous between a and b, we can prove that

$$A = \int_a^b f(x)\,dx = F(b) - F(a).$$

When we recognize a function F(x) which has the property expressed by the equation

$$\frac{dF(x)}{dx} = f(x),$$

we are said to *integrate* the function $f(x)$, and F(x) is called the *indefinite integral* of $f(x)$ *with respect to* x, and is written

$$\int f(x)\,dx.$$

Differentials.

7. In the process of § 4 the increment Δy is not in general equal to the product of the increment Δx and the derived function $f'(x)$. In general we can write down an equation of the form

$$\Delta y = f'(x)\,\Delta x + R,$$

in which R is different from zero when Δx is different from zero; and then we have not only

$$\lim_{\Delta x=0} R = 0,$$

but also

$$\lim_{\Delta x=0} \frac{R}{\Delta x} = 0.$$

We may separate Δy into two parts: the part $f'(x)\Delta x$ and the part R. The part $f'(x)\Delta x$ alone is useful for forming the differential coefficient, and it is convenient to give it a name. It is called the *differential* of $f(x)$, and is written $df(x)$, or dy when y is written for $f(x)$. When this notation is adopted dx is written instead of Δx, and is called the "differential of x," so that we have

$$df(x) = f'(x)\, dx.$$

Thus the differential of an independent variable such as x is a finite difference; in other words it is any number we please. The differential of a dependent variable such as y, or of a function of the independent variable x, is the product of the differential of x and the differential coefficient or derived function. It is important to observe that the differential coefficient is not to be defined as the ratio of differentials, but the ratio of differentials is to be defined as the previously introduced differential coefficient. The differentials are either finite differences, or are so much of certain finite differences as are useful for forming differential coefficients.

Again let F(x) be the indefinite integral of a continuous function $f(x)$, so that we have

$$\frac{dF(x)}{dx} = f(x), \qquad \int_a^b f(x)\, dx = F(b) - F(a).$$

When the points M of the process explained in § 5 are inserted between the points whose abscissae are a and b, we may take them to be $n - 1$ in number, so that the segment AB is divided into n segments. Let $x_1, x_2, \ldots x_{n-1}$ be the abscissae of the points in order. The integral is the limit of the sum

$$f(a)\,(x_1 - a) + f(x_1)\,(x_2 - x_1) + \ldots + f(x_r)\,(x_{r+1} - x_r) + \ldots + f(x_{n-1})\,(b - x_{n-1}),$$

every term of which is a differential of the form $f(x)dx$. Further the integral is equal to the sum of differences

$$\{F(x_1) - F(a)\} + \{F(x_2) - F(x_1)\} + \ldots + \{F(x_{r+1}) - F(x_r)\} + \ldots + \{F(b) - F(x_{n-1})\},$$

for this sum is $F(b) - F(a)$. Now the difference $F(x_{r+1}) - F(x_r)$ is *not* equal to the differential $f(x_r)\,(x_{r+1} - x_r)$, but the sum of the differences is equal to the *limit* of the sum of these differentials. The differential may be regarded as so much of the difference as is required to form the integral. From this point of view a differential is called a *differential element of an integral*, and the integral is the limit of the sum of differential elements. In like manner the differential element ydx of the area of a curve (§ 5) is not the area of the portion contained between two ordinates, however near together, but is so much of this area as need be retained for the purpose of finding the area of the curve by the limiting process described.

Notation.

8. The notation of the infinitesimal calculus is intimately bound up with the notions of differentials and sums of elements. The letter "d" is the initial letter of the word *differentia* (difference) and the symbol $\int$ is a conventionally written "S," the initial letter of the word *summa* (sum or whole). The notation was introduced by Leibnitz (see §§ 25-27, below).

Fundamental Artifice.

9. The fundamental artifice of the calculus is the artifice of forming differentials without first forming differential coefficients. From an equation containing x and y we can deduce a new equation, containing also Δx and Δy, by substituting $x + \Delta x$ for x and $y + \Delta y$ for y. If there is a differential coefficient of y with respect to x, then Δy can be expressed in the form $\varphi.\Delta x + R$, where $\lim_{\Delta x=0} (R/\Delta x) = 0$, as in § 7 above. The artifice consists in rejecting *ab initio* all terms of the equation which belong to R. We do not form R at all, but only $\varphi \cdot \Delta x$, or $\varphi.dx$, which is the differential dy. In the same way, in all applications of the integral calculus to geometry or mechanics we form the *element* of an integral in the same way as the element of area $y \cdot dx$ is formed. In fig. 3 of § 5 the element of area $y \cdot dx$ is the area of the rectangle RM. The actual area of the curvilinear figure PQNM is greater than the area of this rectangle by the area of the curvilinear figure PQR; but the excess is less than the area of the rectangle PRQS, which is measured by the product of the numerical measures of MN and QR, and we have

$$\lim_{MN=0} \frac{MN \cdot QR}{MN} = 0.$$

Thus the artifice by which differential elements of integrals are formed is in principle the same as that by which differentials are formed without first forming differential coefficients.

Orders of small quantities.

10. This principle is usually expressed by introducing the notion of orders of small quantities. If x, y are two variable numbers which are connected together by any relation, and if when x tends to zero y also tends to zero, the fraction y/x may tend to a finite limit. In this case x and y are said to be "of the same order." When this is not the case we may have either

$$\lim_{x=0} \frac{x}{y} = 0,$$

or

$$\lim_{x=0} \frac{y}{x} = 0,$$

In the former case y is said to be "of a lower order" than x; in the latter case y is said to be "of a higher order" than x. In accordance with this notion we may say that the fundamental artifice of the infinitesimal calculus consists in the rejection of small quantities of an unnecessarily high order. This artifice is now merely an incident in the conduct of a limiting process, but in the 17th century, when limiting processes other than the Greek methods for quadratures were new, the introduction of the artifice was a great advance.

Rules of Differentiation.

11. By the aid of this artifice, or directly by carrying out the appropriate limiting processes, we may obtain the rules by which differential coefficients are formed. These rules may be classified as "formal rules" and "particular results." The formal rules may be stated as follows:—

(i.) The differential coefficient of a *constant* is zero.

(ii.) For a *sum* $u + v + \ldots + z$, where u, v, ... are functions of x,

$$\frac{d(u + v + \ldots + z)}{dx} = \frac{du}{dx} + \frac{dv}{dx} + \ldots + \frac{dz}{dx}.$$

(iii.) *For a product uv*

$$\frac{d(uv)}{dx} = u\frac{dv}{dx} + v\frac{du}{dx}.$$

(iv.) *For a quotient u/v*

$$\frac{d(u/v)}{dx} = \left(v\frac{du}{dx} - u\frac{dv}{dx}\right) / v^2.$$

(v.) For a *function of a function*, that is to say, for a function y expressed in terms of a variable z, which is itself expressed as a function of x,

$$\frac{dy}{dx} = \frac{dy}{dz}\cdot\frac{dz}{dx}.$$

In addition to these formal rules we have particular results as to the differentiation of simple functions. The most important results are written down in the following table:—

y	dy/dx
x^n	nx^{n-1} for all values of n
$\log_a x$	$x^{-1}\log_a e$
a^x	$a^x \log_e a$
sin x	cos x
cos x	−sin x
$\sin^{-1}x$	$(1 - x^2)^{-1/2}$
$\tan^{-1}x$	$(1 + x^2)^{-1}$

Each of the formal rules, and each of the particular results in the table, is a theorem of the differential calculus. All functions (or rather expressions) which can be made up from those in the table by a finite number of operations of addition, subtraction, multiplication or division can be differentiated by the formal rules. All such functions are called *explicit* functions. In addition to these we have *implicit* functions, or such as are determined by an equation containing two variables when the equation cannot be solved so as to exhibit the one variable expressed in terms of the other. We have also functions of several variables. Further, since the derived function of a given function is itself a function, we may seek to differentiate it, and thus there arise the second and higher differential coefficients. We postpone for the present the problems of differential calculus which arise from these considerations. Again, we may have explicit functions which are expressed as the results of limiting operations, or by the limits of the results obtained by performing an infinite number of algebraic operations upon the simple functions. For the problem of differentiating such functions reference may be made to FUNCTION.

Indefinite Integrals.

12. The processes of the integral calculus consist largely in transformations of the functions to be integrated into such forms that they can be recognized as differential coefficients of functions which have previously been differentiated. Corresponding to the results in the table of § 11 we have those in the following table:—

f(x)	$\int f(x)dx$
x^n	$x^{n+1} / (n + 1)$ for all values of n except −1
1/x	$\log_e x$
e^{ax}	$a^{-1}e^{ax}$
cos x	sin x
sin x	−cos x
$(a^2 - x^2)^{-1/2}$	$\sin^{-1}(x/a)$
$1 / (a^2 + x^2)$	$(1/a)\tan^{-1}(x/a)$

The formal rules of § 11 give us means for the transformation of integrals into recognizable forms. For example, the rule (ii.) for a sum leads to the result that the integral of a sum of a finite number of terms is the sum of the integrals of the several terms. The rule (iii.) for a product leads to the method of integration by parts. The rule (v.) for a function of a function leads to the method of substitution (see § 48 below.)

II. *History.*

13. The new limiting processes which were introduced in the development of the higher analysis were in the first instance related to problems of the integral calculus. Johannes Kepler in his *Astronomia nova ... de motibus stellae Martis* (1609) stated his laws of planetary motion, to the effect that the orbits of the planets are ellipses with the sun at a focus, and that the radii vectores drawn from the sun to the planets describe equal areas in equal times. From these statements it is to be concluded that Kepler could measure the areas of focal sectors of an ellipse. When he made out these laws there was no method of evaluating areas except the Greek methods. These methods would have sufficed for the purpose, but Kepler invented his own method. He regarded the area as measured by the "sum of the radii" drawn from the focus, and he verified his laws of planetary motion by actually measuring a large number of radii of the orbit, spaced according to a rule, and adding their lengths.

Kepler's methods of Integration.

He had observed that the focal radius vector SP (fig. 5) is equal to the perpendicular SZ drawn from S to the tangent at p to the auxiliary circle, and he had further established the theorem which we should now express in the form—the differential element of the area ASp as Sp turns about S, is equal to the product of SZ and the differential adφ, where a is the radius of the auxiliary circle, and φ is the angle ACp, that is the eccentric angle of P on the ellipse. The area ASP bears to the area ASp the ratio of the minor to the major axis, a result known to Archimedes. Thus Kepler's radii are spaced according to the rule that the eccentric angles of their ends are equidifferent, and his "sum of radii" is proportional to the expression which we should now write

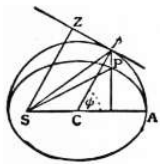

FIG. 5.

$$\int_0^{\varphi} (a + ae \cos \varphi)\, d\varphi,$$

where e is the eccentricity. Kepler evaluated the sum as proportional to φ + e sin φ.

Kepler soon afterwards occupied himself with the volumes of solids. The vintage of the year 1612 was extraordinarily abundant, and the question of the cubic content of wine casks was brought under his notice. This fact accounts for the title of his work, *Nova stereometria doliorum; accessit stereometriae Archimedeae supplementum* (1615). In this treatise he regarded solid bodies as being made up, as it were (*veluti*), of "infinitely" many "infinitely" small cones or "infinitely" thin disks, and he used the notion of summing the areas of the disks in the way he had previously used the notion of summing the focal radii of an ellipse.

Logarithms.

14. In connexion with the early history of the calculus it must not be forgotten that the method by which logarithms were invented (1614) was effectively a method of infinitesimals. Natural logarithms were not invented as the indices of a certain base, and the notation e for the base was first introduced by Euler more than a century after the invention. Logarithms were introduced as numbers which increase in arithmetic progression when other related numbers increase in geometric progression. The two sets of numbers were supposed to increase together, one at a uniform rate, the other at a variable rate, and the increments were regarded for purposes of calculation as very small and as accruing discontinuously.

Cavalieri's Indivisibles.

15. Kepler's methods of integration, for such they must be called, were the origin of Bonaventura Cavalieri's theory of the summation of indivisibles. The notion of a continuum, such as the area within a closed curve, as being made up of indivisible parts, "atoms" of area, if the expression may be allowed, is traceable to the speculations of early Greek philosophers; and although the nature of continuity was better understood by Aristotle and many other ancient writers yet the unsound atomic conception was revived in the 13th century and has not yet been finally uprooted. It is possible to contend that Cavalieri did not himself hold the unsound doctrine, but his writing on this point is rather obscure. In his treatise *Geometria indivisibilibus continuorum nova quadam ratione promota* (1635) he regarded a plane figure as generated by a line moving so as to be always parallel to a fixed line, and a solid figure as generated by a plane moving so as to be always parallel to a fixed plane; and he compared the areas of two plane figures, or the volumes of two solids, by determining the ratios of the sums of all the indivisibles of which they are supposed to be made up, these indivisibles being segments of parallel lines equally spaced in the case of plane figures, and areas marked out upon parallel planes equally spaced in the case of solids. By this method Cavalieri was able to effect numerous integrations relating to the areas of portions of conic sections and the volumes generated by the revolution of these portions about various axes. At a later date, and partly in answer to an attack made upon him by Paul Guldin, Cavalieri published a treatise entitled *Exercitationes geometricae sex* (1647), in which he adapted his method to the determination of centres of gravity, in particular for solids of variable density.

Among the results which he obtained is that which we should now write

$$\int_0^x x^m\, dx = \frac{x^{m+1}}{m+1}, \text{ (m integral).}$$

He regarded the problem thus solved as that of determining the sum of the mth powers of all the lines drawn across a parallelogram parallel to one of its sides.

Successors of Cavalieri.

At this period scientific investigators communicated their results to one another through one or more intermediate persons. Such intermediaries were Pierre de Carcavy and Pater Marin Mersenne; and among the writers thus in communication were Bonaventura Cavalieri, Christiaan Huygens, Galileo Galilei, Giles Personnier de Roberval, Pierre de Fermat, Evangelista Torricelli, and a little later Blaise Pascal; but the letters of Carcavy or Mersenne would probably come into the hands of any man who was likely to be interested in the matters discussed. It often happened that, when some new method was invented, or some new result obtained, the method or result was quickly known to a wide circle, although it might not be printed until after the lapse of a long time. When Cavalieri was printing his two treatises there was much discussion of the problem of quadratures. Roberval (1634) regarded an area as made up of "infinitely" many "infinitely" narrow strips, each of which may be considered to be a rectangle, and he had similar ideas in regard to lengths and volumes. He knew how to approximate to the quantity which we express by $\int_0^1 x^m dx$ by the process of forming the sum

$$\frac{0^m + 1^m + 2^m + \ldots (n-1)^m}{n^{m+1}},$$

and he claimed to be able to prove that this sum tends to 1/(m + 1), as n increases for all positive integral values of m. The method of integrating x^m by forming this sum was found also by Fermat (1636), who stated expressly that he arrived at it by generalizing a method employed by Archimedes (for the cases m = 1 and m = 2) in his books on *Conoids and Spheroids* and on *Spirals* (see T. L. Heath, *The Works of Archimedes*, Cambridge, 1897). Fermat extended the result to the case where m is fractional (1644), and to the case where m is negative. This latter extension and the proofs were given in his memoir, *Proportionis geometricae in quadrandis parabolis et hyperbolis usus*, which appears to have received a final form before 1659, although not published until 1679. Fermat did not use fractional or negative indices, but he regarded his problems as the quadratures of parabolas and hyperbolas of various orders. His method was to divide the interval of integration into parts by means of intermediate points the abscissae of which are in geometric progression. In the process of § 5 above, the points M must be chosen according to this rule. This restrictive condition being understood, we may say that Fermat's formulation of the problem of quadratures is the same as our definition of a definite integral.

Fermat's method of Integration.

The result that the problem of quadratures could be solved for any curve whose equation could be expressed in the form

$$y = x^m \ (m \neq -1),$$

or in the form

$$y = a_1 x^{m1} + a_2 x^{m2} + \ldots + a_n x^{m_n},$$

Various Integrations.

where none of the indices is equal to −1, was used by John Wallis in his *Arithmetica infinitorum* (1655) as well as by Fermat (1659). The case in which m = −1 was that of the ordinary rectangular hyperbola; and Gregory of St Vincent in his *Opus geometricum quadraturae circuli et sectionum coni* (1647) had proved by the method of exhaustions that the area contained between the curve, one asymptote, and two ordinates parallel to the other asymptote, increases in arithmetic progression as the distance between the ordinates (the one nearer to the centre being kept fixed) increases in geometric progression. Fermat described his method of integration as a logarithmic method, and thus it is clear that the relation between the quadrature of the hyperbola and logarithms was understood although it was not expressed analytically. It was not very long before the relation was used for the calculation of logarithms by Nicolaus Mercator in his *Logarithmotechnia* (1668). He began by writing the equation of the curve in the form y = 1/(1 + x), expanded this expression in powers of x by the method of division, and integrated it term by term in accordance with the well-understood rule for finding the quadrature of a curve given by such an equation as that written at the foot of p. 325.

Integration before the Integral Calculus.

By the middle of the 17th century many mathematicians could perform integrations. Very many particular results had been obtained, and applications of them had been made to the quadrature of the circle and other conic sections, and to various problems concerning the lengths of curves, the areas they enclose, the volumes and superficial areas of solids, and centres of gravity. A systematic account of the methods then in use was given, along with much that was original on his part, by Blaise Pascal in his *Lettres de Amos Dettonville sur quelques-unes de ses inventions en géométrie* (1659).

Fermat's methods of Differentiation.

16. The problem of maxima and minima and the problem of tangents had also by the same time been effectively solved. Oresme in the 14th century knew that at a point where the ordinate of a curve is a maximum or a minimum its variation from point to point of the curve is slowest; and Kepler in the *Stereometria doliorum* remarked that at the places where the ordinate passes from a smaller value to the greatest value and then again to a smaller value, its variation becomes insensible. Fermat in 1629 was in possession of a method which he then communicated to one Despagnet of Bordeaux, and which he referred to in a letter to Roberval of 1636. He communicated it to René Descartes early in 1638 on receiving a copy of Descartes's *Géométrie* (1637), and with it he sent to Descartes an account of his methods for solving the problem of tangents and for determining centres of gravity.

Fermat's method for maxima and minima is essentially our method. Expressed in a more modern notation, what he did was to begin by connecting the ordinate y and the abscissa x of a point of a curve by an equation which holds at all points of the curve, then to subtract the value of y in terms of x from the value obtained by substituting x + E for x, then to divide the difference by E, to put E = 0 in the quotient, and to equate the quotient to zero. Thus he differentiated with respect to x and equated the differential coefficient to zero.

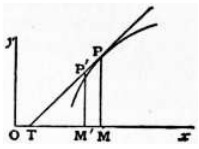

Fig. 6.

Fermat's method for solving the problem of tangents may be explained as follows:—Let (x, y) be the coordinates of a point P of a curve, (x′, y′), those of a neighbouring point P′ on the tangent at P, and let MM′ = E (fig. 6).

From the similarity of the triangles P′TM′, PTM we have

$$y' : A - E = y : A,$$

where A denotes the subtangent TM. The point P′ being near the curve, we may substitute in the equation of the curve x − E for x and (yA − yE)/A for y. The equation of the curve is approximately satisfied. If it is taken to be satisfied exactly, the result is an equation of the form φ(x, y, A, E) = 0, the left-hand member of which is divisible by E. Omitting the factor E, and putting E = 0 in the remaining factor, we have an equation which gives A. In this problem of tangents also Fermat found the required result by a process equivalent to differentiation.

Fermat gave several examples of the application of his method; among them was one in which he showed that he could differentiate very complicated irrational functions. For such functions his method was to begin by obtaining a rational equation. In rationalizing equations Fermat, in other writings, used the device of introducing new variables, but he did not use this device to simplify the process of differentiation. Some of his results were published by Pierre Hérigone in his *Supplementum cursus mathematici* (1642). His communication to Descartes was not published in full until after his death (Fermat, *Opera varia*, 1679). Methods similar to Fermat's were devised by René de Sluse (1652) for tangents, and by Johannes Hudde (1658) for maxima and minima. Other methods for the solution of the problem of tangents were devised by Roberval and Torricelli, and published almost simultaneously in 1644. These methods were founded upon the composition of motions, the theory of which had been taught by Galileo (1638), and, less completely, by Roberval (1636). Roberval and Torricelli could construct the tangents of many curves, but they did not arrive at Fermat's artifice. This artifice is that which we have noted in § 10 as the fundamental artifice of the infinitesimal calculus.

Barrow's Differential Triangle.

17. Among the comparatively few mathematicians who before 1665 could perform differentiations was Isaac Barrow. In his book entitled *Lectiones opticae et geometricae*, written apparently in 1663, 1664, and published in 1669, 1670, he gave a method of tangents like that of Roberval and Torricelli, compounding two velocities in the directions of the axes of x and y to obtain a resultant along the tangent to a curve. In an appendix to this book he gave another method which differs from Fermat's in the introduction of a differential equivalent to our dy as well as dx. Two neighbouring ordinates PM and QN of a curve (fig. 7) are regarded as containing an indefinitely small (*indefinite parvum*) arc, and PR is drawn parallel to the axis of x. The tangent PT at P is regarded as identical with the secant PQ, and the position of the tangent is determined by the similarity of the triangles PTM, PQR. The increments QR, PR of the ordinate and abscissa are denoted by a and e; and the ratio of a to e is determined by substituting x + e for x and y + a for y in the equation of the curve, rejecting all terms which are of order higher than the first in a and e, and omitting the terms which do not contain a or e. This process is equivalent to differentiation. Barrow appears to have invented it himself, but to have put it into his book at Newton's request. The triangle PQR is sometimes called "Barrow's differential triangle."

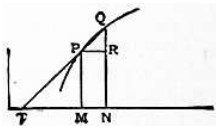

Fig. 7.

Barrow's Inversion-theorem.

The reciprocal relation between differentiation and integration (§ 6) was first observed explicitly by Barrow in the book cited above. If the quadrature of a curve y = f(x) is known, so that the area up to the ordinate x is given by F(x), the curve y = F(x) can be drawn, and Barrow showed that the subtangent of this curve is measured by the ratio of its ordinate to the ordinate of the original curve. The curve y = F(x) is often called the "quadratrix" of the original curve; and the result has been called "Barrow's inversion-theorem." He did not use it as we do for the determination of quadratures, or indefinite integrals, but for the solution of problems of the kind which were then called "inverse problems of tangents." In these problems it was sought to determine a curve from some property of its tangent, *e.g.* the property that the subtangent is proportional to the square of the abscissa. Such problems are now classed under "differential equations." When Barrow

wrote, quadratures were familiar and differentiation unfamiliar, just as hyperbolas were trusted while logarithms were strange. The functional notation was not invented till long afterwards (see FUNCTION), and the want of it is felt in reading all the mathematics of the 17th century.

18. The great secret which afterwards came to be called the "infinitesimal calculus" was almost discovered by Fermat, and still more nearly by Barrow. Barrow went farther than Fermat in the theory of differentiation, though not in the practice, for he compared two increments; he went farther in the theory of integration, for he obtained the inversion-theorem. The great discovery seems to consist partly in the recognition of the fact that differentiation, known to be a useful process, could always be performed, at least for the functions then known, and partly in the recognition of the fact that the inversion-theorem could be applied to problems of quadrature. By these steps the problem of tangents could be solved once for all, and the operation of integration, as we call it, could be rendered systematic. A further step was necessary in order that the discovery, once made, should become accessible to mathematicians in general; and this step was the introduction of a suitable notation. The definite abandonment of the old tentative methods of integration in favour of the method in which this operation is regarded as the inverse of differentiation was especially the work of Isaac Newton; the precise formulation of simple rules for the process of differentiation in each special case, and the introduction of the notation which has proved to be the best, were especially the work of Gottfried Wilhelm Leibnitz. This statement remains true although Newton invented a systematic notation, and practised differentiation by rules equivalent to those of Leibnitz, before Leibnitz had begun to work upon the subject, and Leibnitz effected integrations by the method of recognizing differential coefficients before he had had any opportunity of becoming acquainted with Newton's methods.

Nature of the discovery called the Infinitesimal Calculus.

19. Newton was Barrow's pupil, and he knew to start with in 1664 all that Barrow knew, and that was practically all that was known about the subject at that time. His original thinking on the subject dates from the year of the great plague (1665-1666), and it issued in the invention of the "Calculus of Fluxions," the principles and methods of which were developed by him in three tracts entitled *De analysi per aequationes numero terminorum infinitas, Methodus fluxionum et serierum infinitarum, and De quadratura curvarum*. None of these was published until long after they were written. The *Analysis per aequationes* was composed in 1666, but not printed until 1711, when it was published by William Jones. The *Methodus fluxionum* was composed in 1671 but not printed till 1736, nine years after Newton's death, when an English translation was published by John Colson. In Horsley's edition of Newton's works it bears the title *Geometria analytica*. The *Quadratura* appears to have been composed in 1676, but was first printed in 1704 as an appendix to Newton's *Opticks*.

Newton's investigations.

20. The tract *De Analysi per aequationes ...* was sent by Newton to Barrow, who sent it to John Collins with a request that it might be made known. One way of making it known would have been to print it in the *Philosophical Transactions* of the Royal Society, but this course was not adopted. Collins made a copy of the tract and sent it to Lord Brouncker, but neither of them brought it before the Royal Society. The tract contains a general proof of Barrow's inversion-theorem which is the same in principle as that in § 6 above. In this proof and elsewhere in the tract a notation is introduced for the momentary increment (*momentum*) of the abscissa or area of a curve; this "moment" is evidently meant to represent a moment of time, the abscissa representing time, and it is effectively the same as our differential element—the thing that Fermat had denoted by E, and Barrow by e, in the case of the abscissa. Newton denoted the moment of the abscissa by o, that of the area z by ov. He used the letter v for the ordinate y, thus suggesting that his curve is a velocity-time graph such as Galileo had used. Newton gave the formula for the area of a curve $v = x^m (m \pm -1)$ in the form $z = x^{m+1}/(m + 1)$. In the proof he transformed this formula to the form $z^n = c^n x^p$, where n and p are positive integers, substituted x + o for x and z + ov for z, and expanded by the binomial theorem for a positive integral exponent, thus obtaining the relation

Newton's method of Series.

$$z^n + nz^{n-1}\,ov + \ldots = c^n (x_p + px^{p-1}\,o + \ldots),$$

from which he deduced the relation

$$nz_{n-1}\,v = c^n\,px^{p-1}$$

by omitting the equal terms z^n and $c^n x^p$ and dividing the remaining terms by o, tacitly putting o = 0 after division. This relation is the same as $v = x^m$. Newton pointed out that, conversely, from the relation $v = x^m$ the relation $z = x^{m+1} / (m + 1)$ follows. He applied his formula to the quadrature of curves whose ordinates can be expressed as the sum of a finite number of terms of the form ax^m; and gave examples of its application to curves in which the ordinate is expressed by an infinite series, using for this purpose the binomial theorem for negative and fractional exponents, that is to say, the expansion of $(1 + x)^n$ in an infinite series of powers of x. This theorem he had discovered; but he did not in this tract state it in a general form or give any proof of it. He pointed out, however, how it may be used for the solution of equations by means of infinite series. He observed also that all questions concerning lengths of curves, volumes enclosed by surfaces, and centres of gravity, can be formulated as problems of quadratures, and can thus be solved either in finite terms or by means of infinite series. In the *Quadratura* (1676) the method of integration which is founded upon the inversion-theorem was carried out systematically. Among other results there given is the quadrature of curves expressed by equations of the form $y = x^n (a + bx^m)^p$; this has passed into text-books under the title "integration of binomial differentials" (see § 49). Newton announced the result in letters to Collins and Oldenburg of 1676.

21. In the *Methodus fluxionum* (1671) Newton introduced his characteristic notation. He regarded variable quantities as generated by the motion of a point, or line, or plane, and called the generated quantity a "fluent" and its rate of generation a "fluxion." The fluxion of a fluent x is represented by x, and its moment, or "infinitely" small increment accruing in an "infinitely" short time, is represented by $\dot{x}o$. The problems of the calculus are stated to be (i.) to find the velocity at any time when the distance traversed is given; (ii.) to find the distance traversed when the velocity is given. The first of these leads to differentiation. In any rational equation containing x and y the expressions $x + \dot{x}o$ and $y + \dot{y}o$ are to be substituted for x and y, the resulting equation is to be divided by o, and afterwards o is to be omitted. In the case of irrational functions, or rational functions which are not integral, new variables are introduced in such a way as to make the equations contain rational integral terms only. Thus Newton's rules of differentiation would be in our notation the rules (i.), (ii.), (v.) of § 11, together with the particular result which we write

Newton's method of Fluxions.

$$\frac{dx^m}{dx} = mx^{m-1},\ (\text{m integral}).$$

a result which Newton obtained by expanding $(x = \dot{x}o)^m$ by the binomial theorem. The second problem is the problem of integration, and Newton's method for solving it was the method of series founded upon the particular result which we write

$$\int x^m\,dx = \frac{x^{m+1}}{m + 1}\,.$$

Newton added applications of his methods to maxima and minima, tangents and curvature. In a letter to Collins of date 1672 Newton stated that he had certain methods, and he described certain results which he had found by using them.

These methods and results are those which are to be found in the *Methodus fluxionum*; but the letter makes no mention of fluxions and fluents or of the characteristic notation. The rule for tangents is said in the letter to be analogous to de Sluse's, but to be applicable to equations that contain irrational terms.

22. Newton gave the fluxional notation also in the tract De *Quadratura curvarum* (1676), and he there added to it notation for the higher differential coefficients and for indefinite integrals, as we call them. Just as x, y, z, ... are fluents of which $\dot{x}$, $\dot{y}$, $\dot{z}$, ... are the fluxions, so $\dot{x}$, $\dot{y}$, $\dot{z}$, ... can be treated as fluents of which the fluxions may be denoted by $\ddot{x}$, $\ddot{y}$, $\ddot{z}$,... In like manner the fluxions of these may be denoted by $\dddot{x}$, $\dddot{y}$, $\dddot{z}$, ... and so on. Again x, y, z, ... may be regarded as fluxions of which the fluents may be denoted by x', y', z', ... and these again as fluxions of other quantities denoted by x'', y'', z'', ... and so on. No use was made of the notation x', x'', ... in the course of the tract. The first publication of the fluxional notation was made by Wallis in the second edition of his *Algebra* (1693) in the form of extracts from communications made to him by Newton in 1692. In this account of the method the symbols 0, $\dot{x}$, $\ddot{x}$, ... occur, but not the symbols x', x'', ... Wallis's treatise also contains Newton's formulation of the problems of the calculus in the words *Data aequatione fluentes quotcumque quantitates involvente fluxiones invenire et vice versa* ("an equation containing any number of fluent quantities being given, to find their fluxions and vice versa"). In the *Philosophiae naturalis principia mathematica* (1687), commonly called the "Principia," the words "fluxion" and "moment" occur in a lemma in the second book; but the notation which is characteristic of the calculus of fluxions is nowhere used.

Publication of the Fluxional Notation.

23. It is difficult to account for the fragmentary manner of publication of the Fluxional Calculus and for the long delays which took place. At the time (1671) when Newton composed the *Methodus fluxionum* he contemplated bringing out an edition of Gerhard Kinckhuysen's treatise on algebra and prefixing his tract to this treatise. In the same year his "Theory of Light and Colours" was published in the *Philosophical Transactions*, and the opposition which it excited led to the abandonment of the project with regard to fluxions. In 1680 Collins sought the assistance of the Royal Society for the publication of the tract, and this was granted in 1682. Yet it remained unpublished. The reason is unknown; but it is known that about 1679, 1680, Newton took up again the studies in natural philosophy which he had intermitted for several years, and that in 1684 he wrote the tract *De motu* which was in some sense a first draft of the *Principia*, and it may be conjectured that the fluxions were held over until the *Principia* should be finished. There is also reason to think that Newton had become dissatisfied with the arguments about infinitesimals on which his calculus was based. In the preface to the *De quadratura curvarum* (1704), in which he describes this tract as something which he once wrote ("*olim scripsi*") he says that there is no necessity to introduce into the method of fluxions any argument about infinitely small quantities; and in the *Principia* (1687) he adopted instead of the method of fluxions a new method, that of "Prime and Ultimate Ratios." By the aid of this method it is possible, as Newton knew, and as was afterwards seen by others, to found the calculus of fluxions on an irreproachable method of limits. For the purpose of explaining his discoveries in dynamics and astronomy Newton used the method of limits only, without the notation of fluxions, and he presented all his results and demonstrations in a geometrical form. There is no doubt that he arrived at most of his theorems in the first instance by using the method of fluxions. Further evidence of Newton's dissatisfaction with arguments about infinitely small quantities is furnished by his tract *Methodus diferentialis*, published in 1711 by William Jones, in which he laid the foundations of the "Calculus of Finite Differences."

Retarded Publication of the method of Fluxions.

24. Leibnitz, unlike Newton, was practically a self-taught mathematician. He seems to have been first attracted to mathematics as a means of symbolical expression, and on the occasion of his first visit to London, early in 1673, he learnt about the doctrine of infinite series which James Gregory, Nicolaus Mercator, Lord Brouncker and others, besides Newton, had used in their investigations. It appears that he did not on this occasion become acquainted with Collins, or see Newton's *Analysis per aequationes*, but he purchased Barrow's *Lectiones*. On returning to Paris he made the acquaintance of Huygens, who recommended him to read Descartes' *Géométrie*. He also read Pascal's *Lettres de Dettonville*, Gregory of St Vincent's *Opus geometricum*, Cavalieri's *Indivisibles* and the *Synopsis geometrica* of Honoré Fabri, a book which is practically a commentary on Cavalieri; it would never have had any importance but for the influence which it had on Leibnitz's thinking at this critical period. In August of this year (1673) he was at work upon the problem of tangents, and he appears to have made out the nature of the solution—the method involved in Barrow's differential triangle—for himself by the aid of a diagram drawn by Pascal in a demonstration of the formula for the area of a spherical surface. He saw that the problem of the relation between the differences of neighbouring ordinates and the ordinates themselves was the important problem, and then that the solution of this problem was to be effected by quadratures. Unlike Newton, who arrived at differentiation and tangents through integration and areas, Leibnitz proceeded from tangents to quadratures. When he turned his attention to quadratures and indivisibles, and realized the nature of the process of finding areas by summing "infinitesimal" rectangles, he proposed to replace the rectangles by triangles having a common vertex, and obtained by this method the result which we write

Leibnitz's course of discovery.

$$\tfrac{1}{4}\pi = 1 - \tfrac{1}{3} + \tfrac{1}{5} - \tfrac{1}{7} + \ldots$$

In 1674 he sent an account of his method, called "transmutation," along with this result to Huygens, and early in 1675 he sent it to Henry Oldenburg, secretary of the Royal Society, with inquiries as to Newton's discoveries in regard to quadratures. In October of 1675 he had begun to devise a symbolical notation for quadratures, starting from Cavalieri's indivisibles. At first he proposed to use the word *omnia* as an abbreviation for Cavalieri's "sum of all the lines," thus writing *omnia* y for that which we write "$\int$ ydx," but within a day or two he wrote "$\int$ y". He regarded the symbol "$\int$" as representing an operation which raises the dimensions of the subject of operation—a line becoming an area by the operation—and he devised his symbol "d" to represent the inverse operation, by which the dimensions are diminished. He observed that, whereas "$\int$" represents "sum," "d" represents "difference." His notation appears to have been practically settled before the end of 1675, for in November he wrote $\int y\,dy = \tfrac{1}{2} y^2$, just as we do now.

25. In July of 1676 Leibnitz received an answer to his inquiry in regard to Newton's methods in a letter written by Newton to Oldenburg. In this letter Newton gave a general statement of the binomial theorem and many results relating to series. He stated that by means of such series he could find areas and lengths of curves, centres of gravity and volumes and surfaces of solids, but, as this would take too long to describe, he would illustrate it by examples. He gave no proofs. Leibnitz replied in August, stating some results which he had obtained, and which, as it seemed, could not be obtained easily by the method of series, and he asked for further information. Newton replied in a long letter to Oldenburg of the 24th of October 1676. In this letter he gave a much fuller account of his binomial theorem and indicated a method of proof. Further he gave a number of results relating to quadratures; they were afterwards printed in the tract *De quadratura curvarum*. He gave many other results relating to the computation of natural logarithms and other calculations in which series could be used. He gave a general statement, similar to that in the letter to Collins, as to the kind of problems relating to tangents, maxima and minima, &c., which he could solve by his method, but he concealed his formulation of the calculus in an anagram of transposed letters. The solution of the anagram was given eleven years later in the *Principia* in the words we have quoted from Wallis's *Algebra*. In neither of the letters to Oldenburg does the characteristic notation of the fluxional calculus occur, and the words "fluxion" and "fluent" occur only in anagrams of

Correspondence of Newton and Leibnitz.

transposed letters. The letter of October 1676 was not despatched until May 1677, and Leibnitz answered it in June of that year. In October 1676 Leibnitz was in London, where he made the acquaintance of Collins and read the *Analysis per aequationes*, and it seems to have been supposed afterwards that he then read Newton's letter of October 1676, but he left London before Oldenburg received this letter. In his answer of June 1677 Leibnitz gave Newton a candid account of his differential calculus, nearly in the form in which he afterwards published it, and explained how he used it for quadratures and inverse problems of tangents. Newton never replied.

26. In the *Acta eruditorum* of 1684 Leibnitz published a short memoir entitled *Nova methodus pro maximis et minimis, itemque tangentibus, quae nec fractas nec irrationales quantitates moratur, et singulare pro illis calculi genus*.

Leibnitz's Differential Calculus.

In this memoir the differential dx of a variable x, considered as the abscissa of a point of a curve, is said to be an arbitrary quantity, and the differential dy of a related variable y, considered as the ordinate of the point, is defined as a quantity which has to dx the ratio of the ordinate to the subtangent, and rules are given for operating with differentials. These are the rules for forming the differential of a constant, a sum (or difference), a product, a quotient, a power (or root). They are equivalent to our rules (i.)-(iv.) of § 11 and the particular result

$$d(x^m) = mx^{m-1}\,dx.$$

The rule for a function of a function is not stated explicitly but is illustrated by examples in which new variables are introduced, in much the same way as in Newton's *Methodus fluxionum*. In connexion with the problem of maxima and minima, it is noted that the differential of y is positive or negative according as y increases or decreases when x increases, and the discrimination of maxima from minima depends upon the sign of ddy, the differential of dy. In connexion with the problem of tangents the differentials are said to be proportional to the momentary increments of the abscissa and ordinate. A tangent is defined as a line joining two "infinitely" near points of a curve, and the "infinitely" small distances (*e.g.*, the distance between the feet of the ordinates of such points) are said to be expressible by means of the differentials (*e.g.*, dx). The method is illustrated by a few examples, and one example is given of its application to "inverse problems of tangents." Barrow's inversion-theorem and its application to quadratures are not mentioned. No proofs are given, but it is stated that they can be obtained easily by any one versed in such matters. The new methods in regard to differentiation which were contained in this memoir were the use of the second differential for the discrimination of maxima and minima, and the introduction of new variables for the purpose of differentiating complicated expressions. A greater novelty was the use of a letter (d), not as a symbol for a number or magnitude, but as a symbol of operation. None of these novelties account for the far-reaching effect which this memoir has had upon the development of mathematical analysis. This effect was a consequence of the simplicity and directness with which the rules of differentiation were stated. Whatever indistinctness might be felt to attach to the symbols, the processes for solving problems of tangents and of maxima and minima were reduced once for all to a definite routine.

27. This memoir was followed in 1686 by a second, entitled *De Geometria recondita et analysi indivisibilium atque infinitorum*, in which Leibnitz described the method of using his new differential calculus for the problem of quadratures. This was the first publication of the notation ∫ ydx. The new method was called *calculus summatorius*. The brothers Jacob (James) and Johann (John) Bernoulli were able by 1690 to begin to make substantial contributions to the development of the new calculus, and Leibnitz adopted their word "integral" in 1695, they at the same time adopting his symbol "∫." In 1696 the marquis de l'Hospital published the first treatise on the differential calculus with the title *Analyse des infiniment petits pour l'intelligence des lignes courbes*. The few references to fluxions in Newton's *Principia* (1687) must have been quite unintelligible to the mathematicians of the time, and the publication of the fluxional notation and calculus by Wallis in 1693 was too late to be effective. Fluxions had been supplanted before they were introduced.

Development of the Calculus.

The differential calculus and the integral calculus were rapidly developed in the writings of Leibnitz and the Bernoullis. Leibnitz (1695) was the first to differentiate a logarithm and an exponential, and John Bernoulli was the first to recognize the property possessed by an exponential (a^x) of becoming infinitely great in comparison with any power (x^n) when x is increased indefinitely. Roger Cotes (1722) was the first to differentiate a trigonometrical function. A great development of infinitesimal methods took place through the founding in 1696-1697 of the "Calculus of Variations" by the brothers Bernoulli.

28. The famous dispute as to the priority of Newton and Leibnitz in the invention of the calculus began in 1699 through the publication by Nicolas Fatio de Duillier of a tract in which he stated that Newton was not only the first, but by many years the first inventor, and insinuated that Leibnitz had stolen it. Leibnitz in his reply (*Acta Eruditorum*, 1700) cited Newton's letters and the testimony which Newton had rendered to him in the *Principia* as proofs of his independent authorship of the method. Leibnitz was especially hurt at what he understood to be an endorsement of Duillier's attack by the Royal Society, but it was explained to him that the apparent approval was an accident. The dispute was ended for a time. On the publication of Newton's tract *De quadratura curvarum*, an anonymous review of it, written, as has since been proved, by Leibnitz, appeared in the *Acta Eruditorum*, 1705. The anonymous reviewer said: "Instead of the Leibnitzian differences Newton uses and always has used fluxions ... just as Honoré Fabri in his *Synopsis Geometrica* substituted steps of movements for the method of Cavalieri." This passage, when it became known in England, was understood not merely as belittling Newton by comparing him with the obscure Fabri, but also as implying that he had stolen his calculus of fluxions from Leibnitz. Great indignation was aroused; and John Keill took occasion, in a memoir on central forces which was printed in the *Philosophical Transactions* for 1708, to affirm that Newton was without doubt the first inventor of the calculus, and that Leibnitz had merely changed the name and mode of notation. The memoir was published in 1710. Leibnitz wrote in 1711 to the secretary of the Royal Society (Hans Sloane) requiring Keill to retract his accusation. Leibnitz's letter was read at a meeting of the Royal Society, of which Newton was then president, and Newton made to the society a statement of the course of his invention of the fluxional calculus with the dates of particular discoveries. Keill was requested by the society "to draw up an account of the matter under dispute and set it in a just light." In his report Keill referred to Newton's letters of 1676, and said that Newton had there given so many indications of his method that it could have been understood by a person of ordinary intelligence. Leibnitz wrote to Sloane asking the society to stop these unjust attacks of Keill, asserting that in the review in the *Acta Eruditorum* no one had been injured but each had received his due, submitting the matter to the equity of the Royal Society, and stating that he was persuaded that Newton himself would do him justice. A committee was appointed by the society to examine the documents and furnish a report. Their report, presented in April 1712, concluded as follows:

Dispute concerning Priority.

> "The *differential method* is one and the same with the *method of fluxions*, excepting the name and mode of notation; Mr Leibnitz calling those quantities *differences* which Mr Newton calls *moments* or *fluxions*, and marking them with the letter d, a mark not used by Mr Newton. And therefore we take the proper question to be, not who invented this or that method, but who was the first inventor of the method; and we believe that those who have reputed Mr Leibnitz the first inventor, knew little or nothing of his correspondence with Mr Collins and Mr Oldenburg long before; nor of Mr Newton's having that method above fifteen years before Mr. Leibnitz began to publish it in the *Acta Eruditorum* of Leipzig. For which reasons we reckon Mr Newton the first inventor, and are of opinion that Mr Keill, in asserting the

same, has been no ways injurious to Mr Leibnitz."

The report with the letters and other documents was printed (1712) under the title *Commercium Epistolicum D. Johannis Collins et aliorum de analysi promota, jussu Societatis Regiae in lucem editum*, not at first for publication. An account of the contents of the *Commercium Epistolicum* was printed in the *Philosophical Transactions* for 1715. A second edition of the *Commercium Epistolicum* was published in 1722. The dispute was continued for many years after the death of Leibnitz in 1716. To translate the words of Moritz Cantor, it "redounded to the discredit of all concerned."

29. One lamentable consequence of the dispute was a severance of British methods from continental ones. In Great Britain it became a point of honour to use fluxions and other Newtonian methods, while on the continent the notation of Leibnitz was universally adopted. This severance did not at first prevent a great advance in mathematics in Great Britain. So long as attention was directed to problems in which there is but one independent variable (the time, or the abscissa of a point of a curve), and all the other variables depend upon this one, the fluxional notation could be used as well as the differential and integral notation, though perhaps not quite so easily. Up to about the middle of the 18th century important discoveries continued to be made by the use of the method of fluxions. It was the introduction of partial differentiation by Leonhard Euler (1734) and Alexis Claude Clairaut (1739), and the developments which followed upon the systematic use of partial differential coefficients, which led to Great Britain being left behind; and it was not until after the reintroduction of continental methods into England by Sir John Herschel, George Peacock and Charles Babbage in 1815 that British mathematics began to flourish again. The exclusion of continental mathematics from Great Britain was not accompanied by any exclusion of British mathematics from the continent. The discoveries of Brook Taylor and Colin Maclaurin were absorbed into the rapidly growing continental analysis, and the more precise conceptions reached through a critical scrutiny of the true nature of Newton's fluxions and moments stimulated a like scrutiny of the basis of the method of differentials.

British and Continental Schools of Mathematics.

30. This method had met with opposition from the first. Christiaan Huygens, whose opinion carried more weight than that of any other scientific man of the day, declared that the employment of differentials was unnecessary, and that Leibnitz's second differential was meaningless (1691). A Dutch physician named Bernhard Nieuwentijt attacked the method on account of the use of quantities which are at one stage of the process treated as somethings and at a later stage as nothings, and he was especially severe in commenting upon the second and higher differentials (1694, 1695). Other attacks were made by Michel Rolle (1701), but they were directed rather against matters of detail than against the general principles. The fact is that, although Leibnitz in his answers to Nieuwentijt (1695), and to Rolle (1702), indicated that the processes of the calculus could be justified by the methods of the ancient geometry, he never expressed himself very clearly on the subject of differentials, and he conveyed, probably without intending it, the impression that the calculus leads to correct results by compensation of errors. In England the method of fluxions had to face similar attacks. George Berkeley, bishop and philosopher, wrote in 1734 a tract entitled *The Analyst; or a Discourse addressed to an Infidel Mathematician*, in which he proposed to destroy the presumption that the opinions of mathematicians in matters of faith are likely to be more trustworthy than those of divines, by contending that in the much vaunted fluxional calculus there are mysteries which are accepted unquestioningly by the mathematicians, but are incapable of logical demonstration. Berkeley's criticism was levelled against all infinitesimals, that is to say, all quantities vaguely conceived as in some intermediate state between nullity and finiteness, as he took Newton's moments to be conceived. The tract occasioned a controversy which had the important consequence of making it plain that all arguments about infinitesimals must be given up, and the calculus must be founded on the method of limits. During the controversy Benjamin Robins gave an exceedingly clear explanation of Newton's theories of fluxions and of prime and ultimate ratios regarded as theories of limits. In this explanation he pointed out that Newton's *moment* (Leibnitz's "differential") is to be regarded as so much of the actual difference between two neighbouring values of a variable as is needful for the formation of the fluxion (or differential coefficient) (see G. A. Gibson, "The Analyst Controversy," *Proc. Math. Soc.*, Edinburgh, xvii., 1899). Colin Maclaurin published in 1742 a *Treatise of Fluxions*, in which he reduced the whole theory to a theory of limits, and demonstrated it by the method of Archimedes. This notion was gradually transferred to the continental mathematicians. Leonhard Euler in his *Institutiones Calculi differentialis* (1755) was reduced to the position of one who asserts that all differentials are zero, but, as the product of zero and any finite quantity is zero, the ratio of two zeros can be a finite quantity which it is the business of the calculus to determine. Jean le Rond d'Alembert in the *Encyclopédie méthodique* (1755, 2nd ed. 1784) declared that differentials were unnecessary, and that Leibnitz's calculus was a calculus of mutually compensating errors, while Newton's method was entirely rigorous. D'Alembert's opinion of Leibnitz's calculus was expressed also by Lazare N. M. Carnot in his *Réflexions sur la métaphysique du calcul infinitésimal* (1799) and by Joseph Louis de la Grange (generally called Lagrange) in writings from 1760 onwards. Lagrange proposed in his *Théorie des fonctions analytiques* (1797) to found the whole of the calculus on the theory of series. It was not until 1823 that a treatise on the differential calculus founded upon the method of limits was published. The treatise was the *Résumé des leçons ... sur le calcul infinitésimal* of Augustin Louis Cauchy. Since that time it has been understood that the use of the phrase "infinitely small" in any mathematical argument is a figurative mode of expression pointing to a limiting process. In the opinion of many eminent mathematicians such modes of expression are confusing to students, but in treatises on the calculus the traditional modes of expression are still largely adopted.

Oppositions to the calculus.

The "Analyst" controversy.

Cauchy's method of limits.

31. Defective modes of expression did not hinder constructive work. It was the great merit of Leibnitz's symbolism that a mathematician who used it knew what was to be done in order to formulate any problem analytically, even though he might not be absolutely clear as to the proper interpretation of the symbols, or able to render a satisfactory account of them. While new and varied results were promptly obtained by using them, a long time elapsed before the theory of them was placed on a sound basis. Even after Cauchy had formulated his theory much remained to be done, both in the rapidly growing department of complex variables, and in the regions opened up by the theory of expansions in trigonometric series. In both directions it was seen that rigorous demonstration demanded greater precision in regard to fundamental notions, and the requirement of precision led to a gradual shifting of the basis of analysis from geometrical intuition to arithmetical law. A sketch of the outcome of this movement—the "arithmetization of analysis," as it has been called—will be found in Function. Its general tendency has been to show that many theories and processes, at first accepted as of general validity, are liable to exceptions, and much of the work of the analysts of the latter half of the 19th century was directed to discovering the most general conditions in which particular processes, frequently but not universally applicable, can be used without scruple.

Arithmetical basis of modern analysis.

III. *Outlines of the Infinitesimal Calculus.*

32. The general notions of functionality, limits and continuity are explained in the article Function. Illustrations of the more immediate ways in which these notions present themselves in the development of the differential and integral

calculus will be useful in what follows.

33. Let y be given as a function of x, or, more generally, let x and y be given as functions of a variable t. The first of these cases is included in the second by putting x = t. If certain conditions are satisfied the aggregate of the points determined by the functional relations form a curve. The first condition is that the aggregate of the values of t to which values of x and y correspond must be continuous, or, in other words, that these values must consist of all real numbers, or of all those real numbers which lie between assigned extreme numbers. When this condition is satisfied the points are "ordered," and their order is determined by the order of the numbers t, supposed to be arranged in order of increasing or decreasing magnitude; also there are two senses of description of the curve, according as t is taken to increase or to diminish. The second condition is that the aggregate of the points which are determined by the functional relations must be "continuous." This condition means that, if any point P determined by a value of t is taken, and any distance δ, however small, is chosen, it is possible to find two points Q, Q′ of the aggregate which are such that (i.) P is between Q and Q′, (ii.) if R, R′ are any points between Q and Q′ the distance RR′ is less than δ. The meaning of the word "between" in this statement is fixed by the ordering of the points. Sometimes additional conditions are imposed upon the functional relations before they are regarded as defining a curve. An aggregate of points which satisfies the two conditions stated above is sometimes called a "Jordan curve." It by no means follows that every curve of this kind has a tangent. In order that the curve may have a tangent at P it is necessary that, if any angle α, however small, is specified, a distance δ can be found such that when P is between Q and Q′, and PQ and PQ′ are less than δ, the angle RPR′ is less than α for all pairs of points R, R′ which are between P and Q, or between P and Q′ (fig. 8). When this condition is satisfied y is a function of x which has a differential coefficient. The only way of finding out whether this condition is satisfied or not is to attempt to form the differential coefficient. If the quotient of differences Δy/Δx has a limit when Δx tends to zero, y is a differentiable function of x, and the limit in question is the differential coefficient. The derived function, or differential coefficient, of a function f(x) is always defined by the formula

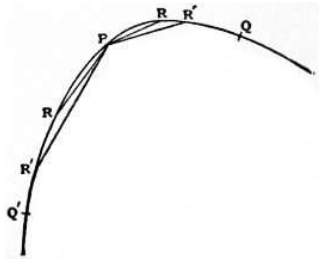

FIG. 8.

Geometrical limits.

Tangents.

$$f'(x) = \frac{df(x)}{dx} = \lim_{h=0} \frac{f(x+h) - f(x)}{h}.$$

Rules for the formation of differential coefficients in particular cases have been given in § 11 above. The definition of a differential coefficient, and the rules of differentiation are quite independent of any geometrical interpretation, such as that concerning tangents to a curve, and the tangent to a curve is properly defined by means of the differential coefficient of a function, not the differential coefficient by means of the tangent.

It may happen that the limit employed in defining the differential coefficient has one value when h approaches zero through positive values, and a different value when h approaches zero through negative values. The two limits are then called the "progressive" and "regressive" differential coefficients. In applications to dynamics, when x denotes a coordinate and t the time, dx/dt denotes a velocity. If the velocity is changed suddenly the progressive differential coefficient measures the velocity just after the change, and the regressive differential coefficient measures the velocity just before the change. Variable velocities are properly defined by means of differential coefficients.

Progressive and Regressive Differential Coefficients.

All geometrical limits may be specified in terms similar to those employed in specifying the tangent to a curve; in difficult cases they must be so specified. Geometrical intuition may fail to answer the question of the existence or non-existence of the appropriate limits. In the last resort the definitions of many quantities of geometrical import must be analytical, not geometrical. As illustrations of this statement we may take the definitions of the areas and lengths of curves. We may not assume that every curve has an area or a length. To find out whether a curve has an area or not, we must ascertain whether the limit expressed by ∫ydx exists. When the limit exists the curve has an area. The definition of the integral is quite independent of any geometrical interpretation. The length of a curve again is defined by means of a limiting process. Let P, Q be two points of a curve, and R_1, R_2, ... R_{n-1} a set of intermediate points of the curve, supposed to be described in the sense in which Q comes after P. The points R are supposed to be reached successively in the order of the suffixes when the curve is described in this sense. We form a sum of lengths of chords

Areas.

$$PR_1 + R_1R_2 + \ldots + R_{n-1}Q.$$

If this sum has a limit when the number of the points R is increased indefinitely and the lengths of all the chords are diminished indefinitely, this limit is the length of the arc PQ. The limit is the same whatever law may be adopted for inserting the intermediate points R and diminishing the lengths of the chords. It appears from this statement that the differential element of the arc of a curve is the length of the chord joining two neighbouring points. In accordance with the fundamental artifice for forming differentials (§§ 9, 10), the differential element of arc ds may be expressed by the formula

Lengths of Curves.

$$ds = \sqrt{\{(dx)^2 + (dy)^2\}},$$

of which the right-hand member is really the measure of the distance between two neighbouring points on the tangent. The square root must be taken to be positive. We may describe this differential element as being so much of the actual arc between two neighbouring points as need be retained for the purpose of forming the integral expression for an arc. This is a description, not a definition, because the length of the short arc itself is only definable by means of the integral expression. Similar considerations to those used in defining the areas of plane figures and the lengths of plane curves are applicable to the formation of expressions for differential elements of volume or of the areas of curved surfaces.

34. In regard to differential coefficients it is an important theorem that, if the derived function f′(x) vanishes at all points of an interval, the function f(x) is constant in the interval. It follows that, if two functions have the same derived function they can only differ by a constant. Conversely, indefinite integrals are indeterminate to the extent of an additive constant.

Constants of Integration.

35. The differential coefficient dy/dx, or the derived function f′(x), is itself a function of x, and its differential coefficient is denoted by f″(x) or d^2y/dx^2. In the second of these notations d/dx is regarded as the symbol of an operation, that of differentiation with respect to x, and the index 2 means that the operation is repeated. In like manner we may express the results of n successive differentiations by $f^{(n)}(x)$ or by d^ny/dx^n. When the second differential coefficient exists, or the first is differentiable, we have the relation

Higher Differential Coefficients.

$$f''(x) = \lim_{h=0} \frac{f(x+h) - 2f(x) + f(x-h)}{h^2}. \qquad \text{(i.)}$$

The limit expressed by the right-hand member of this equation may exist in cases in which f′(x) does not exist or is not differentiable. The result that, when the limit here expressed can be shown to vanish at all points of an interval, then

$f(x)$ must be a linear function of x in the interval, is important.

The relation (i.) is a particular case of the more general relation

$$f^{(n)}(x) = \lim_{h=0} h^{-n} \left[f(x + nh) - nf\{(x + (n-1)h\} + \frac{n(n-1)}{2!} f\{x + (n-2)h\} - \ldots + (-1)^n f(x) \right]. \quad \text{(ii.)}$$

As in the case of relation (i.) the limit expressed by the right-hand member may exist although some or all of the derived functions $f'(x)$, $f''(x)$, ... $f^{(n-1)}(x)$ do not exist.

Corresponding to the rule iii. of § 11 we have the rule for forming the nth differential coefficient of a product in the form

$$\frac{d^n(uv)}{dx^n} = u\frac{d^nv}{dx^n} + n\frac{du}{dx}\frac{d^{n-1}v}{dx^{n-1}} + \frac{n(n-1)}{1\cdot 2}\frac{d^2u}{dx^2}\frac{d^{n-2}v}{dx^{n-2}} + \ldots + \frac{d^nu}{dx^n}v,$$

where the coefficients are those of the expansion of $(1 + x)^n$ in powers of x (n being a positive integer). The rule is due to Leibnitz, (1695).

Differentials of higher orders may be introduced in the same way as the differential of the first order. In general when $y = f(x)$, the nth differential d^ny is defined by the equation

$$d^ny = f^{(n)}(x)(dx)^n,$$

in which dx is the (arbitrary) differential of x.

Symbols of operation.

When d/dx is regarded as a single symbol of operation the symbol $\int \ldots dx$ represents the inverse operation. If the former is denoted by D, the latter may be denoted by D^{-1}. D^n means that the operation D is to be performed n times in succession; D^{-n} that the operation of forming the indefinite integral is to be performed n times in succession. Leibnitz's course of thought (§ 24) naturally led him to inquire after an interpretation of D^n. where n is not an integer. For an account of the researches to which this inquiry gave rise, reference may be made to the article by A. Voss in *Ency. d. math. Wiss.* Bd. ii. A, 2 (Leipzig, 1889). The matter is referred to as "fractional" or "generalized" differentiation.

Theorem of Intermediate Value.

36. After the formation of differential coefficients the most important theorem of the differential calculus is the *theorem of intermediate value* ("theorem of mean value," "theorem of finite increments," "Rolle's theorem," are other names for it). This theorem may be explained as follows: Let A, B be two points of a curve $y = f(x)$ (fig. 9). Then there is a point P between A and B at which the tangent is parallel to the secant AB. This theorem is expressed analytically in the statement that if $f'(x)$ is continuous between a and b, there is a value x_1 of x between a and b which has the property expressed by the equation

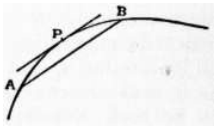

FIG. 9.

$$\frac{f(b) - f(a)}{b - a} = f'(x_1). \quad \text{(i.)}$$

The value x_1 can be expressed in the form $a + \theta(b - a)$ where θ is a number between 0 and 1.

A slightly more general theorem was given by Cauchy (1823) to the effect that, if $f'(x)$ and $F'(x)$ are continuous between $x = a$ and $x = b$, then there is a number θ between 0 and 1 which has the property expressed by the equation

$$\frac{F(b) - F(a)}{f(b) - f(a)} = \frac{F'\{a + \theta(b-a)\}}{f'\{a + \theta(b-a)\}}.$$

The theorem expressed by the relation (i.) was first noted by Rolle (1690) for the case where $f(x)$ is a rational integral function which vanishes when $x = a$ and also when $x = b$. The general theorem was given by Lagrange (1797). Its fundamental importance was first recognized by Cauchy (1823). It may be observed here that the theorem of integral calculus expressed by the equation

$$F(b) - F(a) = \int_a^b F'(x)\,dx$$

follows at once from the definition of an integral and the theorem of intermediate value.

The theorem of intermediate value may be generalized in the statement that, if $f(x)$ and all its differential coefficients up to the nth inclusive are continuous in the interval between $x = a$ and $x = b$, then there is a number θ between 0 and 1 which has the property expressed by the equation

$$f(b) = f(a) + (b-a)f'(a) + \frac{(b-a)^2}{2!}f''(a) + \ldots + \frac{(b-a)^{n-1}}{(n-1)!}f^{(n-1)}(a) + \frac{(b-a)^n}{n!}f^{(n)}\{a + \theta(b-a)\}. \quad \text{(ii.)}$$

Taylor's Theorem.

37. This theorem provides a means for computing the values of a function at points near to an assigned point when the value of the function and its differential coefficients at the assigned point are known. The function is expressed by a terminated series, and, when the remainder tends to zero as n increases, it may be transformed into an infinite series. The theorem was first given by Brook Taylor in his *Methodus Incrementorum* (1717) as a corollary to a theorem concerning finite differences. Taylor gave the expression for $f(x + z)$ in terms of $f(x)$, $f'(x)$, ... as an infinite series proceeding by powers of z. His notation was that appropriate to the method of fluxions which he used. This rule for expressing a function as an infinite series is known as Taylor's theorem. The relation (i.), in which the remainder after n terms is put in evidence, was first obtained by Lagrange (1797). Another form of the remainder was given by Cauchy (1823) viz.,

$$\frac{(b-a)^n}{(n-1)!}(1-\theta)^{n-1}f^n\{a + \theta(b-a)\}.$$

The conditions of validity of Taylor's expansion in an infinite series have been investigated very completely by A. Pringsheim (*Math. Ann.* Bd. xliv., 1894). It is not sufficient that the function and all its differential coefficients should be finite at $x = a$; there must be a *neighbourhood* of a within which Cauchy's form of the remainder tends to zero as n increases (cf. FUNCTION).

An example of the necessity of this condition is afforded by the function f(x) which is given by the equation

$$f(x) = \frac{1}{1 + x^2} + \sum_{n=1}^{n=\infty} \frac{(-1)^n}{n!} \frac{1}{1 + 3^{2n}x^2}. \quad \text{(i.)}$$

The sum of the series

$$f(0) + xf'(0) + \frac{x^2}{2!}f''(0) + \ldots \qquad \text{(ii.)}$$

is the same as that of the series

$$e^{-1} - x^2\, e^{-3^2} + x^4\, e^{-3^4} - \ldots$$

It is easy to prove that this is less than e^{-1} when x lies between 0 and 1, and also that f(x) is greater than e^{-1} when $x = 1/\sqrt{3}$. Hence the sum of the series (i.) is not equal to the sum of the series (ii.).

The particular case of Taylor's theorem in which a = 0 is often called Maclaurin's theorem, because it was first explicitly stated by Colin Maclaurin in his *Treatise of Fluxions* (1742). Maclaurin like Taylor worked exclusively with the fluxional calculus.

Expansions in power series. Examples of expansions in series had been known for some time. The series for log (1 + x) was obtained by Nicolaus Mercator (1668) by expanding $(1 + x)^{-1}$ by the method of algebraic division, and integrating the series term by term. He regarded his result as a "quadrature of the hyperbola." Newton (1669) obtained the expansion of $\sin^{-1}x$ by expanding $(1 - x^2)^{-1/2}$ by the binomial theorem and integrating the series term by term. James Gregory (1671) gave the series for $\tan^{-1}x$. Newton also obtained the series for sin x, cos x, and e^x by reversion of series (1669). The symbol e for the base of the Napierian logarithms was introduced by Euler (1739). All these series can be obtained at once by Taylor's theorem. James Gregory found also the first few terms of the series for tan x and sec x; the terms of these series may be found successively by Taylor's theorem, but the numerical coefficient of the general term cannot be obtained in this way.

Taylor's theorem for the expansion of a function in a power series was the basis of Lagrange's theory of functions, and it is fundamental also in the theory of analytic functions of a complex variable as developed later by Karl Weierstrass. It has also numerous applications to problems of maxima and minima and to analytical geometry. These matters are treated in the appropriate articles.

The forms of the coefficients in the series for tan x and sec x can be expressed most simply in terms of a set of numbers introduced by James Bernoulli in his treatise on probability entitled *Ars Conjectandi* (1713). These numbers B_1, B_2, ... called Bernoulli's numbers, are the coefficients so denoted in the formula

$$\frac{x}{e^x - 1} = 1 - \frac{x}{2} + \frac{B_1}{2!}x^2 - \frac{B_2}{4!}x^4 + \frac{B_3}{6!}x^6 - \ldots,$$

and they are connected with the sums of powers of the reciprocals of the natural numbers by equations of the type

$$B_n = \frac{(2n)!}{2^{2n-1}\pi^{2n}}\left(\frac{1}{1^{2n}} + \frac{1}{2^{2n}} + \frac{1}{3^{2n}} + \ldots\right).$$

The function

$$x^m - \frac{m}{2}x^{m-1} + \frac{m \cdot m-1}{2!}B_1\, x^{m-2} - \ldots$$

has been called Bernoulli's function of the mth order by J. L. Raabe (Crelle's *J. f. Math.* Bd. xlii., 1851). Bernoulli's numbers and functions are of especial importance in the calculus of finite differences (see the article by D. Seliwanoff in *Ency. d. math. Wiss.* Bd. i., E., 1901).

When x is given in terms of y by means of a power series of the form

$$x = y(C_0 + C_1y + C_2y^2 + \ldots) \qquad (C_0 \neq 0) = yf_0(y), \text{ say,}$$

there arises the problem of expressing y as a power series in x. This problem is that of *reversion of series*. It can be shown that provided the absolute value of x is not too great,

$$y = \frac{x}{f_0(0)} + \sum_{n=2}^{n=\infty}\left[\frac{x^n}{n!}\cdot\frac{d^{n-1}}{dy^{n-1}}\;\frac{1}{\{f_0(y)\}^n}\right]_{y=0}$$

To this problem is reducible that of expanding y in powers of x when x and y are connected by an equation of the form

$$y = a + xf(y),$$

for which problem Lagrange (1770) obtained the formula

$$y = a + xf(a) + \sum_{n=2}^{n=\infty}\left[\frac{n}{n!}\cdot\frac{d^{n-1}}{da^{n-1}}\{f(a)\}^n\right].$$

For the history of the problem and the generalizations of Lagrange's result reference may be made to O. Stolz, *Grundzüge d. Diff. u. Int. Rechnung*, T. 2 (Leipzig, 1896).

38. An important application of the theorem of intermediate value and its generalization can be made to the problem of evaluating certain limits. If two functions φ(x) and ψ(x) both vanish at x = a, the fraction φ(x)/ψ(x) may have a finite limit at a. This limit is described as the limit of an "indeterminate form." Such indeterminate forms were considered first by de l'Hospital (1696) to whom the problem of evaluating the limit presented itself in the form of tracing the curve y = φ(x)/ψ(x) near the ordinate x = a, when the curves y = φ(x) and y = ψ(x) both cross the axis of x at the same point as this ordinate. In fig. 10 PA and QA represent short arcs of the curves φ, ψ, chosen so that P and Q have the same abscissa. The value of the ordinate of the corresponding point R of the compound curve is given by the ratio of the ordinates PM, QM. De l'Hospital treated PM and QM as "infinitesimal," so that the equations PM : AM =φ′(a) and QM : AM = ψ′(a) could be assumed to hold, and he arrived at the result that the "true value" of φ(a)/ψ(a) is φ′(a)/ψ′(a). It can be proved rigorously that, if ψ′(x) does not vanish at x = a, while φ(a) = 0 and ψ(a) = 0, then

Indeterminate forms.

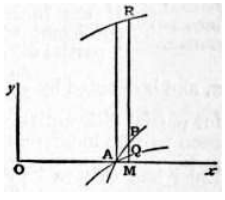

FIG. 10.

$$\lim_{x=a}\frac{\varphi(x)}{\psi(x)} = \frac{\varphi'(a)}{\psi'(a)}.$$

It can be proved further if that $\varphi^m(x)$ and $\psi^n(x)$ are the differential coefficients of lowest order of φ(x) and ψ(x) which do not vanish at x = a, and if m = n, then

$$\lim_{x=a}\frac{\varphi(x)}{\psi(x)} = \frac{\varphi^n(a)}{\psi^n(a)}.$$

If m > n the limit is zero; but if m < n the function represented by the quotient φ(x)/ψ(x) "becomes infinite" at x = a. If the value of the function at x = a is not assigned by the definition of the function, the function does not exist at x = a,

and the meaning of the statement that it "becomes infinite" is that it has no finite limit. The statement does not mean that the function has a value which we call infinity. There is no such value (see FUNCTION).

Such indeterminate forms as that described above are said to be of the form 0/0. Other indeterminate forms are presented in the form $0 \times \infty$, or 1^{∞}, or ∞/∞, or $\infty - \infty$. The most notable of the forms 1^{∞} is $\lim_{x=0}(1 + x)^{1/x}$, which is e. The case in which $\varphi(x)$ and $\psi(x)$ both tend to become infinite at $x = a$ is reducible to the case in which both the functions tend to become infinite when x is increased indefinitely. If $\varphi'(x)$ and $\psi'(x)$ have determinate finite limits when x is increased indefinitely, while $\varphi(x)$ and $\psi(x)$ are determinately (positively or negatively) infinite, we have the result expressed by the equation

$$\lim_{x=\infty} \frac{\varphi(x)}{\psi(x)} = \frac{\lim_{x=\infty} \varphi'(x)}{\lim_{x=\infty} \psi'(x)}.$$

For the meaning of the statement that $\varphi(x)$ and $\psi(x)$ are determinately infinite reference may be made to the article FUNCTION. The evaluation of forms of the type ∞/∞ leads to a scale of increasing "infinities," each being infinite in comparison with the preceding. Such a scale is

$$\log x, \ldots x, x^2, \ldots x^n, \ldots e^x, \ldots x^x;$$

each of the limits expressed by such forms as $\lim_{x=\infty} \varphi(x)/\psi(x)$, where $\varphi(x)$ precedes $\psi(x)$ in the scale, is zero. The construction of such scales, along with the problem of constructing a complete scale was discussed in numerous writings by Paul du Bois-Reymond (see in particular, *Math. Ann.* Bd. xi., 1877). For the general problem of indeterminate forms reference may be made to the article by A. Pringsheim in *Ency. d. math. Wiss.* Bd. ii., A. 1 (1899). Forms of the type 0/0 presented themselves to early writers on analytical geometry in connexion with the determination of the tangents at a double point of a curve; forms of the type ∞/∞ presented themselves in like manner in connexion with the determination of asymptotes of curves. The evaluation of limits has innumerable applications in all parts of analysis. Cauchy's *Analyse algébrique* (1821) was an epoch-making treatise on limits.

If a function $\varphi(x)$ becomes infinite at $x = a$, and another function $\psi(x)$ also becomes infinite at $x = a$ in such a way that $\varphi(x)/\psi(x)$ has a finite limit C, we say that $\varphi(x)$ and $\psi(x)$ become "infinite of the same order." We may write $\varphi(x) = C\psi(x) + \varphi_1(x)$, where $\lim_{x=a}\varphi_1(x)/\psi(x) = 0$, and thus $\varphi_1(x)$ is of a lower order than $\varphi(x)$; it may be finite or infinite at $x = a$. If it is finite, we describe $C\psi(x)$ as the "infinite part" of $\varphi(x)$. The resolution of a function which becomes infinite into an infinite part and a finite part can often be effected by taking the infinite part to be infinite of the same order as one of the functions in the scale written above, or in some more comprehensive scale. This resolution is the inverse of the process of evaluating an indeterminate form of the type $\infty - \infty$.

For example $\lim_{x=0}\{(e^x - 1)^{-1} - x^{-1}\}$ is finite and equal to = ½, and the function $(e^x - 1)^{-1} - x^{-1}$ can be expanded in a power series in x.

Functions of several variables.

39. The nature of a function of two or more variables, and the meaning to be attached to continuity and limits in respect of such functions, have been explained under FUNCTION. The theorems of differential calculus which relate to such functions are in general the same whether the number of variables is two or any greater number, and it will generally be convenient to state the theorems for two variables.

Partial differentiation.

40. Let u or $f(x, y)$ denote a function of two variables x and y. If we regard y as constant, u or f becomes a function of one variable x, and we may seek to differentiate it with respect to x. If the function of x is differentiable, the differential coefficient which is formed in this way is called the "partial differential coefficient" of u or f with respect to x, and is denoted by $\partial u/\partial x$ or $\partial f/\partial x$. The symbol "∂" was appropriated for partial differentiation by C. G. J. Jacobi (1841). It had before been written indifferently with "d" as a symbol of differentiation. Euler had written (df/dx) for the partial differential coefficient of f with respect to x. Sometimes it is desirable to put in evidence the variable which is treated as constant, and then the partial differential coefficient is written "$(df/dx)_y$" or "$(\partial f/\partial x)_y$". This course is often adopted by writers on Thermodynamics. Sometimes the symbols d or ∂ are dropped, and the partial differential coefficient is denoted by u_x or f_x. As a definition of the partial differential coefficient we have the formula

$$\frac{\partial f}{\partial x} = \lim_{h=0} \frac{f(x + h, y) - f(x, y)}{h}.$$

In the same way we may form the partial differential coefficient with respect to y by treating x as a constant.

The introduction of partial differential coefficients enables us to solve at once for a surface a problem analogous to the problem of tangents for a curve; and it also enables us to take the first step in the solution of the problem of maxima and minima for a function of several variables. If the equation of a surface is expressed in the form $z = f(x, y)$, the direction cosines of the normal to the surface at any point are in the ratios $\partial f/\partial x : \partial f/\partial y : = 1$. If f is a maximum or a minimum at (x, y), then $\partial f/\partial x$ and $\partial f/\partial y$ vanish at that point.

In applications of the differential calculus to mathematical physics we are in general concerned with functions of three variables x, y, z, which represent the coordinates of a point; and then considerable importance attaches to partial differential coefficients which are formed by a particular rule. Let F(x, y, z) be the function, P a point (x, y, z), P′ a neighbouring point $(x + \Delta x, y + \Delta y, z + \Delta z)$, and let Δs be the length of PP′. The value of F(x, y, z) at P may be denoted shortly by F(P). A limit of the same nature as a partial differential coefficient is expressed by the formula

$$\lim_{\Delta s=0} \frac{F(P') = F(P)}{\Delta s},$$

in which Δs is diminished indefinitely by bringing P′ up to P, and P′ is supposed to approach P along a straight line, for example, the tangent to a curve or the normal to a surface. The limit in question is denoted by $\partial F/\partial h$, in which it is understood that h indicates a direction, that of PP′. If l, m, n are the direction cosines of the limiting direction of the line PP′, supposed drawn from P to P′, then

$$\frac{\partial F}{\partial h} \quad \frac{\partial F}{\partial x} \quad \frac{\partial F}{\partial y} \quad \frac{\partial F}{\partial z}.$$

The operation of forming $\partial F/\partial h$ is called "differentiation with respect to an axis" or "vector differentiation."

41. The most important theorem in regard to partial differential coefficients is the *theorem of the total differential*. We may write down the equation

$$f(a + h, b + k) - f(a, b) = f(a + h, b + k) - f(a, b + k) + f(a, b + k) - f(a, b).$$

Theorem of the Total Differential.

If f_x is a continuous function of x when x lies between a and $a + h$ and $y = b + k$, and if further f_y is a continuous function of y when y lies between b and $d + k$, there exist values of θ and η which lie between 0 and 1 and have the properties expressed by the equations

$$f(a + h, b + k) - f(a, b + k) = hf_x(a + \theta h, b + k),$$
$$f(a, b + k) - f(a, b) = kf_y(a, b + \eta k).$$

Further, $f_x(a + \theta h, b + k)$ and $f_y(a, b + \eta k)$ tend to the limits $f_x(a, b)$ and $f_y(a, b)$ when h and k tend to zero, provided the differential coefficients f_x, f_y, are continuous at the point (a, b). Hence in this case the above equation can be written

$$f(a + h, b + k) - f(a, b) = hf_x(a, b) + kf_y(a, b) + R,$$

where

$$\lim_{h=0,\, k=0} \frac{R}{h} = 0 \text{ and } \lim_{h=0,\, k=0} \frac{R}{k} = 0.$$

In accordance with the notation of differentials this equation gives

$$df = \frac{\partial f}{\partial x} dx + \frac{\partial y}{\partial y} dy.$$

Just as in the case of functions of one variable, dx and dy are arbitrary finite differences, and df is not the difference of two values of f, but is so much of this difference as need be retained for the purpose of forming differential coefficients.

The theorem of the total differential is immediately applicable to the differentiation of *implicit functions*. When y is a function of x which is given by an equation of the form $f(x, y) = 0$, and it is either impossible or inconvenient to solve this equation so as to express y as an explicit function of x, the differential coefficient dy/dx can be formed without solving the equation. We have at once

$$\frac{dy}{dx} = -\frac{\partial f}{\partial x} \Big/ \frac{\partial f}{\partial y}.$$

This rule was known, in all essentials, to Fermat and de Sluse before the invention of the algorithm, of the differential calculus.

An important theorem, first proved by Euler, is immediately deducible from the theorem of the total differential. If $f(x, y)$ is a homogeneous function of degree n then

$$x \frac{\partial f}{\partial x} + y \frac{\partial f}{\partial y} = nf(x, y).$$

The theorem is applicable to functions of any number of variables and is generally known as *Euler's theorem of homogeneous functions*.

Jacobians. 42. Many problems in which partial differential coefficients occur are simplified by the introduction of certain determinants called "Jacobians" or "functional determinants." They were introduced into Analysis by C. G. J. Jacobi (*J. f. Math.*, Crelle, Bd. 22, 1841, p. 319). The Jacobian of $u_1, u_2, \ldots u_n$ with respect to $x_1, x_2, \ldots x_n$ is the determinant

$$\begin{vmatrix} \frac{\partial u_1}{\partial x_1} & \frac{\partial u_1}{\partial x_2} \cdots \frac{\partial u_1}{\partial x_n} \\ \frac{\partial u_2}{\partial x_1} & \frac{\partial u_2}{\partial x_2} \cdots \frac{\partial u_2}{\partial x_n} \\ \vdots & \\ \frac{\partial u_n}{\partial x_1} & \frac{\partial u_n}{\partial x_2} \cdots \frac{\partial u_n}{\partial x_n} \end{vmatrix}$$

in which the constituents of the rth row are the n partial differential coefficients of u_r, with respect to the n variables x. This determinant is expressed shortly by

$$\frac{\partial(u_1, u_2, \ldots, u_n)}{\partial(x_1, x_2, \ldots, x_n)}.$$

Jacobians possess many properties analogous to those of ordinary differential coefficients, for example, the following:—

$$\frac{\partial(u_1, u_2, \ldots, u_n)}{\partial(x_1, x_2, \ldots, x_n)} \times \frac{\partial(x_1, x_2, \ldots, x_n)}{\partial(u_1, u_2, \ldots, u_n)} = 1,$$
$$\frac{\partial(u_1, u_2, \ldots, u_n)}{\partial(y_1, y_2, \ldots, y_n)} \times \frac{\partial(y_1, y_2, \ldots, y_n)}{\partial(x_1, x_2, \ldots, x_n)} = \frac{\partial(u_1, u_2, \ldots, u_n)}{\partial(x_1, x_2, \ldots, x_n)}.$$

If n functions $(u_1, u_2, \ldots u_n)$ of n variables $(x_1, x_2, \ldots, x_n)$ are not independent, but are connected by a relation $f(u_1, u_2, \ldots u_n) = 0$, then

$$\frac{\partial(u_1, u_2, \ldots, u_n)}{\partial(x_1, x_2, \ldots, x_n)} = 0;$$

and, conversely, when this condition is satisfied identically the functions $u_1, u_2 \ldots, u_n$ are not independent.

Interchange of order of differentiations. 43. Partial differential coefficients of the second and higher orders can be formed in the same way as those of the first order. For example, when there are two variables x, y, the first partial derivatives $\partial f/\partial x$ and $\partial f/\partial y$ are functions of x and y, which we may seek to differentiate partially with respect to x or y. The most important theorem in relation to partial differential coefficients of orders higher than the first is the theorem that the values of such coefficients do not depend upon the order in which the differentiations are performed. For example, we have the equation

$$\frac{\partial}{\partial x}\left(\frac{\partial f}{\partial y}\right) = \frac{\partial}{\partial y}\left(\frac{\partial f}{\partial x}\right). \qquad \text{(i.)}$$

This theorem is not true without limitation. The conditions for its validity have been investigated very completely by H. A. Schwarz (see his *Ges. math. Abhandlungen*, Bd. 2, Berlin, 1890, p. 275). It is a sufficient, though not a necessary, condition that all the differential coefficients concerned should be continuous functions of x, y. In consequence of the relation (i.) the differential coefficients expressed in the two members of this relation are written

$$\frac{\partial^2 f}{\partial x \partial y} \text{ or } \frac{\partial^2 f}{\partial y \partial x}.$$

The differential coefficient

$$\partial^n f$$

$$\frac{}{\partial x^p\,\partial y^q\,\partial z^r},$$

in which p + g + r = n, is formed by differentiating p times with respect to x, q times with respect to y, r times with respect to z, the differentiations being performed in any order. Abbreviated notations are sometimes used in such forms as

$$f_{x^p y^q z^r} \quad \text{or} \quad f^{(p,\,q,\,r)}_{x,\,y,\,z}.$$

Differentials of higher orders are introduced by the defining equation

$$d^n f = \left(dx\,\frac{\partial}{\partial x} + dy\,\frac{\partial}{\partial y} \right)^n f$$
$$= (dx)^n \frac{\partial^n f}{\partial x^n} + n(dx)^{n-1}\,dy\,\frac{\partial^n f}{\partial x^{n-1}\,\partial y} + \ldots$$

in which the expression $(dx\cdot\partial/\partial x + dy\cdot\partial/\partial y)^n$ is developed by the binomial theorem in the same way as if $dx\cdot\partial/\partial x$ and $dy\cdot\partial/\partial y$ were numbers, and $(\partial/\partial x)^r\cdot(\partial/\partial y)^{n-r}\,f$ is replaced by $\partial^n f/\partial x^r\,\partial y^{n-r}$. When there are more than two variables the multinomial theorem must be used instead of the binomial theorem.

The problem of forming the second and higher differential coefficients of *implicit functions* can be solved at once by means of partial differential coefficients, for example, if $f(x, y) = 0$ is the equation defining y as a function of x, we have

$$\frac{d^2y}{dx^2} = \left(\frac{\partial f}{\partial y}\right)^{-3} \left\{ \left(\frac{\partial f}{\partial y}\right)^2 \frac{\partial^2 f}{\partial x^2} - 2\,\frac{\partial f}{\partial x}\cdot\frac{\partial f}{\partial y}\cdot\frac{\partial^2 f}{\partial x\partial y} + \left(\frac{\partial f}{\partial x}\right)^2 \frac{\partial^2 f}{\partial y^2} \right\}.$$

The differential expression Xdx + Ydy, in which both X and Y are functions of the two variables x and y, is a *total differential* if there exists a function f of x and y which is such that

$$\partial f/\partial x = X, \qquad \partial f/\partial y = Y.$$

When this is the case we have the relation

$$\partial Y/\partial x = \partial X/\partial y. \tag{ii.}$$

Conversely, when this equation is satisfied there exists a function f which is such that

$$df = Xdx + Ydy.$$

The expression Xdx + Ydy in which X and Y are connected by the relation (ii.) is often described as a "perfect differential." The theory of the perfect differential can be extended to functions of n variables, and in this case there are ½n(n − 1) such relations as (ii.).

In the case of a function of two variables x, y an abbreviated notation is often adopted for differential coefficients. The function being denoted by z, we write

$$p, q, r, s, t \text{ for } \frac{\partial z}{\partial x}, \frac{\partial z}{\partial y}, \frac{\partial^2 z}{\partial x^2}, \frac{\partial^2 z}{\partial x\partial y}, \frac{\partial^2 z}{\partial y^2}.$$

Partial differential coefficients of the second order are important in geometry as expressing the curvature of surfaces. When a surface is given by an equation of the form $z = f(x, y)$, the lines of curvature are determined by the equation

$$\{ (1 + q^2)s - pqt \}\,(dy)^2 + \{ (1 + q^2)r - (1 + p^2)t \}\,dxdy - \{ (1 + p^2)s - pqr \}\,(dx)^2 = 0,$$

and the principal radii of curvature are the values of R which satisfy the equation

$$R^2(rt - s^2) - R\,\{ (1 + q^2)r - 2pqs + (1 + p^2)t \}\,\sqrt{(1 + p^2 + q^2)} + (1 + p^2 + q^2)^2 = 0.$$

Change of variables.

44. The problem of change of variables was first considered by Brook Taylor in his *Methodus incrementorum*. In the case considered by Taylor y is expressed as a function of z, and z as a function of x, and it is desired to express the differential coefficients of y with respect to x without eliminating z. The result can be obtained at once by the rules for differentiating a product and a function of a function. We have

$$\frac{dy}{dx} = \frac{dy}{dz}\cdot\frac{dz}{dx},$$
$$\frac{d^2y}{dx^2} = \frac{dy}{dz}\cdot\frac{d^2z}{dx^2} + \frac{d^2y}{dz^2}\cdot\left(\frac{dz}{dx}\right)^2,$$
$$\frac{d^3y}{dx^3} = \frac{dy}{dz}\cdot\frac{d^3z}{dx^3} + 3\,\frac{d^2y}{dz^2}\cdot\frac{dz}{dx}\cdot\frac{d^2z}{dx^2} + \frac{d^3y}{dz^3}\cdot\left(\frac{dz}{dx}\right)^3,$$
$$\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

The introduction of partial differential coefficients enables us to deal with more general cases of change of variables than that considered above. If u, v are new variables, and x, y are connected with them by equations of the type

$$x = f_1(u, v), \qquad y = f_2(u, v), \tag{i.}$$

while y is either an explicit or an implicit function of x, we have the problem of expressing the differential coefficients of various orders of y with respect to x in terms of the differential coefficients of v with respect to u. We have

$$\frac{dy}{dx} = \left(\frac{\partial f_2}{\partial u} + \frac{\partial f_2}{\partial v}\,\frac{dv}{du}\right) \Big/ \left(\frac{\partial f_1}{\partial u} + \frac{\partial f_1}{\partial v}\,\frac{dv}{du}\right)$$

by the rule of the total differential. In the same way, by means of differentials of higher orders, we may express d^2y/dx^2, and so on.

Equations such as (i.) may be interpreted as effecting a *transformation* by which a point (u, v) is made to correspond to a point (x, y). The whole theory of transformations, and of functions, or differential expressions, which remain invariant under groups of transformations, has been studied exhaustively by Sophus Lie (see, in particular, his *Theorie der Transformationsgruppen*, Leipzig, 1888-1893). (See also Differential Equations and Groups).

A more general problem of change of variables is presented when it is desired to express the partial differential coefficients of a function V with respect to x, y, ... in terms of those with respect to u, v, ..., where u, v, ... are connected with x, y, ... by any functional relations. When there are two variables x, y, and u, v are given functions of x, y, we have

$$\frac{\partial V}{\partial x} = \frac{\partial V}{\partial u}\,\frac{\partial u}{\partial x} + \frac{\partial V}{\partial v}\,\frac{\partial v}{\partial x},$$
$$\frac{\partial V}{\partial} \quad \frac{\partial V}{\partial} \quad \frac{\partial u}{\partial} \quad \frac{\partial V}{\partial} \quad \frac{\partial v}{\partial}$$

$$\frac{\partial}{\partial y} = \frac{\partial u}{\partial y}\,\frac{\partial}{\partial u} + \frac{\partial v}{\partial y}\,\frac{\partial}{\partial v},$$

and the differential coefficients of higher orders are to be formed by repeated applications of the rule for differentiating a product and the rules of the type

$$\frac{\partial}{\partial x} = \frac{\partial u}{\partial x}\,\frac{\partial}{\partial u} + \frac{\partial v}{\partial x}\,\frac{\partial}{\partial v}.$$

When x, y are given functions of u, v, ... we have, instead of the above, such equations as

$$\frac{\partial V}{\partial u} = \frac{\partial V}{\partial x}\,\frac{\partial x}{\partial u} + \frac{\partial V}{\partial y}\,\frac{\partial y}{\partial u};$$

and $\partial V/\partial x$, $\partial V/\partial y$ can be found by solving these equations, provided the Jacobian $\partial(x, y)/\partial(u, v)$ is not zero. The generalization of this method for the case of more than two variables need not detain us.

In cases like that here considered it is sometimes more convenient not to regard the equations connecting x, y with u, v as effecting a point transformation, but to consider the loci u = const., v = const. as two "families" of curves. Then in any region of the plane of (x, y) in which the Jacobian $\partial(x, y)/\partial(u, v)$ does not vanish or become infinite, any point (x, y) is uniquely determined by the values of u and v which belong to the curves of the two families that pass through the point. Such variables as u, v are then described as "curvilinear coordinates" of the point. This method is applicable to any number of variables. When the loci u = const., ... intersect each other at right angles, the variables are "orthogonal" curvilinear coordinates. Three-dimensional systems of such coordinates have important applications in mathematical physics. Reference may be made to G. Lamé, *Leçons sur les coordonnées curvilignes* (Paris, 1859), and to G. Darboux, *Leçons sur les coordonnées curvilignes et systèmes orthogonaux* (Paris, 1898).

When such a coordinate as u is connected with x and y by a functional relation of the form $f(x, y, u) = 0$ the curves u = const. are a family of curves, and this family may be such that no two curves of the family have a common point. When this is not the case the points in which a curve $f(x, y, u) = 0$ is intersected by a curve $f(x, y, u + \Delta u) = 0$ tend to limiting positions as Δu is diminished indefinitely. The locus of these limiting positions is the "envelope" of the family, and in general it touches all the curves of the family. It is easy to see that, if u, v are the parameters of two families of curves which have envelopes, the Jacobian $\partial(x, y)/\partial(u, v)$ vanishes at all points on these envelopes. It is easy to see also that at any point where the reciprocal Jacobian $\partial(u, v)/\partial(x, y)$ vanishes, a curve of the family u touches a curve of the family v.

If three variables x, y, z are connected by a functional relation $f(x, y, z) = 0$, one of them, z say, may be regarded as an *implicit function* of the other two, and the partial differential coefficients of z with respect to x and y can be formed by the rule of the total differential. We have

$$\frac{\partial z}{\partial x} = -\frac{\partial f}{\partial x} \Big/ \frac{\partial f}{\partial z}, \qquad \frac{\partial z}{\partial y} = -\frac{\partial f}{\partial y} \Big/ \frac{\partial f}{\partial z};$$

and there is no difficulty in proceeding to express the higher differential coefficients. There arises the problem of expressing the partial differential coefficients of x with respect to y and z in terms of those of z with respect to x and y. The problem is known as that of "changing the dependent variable." It is solved by applying the rule of the total differential. Similar considerations are applicable to all cases in which n variables are connected by fewer than n equations.

Extension of Taylor's theorem.

45. Taylor's theorem can be extended to functions of several variables. In the case of two variables the general formula, with a remainder after n terms, can be written most simply in the form

$$f(a + h, b + k) = f(a, b) + df(a, b) + \frac{1}{2!}\,d^2 f(a, b) + \ldots$$
$$+ \frac{1}{(n-1)!}\,d^{n-1} f(a, b) + \frac{1}{n!}\,d^n f(a + \theta h, b + \theta k),$$

in which

$$d^r f(a, b) = \left[\left(h\frac{\partial}{\partial x} + k\frac{\partial}{\partial y} \right)^r f(x, y) \right]_{x=a,\ y=b},$$

and

$$d^n f(a + \theta h, b + \theta k) = \left[\left(h\frac{\partial}{\partial x} + k\frac{\partial}{\partial y} \right)^n f(x, y) \right]_{x=a+\theta h,\ y=b+\theta k}.$$

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The last expression is the remainder after n terms, and in it θ denotes some particular number between 0 and 1. The results for three or more variables can be written in the same form. The extension of Taylor's theorem was given by Lagrange (1797); the form written above is due to Cauchy (1823). For the validity of the theorem in this form it is necessary that all the differential coefficients up to the nth should be continuous in a region bounded by $x = a \pm h$, $y = b \pm k$. When all the differential coefficients, no matter how high the order, are continuous in such a region, the theorem leads to an expansion of the function in a multiple power series. Such expansions are just as important in analysis, geometry and mechanics as expansions of functions of one variable. Among the problems which are solved by means of such expansions are the problem of maxima and minima for functions of more than one variable (see Maxima and Minima).

Plane curves.

46. In treatises on the differential calculus much space is usually devoted to the differential geometry of curves and surfaces. A few remarks and results relating to the differential geometry of plane curves are set down here.

(i.) If ψ denotes the angle which the radius vector drawn from the origin makes with the tangent to a curve at a point whose polar coordinates are r, θ and if p denotes the perpendicular from the origin to the tangent, then

$$\cos\psi = dr/ds, \qquad \sin\psi = rd\theta/ds = p/r,$$

where ds denotes the element of arc. The curve may be determined by an equation connecting p with r.

(ii.) The locus of the foot of the perpendicular let fall from the origin upon the tangent to a curve at a point is called the *pedal* of the curve with respect to the origin. The angle ψ for the pedal is the same as the angle ψ for the curve. Hence the (p, r) equation of the pedal can be deduced. If the pedal is regarded as the primary curve, the curve of which it is the pedal is the "negative pedal" of the primary. We may have pedals of pedals and so on, also negative pedals of negative pedals and so on. Negative pedals are usually determined as envelopes.

(iii.) If φ denotes the angle which the tangent at any point makes with a fixed line, we have

$$r^2 = p^2 + (dp/d\varphi)^2.$$

(iv.) The "average curvature" of the arc Δs of a curve between two points is measured by the quotient

$$\left|\frac{\Delta\varphi}{\Delta s}\right|$$

where the upright lines denote, as usual, that the absolute value of the included expression is to be taken, and φ is the angle which the tangent makes with a fixed line, so that Δφ is the angle between the tangents (or normals) at the points. As one of the points moves up to coincidence with the other this average curvature tends to a limit which is the "curvature" of the curve at the point. It is denoted by

$$\left|\frac{d\varphi}{ds}\right|$$

Sometimes the upright lines are omitted and a rule of signs is given:—Let the arc s of the curve be measured from some point along the curve in a chosen sense, and let the normal be drawn towards that side to which the curve is concave; if the normal is directed towards the left of an observer looking along the tangent in the chosen sense of description the curvature is reckoned positive, in the contrary case negative. The differential dφ is often called the "angle of contingence." In the 14th century the size of the angle between a curve and its tangent seems to have been seriously debated, and the name "angle of contingence" was then given to the supposed angle.

(v.) The curvature of a curve at a point is the same as that of a certain circle which touches the curve at the point, and the "radius of curvature" ρ is the radius of this circle. We have $1/\rho = |d\varphi/ds|$. The centre of the circle is called the "centre of curvature"; it is the limiting position of the point of intersection of the normal at the point and the normal at a neighbouring point, when the second point moves up to coincidence with the first. If a circle is described to intersect the curve at the point P and at two other points, and one of these two points is moved up to coincidence with P, the circle touches the curve at the point P and meets it in another point; the centre of the circle is then on the normal. As the third point now moves up to coincidence with P, the centre of the circle moves to the centre of curvature. The circle is then said to "osculate" the curve, or to have "contact of the second order" with it at P.

(vi.) The following are formulae for the radius of curvature:—

$$\frac{1}{\rho} = \left| \left\{ 1 + \left(\frac{dy}{dx}\right)^2 \right\}^{-3/2} \frac{d^2y}{dx^2} \right|,$$

$$\rho = \left| r\frac{dr}{dp} \right| = \left| p + \frac{d^2p}{d\varphi^2} \right|.$$

(vii.) The points at which the curvature vanishes are "points of inflection." If P is a point of inflection and Q a neighbouring point, then, as Q moves up to coincidence with P, the distance from P to the point of intersection of the normals at P and Q becomes greater than any distance that can be assigned. The equation which gives the abscissae of the points in which a straight line meets the curve being expressed in the form $f(x) = 0$, the function $f(x)$ has a factor $(x - x_0)^3$, where x_0 is the abscissa of the point of inflection P, and the line is the tangent at P. When the factor $(x - x_0)$ occurs $(n + 1)$ times in $f(x)$, the curve is said to have "contact of the nth order" with the line. There is an obvious modification when the line is parallel to the axis of y.

(viii.) The locus of the centres of curvature, or envelope of the normals, of a curve is called the "evolute." A curve which has a given curve as evolute is called an "involute" of the given curve. All the involutes are "parallel" curves, that is to say, they are such that one is derived from another by marking off a constant distance along the normal. The involutes are "orthogonal trajectories" of the tangents to the common evolute.

(ix.) The equation of an algebraic curve of the nth degree can be expressed in the form $u_0 + u_1 + u_2 + \ldots + u_n = 0$, where u_0 is a constant, and u_r is a homogeneous rational integral function of x, y of the rth degree. When the origin is on the curve, u_0 vanishes, and $u_1 = 0$ represents the tangent at the origin. If u_1 also vanishes, the origin is a double point and $u_2 = o$ represents the tangents at the origin. If u_2 has distinct factors, or is of the form $a(y - p_1x)(y - p_2x)$, the value of y on either branch of the curve can be expressed (for points sufficiently near the origin) in a power series, which is either

$$p_1x + \tfrac{1}{2} q_1 x^2 + \ldots, \quad \text{or } p_2x + \tfrac{1}{2} q_2 x^2 + \ldots,$$

where $q_1, \ldots$ and $q_2, \ldots$ are determined without ambiguity. If p_1 and p_2 are real the two branches have radii of curvature ρ_1, ρ_2 determined by the formulae

$$\frac{1}{\rho_1} = \left| (1 + p_1^2)^{-3/2} q_1 \right|, \quad \frac{1}{\rho_2} = \left| (1 + p_2^2)^{-3/2} q_2 \right|.$$

When p_1 and p_2 are imaginary the origin is the real point of intersection of two imaginary branches. In the real figure of the curve it is an *isolated point*. If u_2 is a square, $a(y - px)^2$, the origin is a *cusp*, and in general there is not a series for y in integral powers of x, which is valid in the neighbourhood of the origin. The further investigation of cusps and multiple points belongs rather to analytical geometry and the theory of algebraic functions than to differential calculus.

(x.) When the equation of a curve is given in the form $u_0 + u_1 + \ldots + u_{n-1} + u_n = 0$ where the notation is the same as that in (ix.), the factors of u_n determine the directions of the *asymptotes*. If these factors are all real and distinct, there is an asymptote corresponding to each factor. If $u_n = L_1L_2 \ldots L_n$, where $L_1, \ldots$ are linear in x, y, we may resolve u_{n-1}/u_n into partial fractions according to the formula

$$\frac{u_{n-1}}{u_n} = \frac{A_1}{L_1} + \frac{A_2}{L_2} + \ldots + \frac{A_n}{L_n},$$

and then $L_1 + A_1 = 0$, $L_2 + A_2 = 0, \ldots$ are the equations of the asymptotes. When a real factor of u_n is repeated we may have two parallel asymptotes or we may have a "parabolic asymptote." Sometimes the parallel asymptotes coincide, as in the curve $x^2(x^2 + y^2 - a^2) = a^4$, where $x = 0$ is the only real asymptote. The whole theory of asymptotes belongs properly to analytical geometry and the theory of algebraic functions.

Integral calculus.

47. The formal definition of an integral, the theorem of the existence of the integral for certain classes of functions, a list of classes of "integrable" functions, extensions of the notion of integration to functions which become infinite or indeterminate, and to cases in which the limits of integration become infinite, the definitions of multiple integrals, and the possibility of defining functions by means of definite integrals —all these matters have been considered in Function. The definition of integration has been explained in § 5 above, and the results of some of the simplest integrations have been given in § 12. A few theorems relating to integrations have been noted in §§ 34, 35, 36 above.

48. The chief methods for the evaluation of indefinite integrals are the method of integration by parts, and the

Methods of integration. introduction of new variables.

From the equation d(uv) = u dv + v du we deduce the equation

$$\int u \frac{dv}{dx} dx = uv - \int v \frac{du}{dx} dx,$$

or, as it may be written

$$\int uw\, dx = u \int w\, dx - \int \frac{du}{dx} \left\{ \int w\, dx \right\} dx.$$

This is the rule of "integration by parts."

As an example we have

$$\int xe^{ax} dx = x \frac{e^{ax}}{a} - \int \frac{e^{ax}}{a} dx = \left(\frac{x}{a} - \frac{1}{a^2} \right) e^{ax}.$$

When we introduce a new variable z in place of x, by means of an equation giving x in terms of z, we express $f(x)$ in terms of z. Let $\varphi(z)$ denote the function of z into which $f(x)$ is transformed. Then from the equation

$$dx = \frac{dx}{dz} dz$$

we deduce the equation

$$\int f(x)\, dx = \int \varphi(z) \frac{dx}{dz} dz.$$

As an example, in the integral

$$\int \sqrt{(1 - x^2)} dx$$

put x = sin z; the integral becomes

$$\int \cos z \cdot \cos z\, dz = \int \tfrac{1}{2} (1 + \cos 2z) dz = \tfrac{1}{2} (z + \tfrac{1}{2} \sin 2z) = \tfrac{1}{2} (z + \sin z \cos z).$$

49. The indefinite integrals of certain classes of functions can be expressed by means of a finite number of operations of addition or multiplication in terms of the so-called "elementary" functions. The elementary functions are rational algebraic functions, implicit algebraic functions, exponentials and logarithms, trigonometrical and inverse circular functions. The following are among the classes of functions whose integrals involve the elementary functions only: (i.) all rational functions; (ii.) all irrational functions of the form $f(x, y)$, where f denotes a rational algebraic function of x and y, and y is connected with x by an algebraic equation of the second degree; (iii.) all rational functions of sin x and cos x; (iv.) all rational functions of e^x; (v.) all rational integral functions of the variables x, e^{ax}, e^{bx}, ... sin mx, cos mx, sin nx, cos nx, ... in which a, b, ... and m, n, ... are any constants. The integration of a rational function is generally effected by resolving the function into partial fractions, the function being first expressed as the quotient of two rational integral functions. Corresponding to any simple root of the denominator there is a logarithmic term in the integral. If any of the roots of the denominator are repeated there are rational algebraic terms in the integral. The operation of resolving a fraction into partial fractions requires a knowledge of the roots of the denominator, but the algebraic part of the integral can always be found without obtaining all the roots of the denominator. Reference may be made to C. Hermite, *Cours d'analyse*, Paris, 1873. The integration of other functions, which can be integrated in terms of the elementary functions, can usually be effected by transforming the functions into rational functions, possibly after preliminary integrations by parts. In the case of rational functions of x and a radical of the form $\sqrt{(ax^2 + bx + c)}$ the radical can be reduced by a linear substitution to one of the forms $\sqrt{(a^2 - x^2)}$, $\sqrt{(x^2 - a^2)}$, $\sqrt{(x^2 + a^2)}$. The substitutions x = a sin θ, x = a sec θ, x = a tan θ are then effective in the three cases. By these substitutions the subject of integration becomes a rational function of sin θ and cos θ, and it can be reduced to a rational function of t by the substitution tan ½θ = t. There are many other substitutions by which such integrals can be determined. Sometimes we may have information as to the functional character of the integral without being able to determine it. For example, when the subject of integration is of the form $(ax^4 + bx^3 + cx^2 + dx + e)^{-1/2}$ the integral cannot be expressed explicitly in terms of elementary functions. Such integrals lead to new functions (see Function).

Integration in terms of elementary functions.

Methods of reduction and substitution for the evaluation of indefinite integrals occupy a considerable space in text-books of the integral calculus. In regard to the functional character of the integral reference may be made to G. H. Hardy's tract, *The Integration of Functions of a Single Variable* (Cambridge, 1905), and to the memoirs there quoted. A few results are added here

(i.)

$$\int (x^2 + a)^{-\frac{1}{2}} dx = \log \{x + (x^2 + a)^{1/2}\}.$$

(ii.)

$$\int \frac{dx}{(x - p) \sqrt{(ax^2 + 2bx + c)}}$$

can be evaluated by the substitution x − p = 1/z, and

$$\int \frac{dx}{(x - p)^n \sqrt{(ax^2 + 2bx + c)}}$$

can be deduced by differentiating (n − 1) times with respect to p.

(iii.)

$$\int \frac{(Hx + K)\, dx}{(\alpha x^2 + 2\beta x + \gamma) \sqrt{(ax^2 + 2bx + c)}}$$

can be reduced by the substitution $y^2 = (ax^2 + 2bx + c)/(\alpha x^2 + 2\beta x + \gamma)$ to the form

$$A \int \frac{dy}{\sqrt{(\lambda_1 - y^2)}} + B \int \frac{dy}{\sqrt{(y^2 - \lambda_2)}}$$

where A and B are constants, and λ_1 and λ_2 are the two values of λ for which $(a - \lambda\alpha)x^2 + 2(b - \lambda\beta)x + c - \lambda\gamma$ is a perfect square (see A. G. Greenhill, *A Chapter in the Integral Calculus*, London, 1888).

(iv.) $\int x^m (ax^n + b)^p dx$, in which m, n, p are rational, can be reduced, by putting $ax^n = bt$, to depend upon $\int t^q (1 + t)^p dt$. If p is an integer and q a fraction r/s, we put $t = u^s$. If q is an integer and p = r/s we put $1 + t = u^s$. If p + q is an integer and p = r/s we put $1 + t = tu^s$. These integrals, called "binomial integrals," were investigated by Newton (*De quadratura*

curvarum).

(v.)

$$\int \frac{dx}{\sin x} = \log \tan \frac{x}{2},$$

(vi.)

$$\int \frac{dx}{\cos x} = \log (\tan x + \sec x).$$

(vii.) $\int e^{ax} \sin (bx + \alpha)\, dx = (a^2 + b^2)^{-1}\, e^{ax} \{a \sin (bx + \alpha) - b \cos (bx + \alpha)\}$.

(viii.) $\int \sin^m x \cos^n x\, dx$ can be reduced by differentiating a function of the form $\sin^p x \cos^q x$;

$$e.g.\ \frac{d}{dx}\ \frac{\sin x}{\cos^q x} = \frac{1}{\cos^{q-1} x} + \frac{q \sin^2 x}{\cos^{q+1} x} = \frac{1 - q}{\cos^{q-1} x} + \frac{q}{\cos^{q+1} x}.$$

Hence

$$\int \frac{dx}{\cos^n x} = \frac{\sin x}{(n-1) \cos^{n-1} x} + \frac{n-2}{n-1} \int \frac{dx}{\cos^{n-2} x}.$$

(ix.)

$$\int_0^{1/2\pi} \sin^{2n} x\, dx = \int_0^{1/2\pi} \cos^{2n} x\, dx = \frac{1 \cdot 3 \ldots (2n-1)}{2 \cdot 4 \ldots 2n} \cdot \frac{\pi}{2},\ (n \text{ an integer}).$$

(x.)

$$\int_0^{1/2\pi} \sin^{2n+1} x\, dx = \int_0^{1/2\pi} \cos^{2n+1} x\, dx = \frac{2 \cdot 4 \ldots 2n}{3 \cdot 5 \ldots (2n+1)},\ (n \text{ an integer}).$$

(xi.)

$$\int \frac{dx}{(1 + e \cos x)^n} \text{ can be reduced by one of the substitutions}$$

$$\cos \varphi = \frac{e + \cos x}{1 + e \cos x}, \qquad \cosh u = \frac{e + \cos x}{1 + e \cos x},$$

of which the first or the second is to be employed according as $e <$ or > 1.

New transcendents.

50. Among the integrals of transcendental functions which lead to new transcendental functions we may notice

$$\int_0^x \frac{dx}{\log x}, \qquad \text{or } \int^{\log x}_{-\infty} \frac{e^z}{z}\, dz,$$

called the "logarithmic integral," and denoted by "Li x," also the integrals

$$\int_0^x \frac{\sin x}{x}\, dx \text{ and } \int_\infty^x \frac{\cos x}{x}\, dx,$$

called the "sine integral" and the "cosine integral," and denoted by "Si x" and "Ci x," also the integral

$$\int_0^x e^{-x^2}\, dx$$

called the "error-function integral," and denoted by "Erf x." All these functions have been tabulated (see TABLES, MATHEMATICAL).

Eulerian integrals.

51. New functions can be introduced also by means of the definite integrals of functions of two or more variables with respect to one of the variables, the limits of integration being fixed. Prominent among such functions are the Beta and Gamma functions expressed by the equations

$$B(l, m) = \int_0^1 x^{l-1} (1 - x)^{m-1}\, dx,$$

$$\Gamma(n) = \int_0^\infty e^{-t} t^{n-1}\, dt.$$

When n is a positive integer $\Gamma(n + 1) = n!$. The Beta function (or "Eulerian integral of the first kind") is expressible in terms of Gamma functions (or "Eulerian integrals of the second kind") by the formula

$$B(l, m) \cdot \Gamma(l + m) = \Gamma(l) \cdot \Gamma(m).$$

The Gamma function satisfies the difference equation

$$\Gamma(x + 1) = x\, \Gamma(x),$$

and also the equation

$$\Gamma(x) \cdot \Gamma(1 - x) = \pi / \sin (x\pi),$$

with the particular result

$$\Gamma(\tfrac{1}{2}) = \sqrt{\pi}.$$

The number

$$-\left[\frac{d}{dx} \{ \log \Gamma (1 + x) \}\right]_{x=0}, \text{ or } -\Gamma'(1),$$

is called "Euler's constant," and is equal to the limit

$$\lim_{n=\infty} \left[\left(1 + \tfrac{1}{2} + \tfrac{1}{3} + \ldots + \frac{1}{n}\right) - \log n \right];$$

its value to 15 decimal places is 0.577 215 664 901 532.

The function $\log \Gamma(1 + x)$ can be expanded in the series

$$\log \Gamma (1 + x) = \tfrac{1}{2} \log \left(\frac{x\pi}{\sin x\pi}\right) - \tfrac{1}{2} \log \frac{1 + x}{1 - x} + \{ 1 + \Gamma';(1) \}\, x$$

$$- \tfrac{1}{3} (S_3 - 1)\, x^3 - \tfrac{1}{5} (S_5 - 1)\, x^5 - \ldots,$$

where

$$S_{2r+1} = 1 + \frac{1}{2^{2r+1}} + \frac{1}{3^{2r+1}} + \ldots,$$

and the series for log Γ(1 + x) converges when x lies between −1 and 1.

Definite integrals.

52. Definite integrals can sometimes be evaluated when the limits of integration are some particular numbers, although the corresponding indefinite integrals cannot be found. For example, we have the result

$$\int_0^1 (1 - x^2)^{-1/2} \log x \, dx = -\tfrac{1}{2} \pi \log 2,$$

although the indefinite integral of $(1 - x^2)^{-1/2} \log x$ cannot be found. Numbers of definite integrals are expressible in terms of the transcendental functions mentioned in § 50 or in terms of Gamma functions. For the calculation of definite integrals we have the following methods:—

(i.) Differentiation with respect to a parameter.
(ii.) Integration with respect to a parameter.
(iii.) Expansion in infinite series and integration term by term.
(iv.) Contour integration.

The first three methods involve an interchange of the order of two limiting operations, and they are valid only when the functions satisfy certain conditions of continuity, or, in case the limits of integration are infinite, when the functions tend to zero at infinite distances in a sufficiently high order (see Function). The method of contour integration involves the introduction of complex variables (see Function: § *Complex Variables*).

A few results are added

(i.)

$$\int_0^\infty \frac{x^{a-1}}{1 + x} dx = \frac{\pi}{\sin a\pi}, \; (1 > a > 0),$$

(ii.)

$$\int_0^\infty \frac{x^{a-1} - x^{b-1}}{1 - x} dx = \pi (\cot a\pi - \cot b\pi), \; (0 < a \text{ or } b < 1),$$

(iii.)

$$\int_0^\infty \frac{x^{a-1} \log x}{x - 1} dx = \frac{\pi^2}{\sin^2 a\pi}, \; (a > 1),$$

(iv.)

$$\int_0^\infty x^2 \cdot \cos 2x \cdot e^{-x^2} dx = -\tfrac{1}{4} e^{-1} \sqrt{\pi},$$

(v.)

$$\int_0^1 \frac{1 - x^2}{1 + x^4} \frac{dx}{\log x} = \log \tan \frac{\pi}{8},$$

(vi.)

$$\int_0^\infty \frac{\sin mx}{e^{2\pi x} - 1} dx = \tfrac{1}{2} \left(\frac{1}{e^m} - \frac{1}{m} + \frac{1}{2} \right),$$

(vii.)

$$\int_0^\pi \log (1 - 2\alpha \cos x + \alpha^2) \, dx = 0 \text{ or } 2\pi \log \alpha \text{ according as } \alpha < \text{or} > 1,$$

(viii.)

$$\int_0^\infty \frac{\sin x}{x} dx = \tfrac{1}{2} \pi,$$

(ix.)

$$\int_0^\infty \frac{\cos ax}{x^2 + b^2} dx = \tfrac{1}{2} \pi b^{-1} e^{-ab},$$

(x.)

$$\int_0^\infty \frac{\cos ax - \cos bx}{x^2} dx = \tfrac{1}{2} \pi (b - a),$$

(xi.)

$$\int_0^\infty \frac{\cos ax - \cos bx}{x} dx = \log \frac{b}{a},$$

(xii.)

$$\int_0^\infty \frac{\cos x - e^{-mx}}{x} dx = \log m,$$

(xiii.)

$$\int_{-\infty}^\infty e^{-x^2 + 2ax} dx = \sqrt{\pi} \cdot e^{a2},$$

(xiv.)

$$\int_0^\infty x^{-1/2} \sin x \, dx = \int_0^\infty x^{-1/2} \cos x \, dx = \sqrt{(\tfrac{1}{2} \pi)},$$

Multiple Integrals.

53. The meaning of integration of a function of n variables through a domain of the same number of dimensions is explained in the article Function. In the case of two variables x, y we integrate a function *f*(x, y) over an area; in the case of three variables x, y, z we integrate a function *f*(x, y, z) through a volume. The integral of a function *f*(x, y) over an area in the plane of (x, y) is denoted by

$$\iint f(x, y) \, dx \, dy.$$

The notation refers to a method of evaluating the integral. We may suppose the area divided into a very large number of very small rectangles by lines parallel to the axes. Then we multiply the value of ƒ at any point within a rectangle by the measure of the area of the rectangle, sum for all the rectangles, and pass to a limit by increasing the number of rectangles indefinitely and diminishing all their sides indefinitely. The process is usually effected by summing first for all the rectangles which lie in a strip between two lines parallel to one axis, say the axis of y, and afterwards for all the strips. This process is equivalent to integrating ƒ(x, y) with respect to y, keeping x constant, and taking certain functions of x as the limits of integration for y, and then integrating the result with respect to x between constant limits. The integral obtained in this way may be written in such a form as

$$\int_a^b dx \left\{ \int_{f1(x)}^{f2(x)} f(x, y)dy \right\},$$

and is called a "repeated integral." The identification of a surface integral, such as $\int\int f(x, y)dxdy$, with a repeated integral cannot always be made, but implies that the function satisfies certain conditions of continuity. In the same way volume integrals are usually evaluated by regarding them as repeated integrals, and a volume integral is written in the form

$$\int\int\int f(x, y, z)\, dx\, dy\, dz.$$

Integrals such as surface and volume integrals are usually called "multiple integrals." Thus we have "double" integrals, "triple" integrals, and so on. In contradistinction to multiple integrals the ordinary integral of a function of one variable with respect to that variable is called a "simple integral."

Surface Integrals.

A more general type of surface integral may be defined by taking an arbitrary surface, with or without an edge. We suppose in the first place that the surface is closed, or has no edge. We may mark a large number of points on the surface, and draw the tangent planes at all these points. These tangent planes form a polyhedron having a large number of faces, one to each marked point; and we may choose the marked points so that all the linear dimensions of any face are less than some arbitrarily chosen length. We may devise a rule for increasing the number of marked points indefinitely and decreasing the lengths of all the edges of the polyhedra indefinitely. If the sum of the areas of the faces tends to a limit, this limit is the area of the surface. If we multiply the value of a function ƒ at a point of the surface by the measure of the area of the corresponding face of the polyhedron, sum for all the faces, and pass to a limit as before, the result is a surface integral, and is written

$$\int\int\int f\, dS.$$

Line Integrals.

The extension to the case of an open surface bounded by an edge presents no difficulty. A line integral taken along a curve is defined in a similar way, and is written

$$\int f\, ds$$

where ds is the element of arc of the curve (§ 33). The direction cosines of the tangent of a curve are dx/ds, dy/ds, dz/ds, and line integrals usually present themselves in the form

$$\int \left(u \frac{dx}{ds} + v \frac{dy}{ds} + w \frac{dz}{ds} \right) ds \text{ or } \int_s (u\, dx + v\, dy + w\, dz).$$

In like manner surface integrals usually present themselves in the form

$$\int\int (l\xi + m\eta + n\zeta)\, dS$$

where l, m, n are the direction cosines of the normal to the surface drawn in a specified sense.

The area of a bounded portion of the plane of (x, y) may be expressed either as

$$\tfrac{1}{2} \int (x\, dy - y\, dx),$$

or as

$$\int\int dx\, dy,$$

the former integral being a line integral taken round the boundary of the portion, and the latter a surface integral taken over the area within this boundary. In forming the line integral the boundary is supposed to be described in the positive sense, so that the included area is on the left hand.

Theorems of Green and Stokes.

53*a*. We have two theorems of transformation connecting volume integrals with surface integrals and surface integrals with line integrals. The first theorem, called "Green's theorem," is expressed by the equation

$$\int\int\int \left(\frac{\partial \xi}{\partial x} + \frac{\partial \eta}{\partial y} + \frac{\partial \zeta}{\partial z} \right) dx\, dy\, dz = \int\int (l\xi + m\eta + n\zeta)\, dS,$$

where the volume integral on the left is taken through the volume within a closed surface S, and the surface integral on the right is taken over S, and l, m, n denote the direction cosines of the normal to S drawn outwards. There is a corresponding theorem for a closed curve in two dimensions, viz.,

$$\int\int \left(\frac{\partial \xi}{\partial x} + \frac{\partial \eta}{\partial y} \right) dx\, dy = \int \left(\xi \frac{dy}{ds} - \eta \frac{dx}{ds} \right) ds,$$

the sense of description of s being the positive sense. This theorem is a particular case of a more general theorem called "Stokes's theorem." Let s denote the edge of an open surface S, and let S be covered with a network of curves so that the meshes of the network are nearly plane, then we can choose a sense of description of the edge of any mesh, and a corresponding sense for the normal to S at any point within the mesh, so that these senses are related like the directions of rotation and translation in a right-handed screw. This convention fixes the sense of the normal (l, m, n) at any point on S when the sense of description of s is chosen. If the axes of x, y, z are a right-handed system, we have Stokes's theorem in the form

$$\int_s (u\, dx + v\, dy + w\, dz) = \int\int \left\{ l \left(\frac{\partial w}{\partial y} - \frac{\partial v}{\partial z} \right) + m \left(\frac{\partial u}{\partial z} - \frac{\partial w}{\partial x} \right) + n \left(\frac{\partial v}{\partial x} - \frac{\partial u}{\partial y} \right) \right\} dS,$$

where the integral on the left is taken round the curve s in the chosen sense. When the axes are left-handed, we may either reverse the sense of l, m, n and maintain the formula, or retain the sense of l, m, n and change the sign of the right-hand member of the equation. For the validity of the theorems of Green and Stokes it is in general necessary that the functions involved should satisfy certain conditions of continuity. For example, in Green's theorem the differential coefficients $\partial\xi/\partial x$, $\partial\eta/\partial y$, $\partial\zeta/\partial z$ must be continuous within S. Further, there are restrictions upon the nature of the curves or surfaces involved. For example, Green's theorem, as here stated, applies only to simply-connected regions of space. The correction for multiply-connected regions is important in several physical theories.

54. The process of changing the variables in a multiple integral, such as a surface or volume integral, is divisible into two stages. It is necessary in the first place to determine the differential element expressed by the product of the differentials of the first set of variables in terms of the differentials of the second set of variables. It is necessary in the second place to determine the limits of integration which must be employed when the integral in terms of the new variables is evaluated as a repeated integral. The first part of the problem is solved at once by the introduction of the Jacobian. If the variables of one set are denoted by $x_1, x_2, \ldots, x_n$, and those of the other set by $u_1, u_2, \ldots, u_n$, we have the relation

Change of Variables in a Multiple Integral.

$$dx_1\, dx_2 \ldots dx_n = \frac{\partial (x_1, x_2, \ldots, x_n)}{\partial (u_1, u_2, \ldots, u_n)}\, du_1\, du_2 \ldots du_n.$$

In regard to the second stage of the process the limits of integration must be determined by the rule that the integration with respect to the second set of variables is to be taken through the same domain as the integration with respect to the first set.

For example, when we have to integrate a function $f(x, y)$ over the area within a circle given by $x^2 + y^2 = a^2$, and we introduce polar coordinates so that $x = r \cos \theta$, $y = r \sin \theta$, we find that r is the value of the Jacobian, and that all points within or on the circle are given by $a \geq r \geq 0$, $2\pi \geq \theta \geq 0$, and we have

$$\int_{-a}^{a} dx \int_{-\sqrt{(a2-x2)}}^{\sqrt{(a2-x2)}} f(x, y)\, dy = \int_0^a dr \int_0^{2\pi} f(r \cos \theta, r \sin \theta)\, r\, d\theta.$$

If we have to integrate over the area of a rectangle $a \geq x \geq 0$, $b \geq y \geq 0$, and we transform to polar coordinates, the integral becomes the sum of two integrals, as follows:—

$$\int_0^a dx \int_0^b f(x, y)\, dy = \int_0^{\tan^{-1} b/a} d\theta \int_0^{a \sec \theta} f(r \cos \theta, r \sin \theta)\, r\, dr + \int_{\tan^{-1} b/a}^{1/2\pi} d\theta \int_0^{b \operatorname{cosec} \theta} f(r \cos \theta, r \sin \theta)\, r\, dr.$$

55. A few additional results in relation to line integrals and multiple integrals are set down here.

(i.) Any simple integral can be regarded as a line-integral taken along a portion of the axis of x. When a change of variables is made, the limits of integration with respect to the new variable must be such that the domain of integration is the same as before. This condition may require the replacing of the original integral by the sum of two or more simple integrals.

Line Integrals and Multiple Integrals.

(ii.) The line integral of a perfect differential of a one-valued function, taken along any closed curve, is zero.

(iii.) The area within any plane closed curve can be expressed by either of the formulae

$$\int \tfrac{1}{2} r^2\, d\theta \text{ or } \int \tfrac{1}{2} p\, ds,$$

where r, θ are polar coordinates, and p is the perpendicular drawn from a fixed point to the tangent. The integrals are to be understood as line integrals taken along the curve. When the same integrals are taken between limits which correspond to two points of the curve, in the sense of line integrals along the arc between the points, they represent the area bounded by the arc and the terminal radii vectores.

(iv.) The volume enclosed by a surface which is generated by the revolution of a curve about the axis of x is expressed by the formula

$$\pi \int y^2\, dx,$$

and the area of the surface is expressed by the formula

$$2\pi \int y\, ds,$$

where ds is the differential element of arc of the curve. When the former integral is taken between assigned limits it represents the volume contained between the surface and two planes which cut the axis of x at right angles. The latter integral is to be understood as a line integral taken along the curve, and it represents the area of the portion of the curved surface which is contained between two planes at right angles to the axis of x.

(v.) When we use curvilinear coordinates ξ, η which are conjugate functions of x, y, that is to say are such that

$$\partial\xi/\partial x = \partial\eta/\partial y \text{ and } \partial\xi/\partial y = -\partial\eta/\partial x,$$

the Jacobian $\partial(\xi, \eta)/\partial(x, v)$ can be expressed in the form

$$\left(\frac{\partial \xi}{\partial x}\right)^2 + \left(\frac{\partial \eta}{\partial x}\right)^2,$$

and in a number of equivalent forms. The area of any portion of the plane is represented by the double integral

$$\iint J^{-1}\, d\xi\, d\eta,$$

where J denotes the above Jacobian, and the integration is taken through a suitable domain. When the boundary consists of portions of curves for which ξ = const., or η = const., the above is generally the simplest way of evaluating it.

(vi.) The problem of "rectifying" a plane curve, or finding its length, is solved by evaluating the integral

$$\int \left\{1 + \left(\frac{dy}{dx}\right)^2\right\}^{1/2} dx,$$

or, in polar coordinates, by evaluating the integral

$$\int \left\{r^2 + \left(\frac{dr}{d\theta}\right)^2\right\}^{1/2} d\theta.$$

In both cases the integrals are line integrals taken along the curve.

(vii.) When we use curvilinear coordinates ξ, η as in (v.) above, the length of any portion of a curve ξ = const. is given by the integral

$$\int J^{-1/2}\, d\eta$$

taken between appropriate limits for η. There is a similar formula for the arc of a curve η = const.

(viii.) The area of a surface $z = f(x, y)$ can be expressed by the formula

$$\iint \left\{1 + \left(\frac{\partial z}{\partial x}\right)^2 + \left(\frac{\partial z}{\partial y}\right)^2\right\}^{1/2} dx\, dy.$$

When the coordinates of the points of a surface are expressed as functions of two parameters u, v, the area is expressed

by the formula

$$\iint \left[\left\{ \frac{\partial(y, z)}{\partial(u, v)} \right\}^2 + \left\{ \frac{\partial(z, x)}{\partial(u, v)} \right\}^2 + \left\{ \frac{\partial(x, y)}{\partial(u, v)} \right\}^2 \right]^{1/2} du\, dv.$$

When the surface is referred to three-dimensional polar coordinates r, θ, φ given by the equations

$$x = r \sin\theta \cos\varphi,\ y = r \sin\theta \sin\varphi,\ z = r \cos\theta,$$

and the equation of the surface is of the form $r = f(\theta, \varphi)$, the area is expressed by the formula

$$\iint r \left[\left\{ r^2 + \left(\frac{\partial r}{\partial \theta} \right)^2 \right\} \sin^2\theta + \left(\frac{\partial r}{\partial \varphi} \right)^2 \right]^{1/2} d\theta\, d\varphi.$$

The surface integral of a function of (θ, φ) over the surface of a sphere r = const. can be expressed in the form

$$\int_0^{2\pi} d\varphi \int_0^{\pi} F(\theta,\varphi)\, r^2 \sin\theta\, d\theta.$$

In every case the domain of integration must be chosen so as to include the whole surface.

(ix.) In three-dimensional polar coordinates the Jacobian

$$\frac{\partial(x, y, z)}{\partial(r, \theta, \varphi)} = r^2 \sin\theta.$$

The volume integral of a function F (r, θ, φ) through the volume of a sphere r = a is

$$\int_0^a dr \int_0^{2\pi} d\varphi \int_0^{\pi} F(r, \theta, \varphi)\, r^2 \sin\theta\, d\theta.$$

(x.) Integrations of rational functions through the volume of an ellipsoid $x^2/a^2 + y^2/b^2 + z^2/c^2 = 1$ are often effected by means of a general theorem due to Lejeune Dirichlet (1839), which is as follows: when the domain of integration is that given by the inequality

$$\left(\frac{x_1}{a_1} \right)^{a_1} + \left(\frac{x_2}{a_2} \right)^{a_2} + \ldots + \left(\frac{x_n}{a_n} \right)^{a_n} \leq 1,$$

where the a's and α's are positive, the value of the integral

$$\int\int \ldots x_1^{\,n_1-1} \cdot x_2^{\,n_2-1} \ldots dx_1\, dx_2 \ldots$$

is

$$\frac{a_1^{n_1} a_2^{n_2} \ldots}{\alpha_1 \alpha_2 \ldots} \cdot \frac{\Gamma(n_1/\alpha_1)\, \Gamma(n_2/\alpha_2) \ldots}{\Gamma(1 + n_1/\alpha_1 + n_2/\alpha_2 + \ldots)}.$$

If, however, the object aimed at is an integration through the volume of an ellipsoid it is simpler to reduce the domain of integration to that within a sphere of radius unity by the transformation $x = a\xi$, $y = b\eta$, $z = c\zeta$, and then to perform the integration through the sphere by transforming to polar coordinates as in (ix).

Approximate and Mechanical Integration.

56. Methods of approximate integration began to be devised very early. Kepler's practical measurement of the focal sectors of ellipses (1609) was an approximate integration, as also was the method for the quadrature of the hyperbola given by James Gregory in the appendix to his *Exercitationes geometricae* (1668). In Newton's *Methodus differentialis* (1711) the subject was taken up systematically. Newton's object was to effect the approximate quadrature of a given curve by making a curve of the type

$$y = a_0 + a_1 x + a_2 x^2 + \ldots + a_n x^n$$

pass through the vertices of (n + 1) equidistant ordinates of the given curve, and by taking the area of the new curve so determined as an approximation to the area of the given curve. In 1743 Thomas Simpson in his *Mathematical Dissertations* published a very convenient rule, obtained by taking the vertices of three consecutive equidistant ordinates to be points on the same parabola. The distance between the extreme ordinates corresponding to the abscissae x = a and x = b is divided into 2n equal segments by ordinates $y_1, y_2, \ldots y_{2n-1}$, and the extreme ordinates are denoted by y_0, y_{2n}. The vertices of the ordinates y_0, y_1, y_2 lie on a parabola with its axis parallel to the axis of y, so do the vertices of the ordinates y_2, y_3, y_4, and so on. The area is expressed approximately by the formula

$$\{ (b - a)/6n \} [y_0 + y_{2n} + 2(y_2 + y_4 + \ldots + y_{2n-2}) + 4(y_1 + y_3 + \ldots + y_{2n-1})],$$

which is known as Simpson's rule. Since all simple integrals can be represented as areas such rules are applicable to approximate integration in general. For the recent developments reference may be made to the article by A. Voss in *Ency. d. Math. Wiss.*, Bd. II., A. 2 (1899), and to a monograph by B. P. Moors, *Valeur approximative d'une intégrale définie* (Paris, 1905).

Many instruments have been devised for registering mechanically the areas of closed curves and the values of integrals. The best known are perhaps the "planimeter" of J. Amsler (1854) and the "integraph" of Abdank-Abakanowicz (1882).

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(A. E. H. L.)

INFINITIVE, a form of the verb, properly a noun with verbal functions, but usually taken as a mood (see GRAMMAR). The Latin grammarians gave it the name of *infinitus* or *infinitivus modus*, *i.e.* indefinite, unlimited mood, as not having definite persons or numbers.

INFLEXION (from Lat. *inflectere*, to bend), the action of bending inwards, or turning towards oneself, or the condition of being bent or curved. In optics, the term "inflexion" was used by Newton for what is now known as "diffraction of light" (*q.v.*). For inflexion in geometry see CURVE. Inflexion when used of the voice, in speaking or singing, indicates a change in tone, pitch or expression. In grammar (*q.v.*) inflexion indicates the changes which a word undergoes to bring it into correct relations with the other words with which it is used. In English grammar nouns, pronouns, adjectives (in their degrees of comparison), verbs and adverbs are inflected. Some grammarians, however, regard the inflexions of adverbs more as an actual change in word-formation.

INFLUENCE (Late Lat. *influentia*, from *influere*, to flow in), a word whose principal modern meaning is that of power, control or action affecting others, exercised either covertly or without visible means or direct physical agency. It is one of those numerous terms of astrology (*q.v.*) which have established themselves in current language. From the stars was supposed to flow an ethereal stream which affected the course of events on the earth and the fortunes and characters of men. For the law as to "undue influence" see CONTRACT.

INFLUENZA (syn. "grip," *la grippe*), a term applied to an infectious febrile disorder due to a specific bacillus, characterized specially by catarrh of the respiratory passages and alimentary canal, and occurring mostly as an epidemic. The Italians in the 17th century ascribed it to the influence of the stars, and hence the name "influenza." The French name *grippe* came into use in 1743, and those of *petite poste* and *petit courier* in 1762, while *général* became another synonym in 1780. Apparently the scourge was common; in 1403 and 1557 the sittings of the Paris law courts had to be suspended through it, and in 1427 sermons had to be abandoned through the coughing and sneezing; in 1510 masses could not be sung. Epidemics occurred in 1580, 1676, 1703, 1732 and 1737, and their cessation was supposed to be connected with earthquakes and volcanic eruptions.

The disease is referred to in the works of the ancient physicians, and accurate descriptions of it have been given by medical writers during the last three centuries. These various accounts agree substantially in their narration of the phenomena and course of the disease, and influenza has in all times been regarded as fulfilling all the conditions of an epidemic in its sudden invasion, and rapid and extensive spread. Among the chief epidemics were those of 1762, 1782, 1787, 1803, 1833, 1837 and 1847. It appeared in fleets at sea away from all communication with land, and to such an extent as to disable them temporarily for service. This happened in 1782 in the case of the squadron of Admiral Richard Kempenfelt (1718-1782), which had to return to England from the coast of France in consequence of influenza attacking his crews.

Like cholera and plague, influenza reappeared in the last quarter of the 19th century, after an interval of many years, in epidemic or rather pandemic form. After the year 1848, in which 7963 deaths were directly attributed to influenza in England and Wales, the disease continued prevalent until 1860, with distinct but minor epidemic exacerbations in 1851, 1855 and 1858; during the next decade the mortality dropped rapidly though not steadily, and the diminution continued down to the year 1889, In which only 55 deaths were ascribed to this cause. It is not clear whether the disease ever disappears wholly, and the deaths registered in 1889 are the lowest recorded in any year since the registrar-general's returns began. Occasionally local outbreaks of illness resembling epidemic influenza have been observed during the

period of abeyance, as in Norfolk in 1878 and in Yorkshire in 1887; but whether such outbreaks and the so-called "sporadic" cases are nosologically identical with epidemic influenza is open to doubt. The relation seems rather to be similar to that between Asiatic cholera and "cholera nostras." Individual cases may be indistinguishable, but as a factor in the public health the difference between sporadic and epidemic influenza is as great and unmistakable as that between the two forms of cholera. This fact, which had been forgotten by some since 1847 and never learnt by others, was brought home forcibly to all by the visitation of 1889.

According to the exhaustive report drawn up by Dr H. Franklin Parsons for the Local Government Board, the earliest appearances were observed in May 1889, and three localities are mentioned as affected at the same time, all widely separated from each other—namely, Bokhara in Central Asia, Athabasca in the north-west Territories of Canada and Greenland. About the middle of October it was reported at Tomsk in Siberia, and by the end of the month at St Petersburg. During November Russia became generally affected, and cases were noticed in Paris, Berlin, Vienna, London and Jamaica (?). In December epidemic influenza became established over the whole of Europe, along the Mediterranean, in Egypt and over a large area in the United States. It appeared in several towns in England, beginning with Portsmouth, but did not become generally epidemic until the commencement of the new year. In London the full onset of unmistakable influenza dated from the 1st of January 1890. Everywhere it seems to have exhibited the same explosive character when once fully established. In St Petersburg, out of a government staff of 260 men, 220 were taken ill in one night, the 15th of November. During January 1890 the epidemic reached its height in London, and appeared in a large number of towns throughout the British Islands, though it was less prevalent in the north and north-west than in the south. January witnessed a great extension of the disease in Germany, Holland, Switzerland, Austria-Hungary, Italy, Spain and Portugal; but in Russia, Scandinavia and France it was already declining. The period of greatest activity in Europe was the latter half of December and the earlier half of January, with the change of the year for a central point. Other parts of the world affected in January 1890 were Cape Town, Canada, the United States generally, Algiers, Tunis, Cairo, Corsica, Sardinia, Sicily, Honolulu, Mexico, the West Indies and Montevideo. In February the provincial towns of England were most severely affected, the death-rate rising to 27.4, but in London it fell from 28.1 to 21.2, and for Europe generally the back of the epidemic was broken. At the same time, however, it appeared in Ceylon, Penang, Japan, Hong Kong and India; also in West Africa, attacking Sierra Leone, and Gambia in the middle of the month; and finally in the west, where Newfoundland and Buenos Aires were invaded. In March influenza became widely epidemic in India, particularly in Bengal and Bombay, and made its appearance in Australia and New Zealand. In April and May it was epidemic all over Australasia, in Central America, Brazil, Peru, Arabia and Burma. During the summer and autumn it reached a number of isolated islands, such as Iceland, St Helena, Mauritius and Réunion. Towards the close of the year it was reported from Yunnan in the interior of China, from the Shiré Highlands in Central Africa, Shoa in Abyssinia, and Gilgit in Kashmir. In the course of fifteen months, beginning with its undoubted appearance in Siberia in October 1889, it had traversed the entire globe.

The localities attacked by influenza in 1889-1890 appear in no case to have suffered severely for more than a month or six weeks. Thus in Europe and North America generally the visitation had come to an end in the first quarter of 1890. The earliest signs of an epidemic revival on a large scale occurred in March 1891, in the United States and the north of England. It was reported from Chicago and other large towns in the central states, whence it spread eastwards, reaching New York about the end of March. In England it began in the Yorkshire towns, particularly in Hull, and also independently in South Wales. In London influenza became epidemic for the second time about the end of April, and soon afterwards was widely distributed in England and Wales. The large towns in the north, together with London and Wales, suffered much more heavily in mortality than in the previous attack, but the south-west of England, Scotland and Ireland escaped with comparatively little sickness. The same may be said of the European continent generally, except parts of Russia, Scandinavia and perhaps the north of Germany. This second epidemic coincided with the spring and early summer; it had subsided in London by the end of June. The experience of Sheffield is interesting. In 1890 the attack, contrary to general experience, had been undecided, lingering and mild; in 1891 it was very sudden and extremely severe, the death-rate rising to 73.4 during the month of April, and subsiding with equal rapidity. During the third quarter of the year, while Europe was free, the antipodes had their second attack, which was more severe than the first. As in England, it reversed the previous order of things, beginning in the provinces and spreading thence to the capital towns. The last quarter of the year was signalized by another recrudescence in Europe, which reached its height during the winter. All parts, including Great Britain, were severely affected. In England those parts which had borne the brunt of the epidemic in the early part of the year escaped. In fact, these two revivals may be regarded as one, temporarily interrupted by the summer quarter.

The recrudescence at the end of 1891 lasted through mid-winter, and in many places, notably in London, it only reached its height in January 1892, subsiding slowly and irregularly in February and March. Brighton suffered with exceptional severity. The continent of Europe seems to have been similarly affected. In Italy the notifications of influenza were as follow: 1891—January to October, 0; November, 30; December, 6461; 1892—January, 84,543; February, 55,352; March, 28,046; April, 7962; May, 1468; June, 223. Other parts of the world affected were the West Indies, Tunis, Egypt, Sudan, Cape Town Teheran, Tongking and China. In August 1892 influenza was reported from Peru, and later in the year from various places in Europe.

A fourth recrudescence, but of a milder character, occurred in Great Britain in the spring of 1893, and a fifth in the following winter, but the year 1894 was freer from influenza than any since 1890. In 1895 another extensive epidemic took place. In 1896 influenza seemed to have spent its strength, but there was an increased prevalence of the disease in 1897, which was repeated on a larger scale in 1898, and again in 1899, when 12,417 deaths were recorded in England and Wales. This was the highest death-rate since 1892. After this the death-rate declined to half that amount and remained there with the slight upward variations until 1907, in which the total death-rate was 9257. The experience of other countries has been very similar; they have all been subjected to periodical revivals of epidemic influenza at irregular intervals and of varying intensity since its reappearance in 1889, but there has been a general though not a steady decline in its activity and potency. Its behaviour is, in short, quite in keeping with the experience of 1847-1860, though the later visitation appears to have been more violent and more fatal than the former. Its diffusion was also more rapid and probably more extensive.

The foregoing general summary may be supplemented by some further details of the incidence in Great Britain. The number of deaths directly attributed to influenza, and the death-rates per million in each year in England and Wales, are as follow:—

Year.	Deaths.	Death-rates per million.	Year.	Deaths.	Death-rates per million.
1890	4,523	157	1899	12,417	389
1891	16,686	574	1900	16,245	504
1892	15,737	534	1901	5,666	174
1893	9,669	325	1902	7,366	223
1894	6,625	220	1903	6,322	189
1895	12,880	424	1904	5,694	168

1896	3,753	122	1905	6,953	204
1897	6,088	196	1906	6,310	183
1898	10,405	331	1907	9,257	265

It is interesting to compare these figures with the corresponding ones for the previous visitation:—

Year.	Deaths.	Death-rates per million.	Year.	Deaths.	Death-rates per million.
1847	4,881	285	1852	1,359	76
1848	7,963	460	1853	1,789	99
1849	1,611	92	1854	1,061	58
1850	1,380	78	1855	3,568	193
1851	2,152	120			

The two sets of figures are not strictly comparable, because, during the first period, notification of the cause of death was not compulsory; but it seems clear that the later wave was much the more deadly. The average annual death-rate for the nine years is 320 in the one case against 162 in the other, or as nearly as possible double. In both epidemic periods the second year was far more fatal than the first, and in both a marked revival took place in the ninth year; in both also an intermediate recrudescence occurred, in the fifth year in one case, in the sixth in the other. The chief point of difference is the sudden and marked drop in 1849-1850, against a persistent high mortality in 1892-1893, especially in 1892, which was nearly as fatal as 1891.

To make the significance of these epidemic figures clear, it should be added that in the intervening period 1861-1889 the average annual death-rate from influenza was only fifteen, and in the ten years immediately preceding the 1890 outbreak it was only three. Moreover, in epidemic influenza, the mortality directly attributed to that disease is only a fraction of that actually caused by it. For instance, in January 1890 the deaths from influenza in London were 304, while the excess of deaths from respiratory diseases was 1454 and from all causes 1958 above the average. 554

We have seen above that the mortality was far greater in the second epidemic year than in the first, and this applies to all parts of England, and to rural as well as to urban communities, as the following table shows:—

Deaths from Influenza.

	1890.	1891.
London	624	2302
24 Great Towns over 80,000 population	439	2417
35 Towns between 20,000 and 80,000	186	765
21 Towns between 10,000 and 20,000	46	196
60 Towns under 10,000	62	196
85 Rural Sanitary Districts	317	841

In spite of these figures, it appears that the 1890 attack, which was in general much more sudden in its onset than that of 1891, also caused a great deal more sickness. More people were “down with influenza,” though fewer died. For Instance, the number of persons treated at the Middlesex Hospital in the two months’ winter epidemic of 1890 was 1279; in the far more fatal three months’ spring epidemic of 1891 it was only 726. One explanation of this discrepancy between the incidence of sickness and mortality is that in the second attack, which was more protracted and more insidious, the stress of the disease fell more upon the lungs. Another is that its comparative mildness, combined with the time of year, in itself proved dangerous, because it tempted people to disregard the illness, whereas in the first epidemic they were too ill to resist. On the whole, rural districts showed a higher death-rate than towns, and small towns a higher one than large ones in both years. This is explained by the age distribution in such localities; influenza being particularly fatal to aged people, though no age is exempt. Certain counties were much more severely affected than others. The eastern counties, namely, Essex, Suffolk and Norfolk, together with Hampshire and one or two others, escaped lightly in both years; the western counties, namely, North and South Wales, with the adjoining counties of Monmouth, Hereford and Shropshire, suffered heavily in both years.

It will be convenient to discuss *seriatim* the various points of interest on which light has been thrown by the experience described above.

The bacteriology of influenza is discussed in the article on Parasitic Diseases. The disease is often called “Russian” influenza, and its origin in 1889 suggests that the name may have some foundation in fact. A writer, who saw the epidemic break out in Bokhara, is quoted by him to the following effect:—“The summer of 1888 was exceptionally hot and dry, and was followed by a bitterly cold winter and a rainy spring. The dried-up earth was full of cracks and holes from drought and subsequent frost, so that the spring rains formed ponds in these holes, inundated the new railway cuttings, and turned the country into a perfect marsh. When the hot weather set in the water gave off poisonous exhalations, rendering malaria general.” On account of the severe winter, the people were enfeebled from lack of nourishment, and when influenza broke out suddenly they died in large numbers. Europeans were very severely affected. Russians, hurrying home, carried the disease westwards, and caravans passing eastwards took it into Siberia. There is a striking similarity in the conditions described to those observed in connexion with outbreaks of other diseases, particularly typhoid fever and diphtheria, which have occurred on the supervention of heavy rain after a dry period, causing cracks and fissures in the earth. Assuming the existence of a living poison in the ground, we can easily understand that under certain conditions, such as an exceptionally dry season, it may develop exceptional properties and then be driven out by the subsequent rains, causing a violent outbreak of illness. Some such explanation is required to account for the periodical occurrence of epidemic and pandemic diffusions starting from an endemic centre. We may suppose that a micro-organism of peculiar robustness and virulence is bred and brought into activity by a combination of favourable conditions, and is then disseminated more or less widely according to its “staying power,” by human agency. Whether central Asia is an endemic centre for influenza or not there is no evidence, but the disease seems to be more often prevalent in the Russian Empire than elsewhere. Extensive outbreaks occurred there in 1886 and 1887, and it is certain that the 1889 wave was active in Siberia at an earlier date than in Europe, and that it moved eastwards. The hypothesis that it originated in China is unsupported by evidence. But whatever may be the truth with regard to origin, the dissemination of influenza by human agency must be held to be proved. This is the most important addition to our knowledge of the subject contributed by recent research. The upshot of the inquiry by Dr Parsons was to negative all theories of atmospheric influence, and to establish the conclusion that the disease was “propagated mainly, perhaps entirely, by human intercourse.”

He found that it prevailed independently of climate, season and weather; that it moved in a contrary direction to the

prevailing winds; that it travelled along the lines of human intercourse, and not faster than human beings can travel; that in 1889 it travelled much faster than in previous epidemics, when the means of locomotion were very inferior; that it appeared first in capital towns, seaports and frontier towns, and only affected country districts later; that it never commenced suddenly with a large number of cases in a place previously free from disease, but that epidemic manifestations were generally preceded for some days or weeks by scattered cases; that conveyance of infection by individuals and its introduction into fresh places had been observed in many instances; that persons brought much into contact with others were generally the first to suffer; that persons brought together in large numbers in enclosed spaces suffered more in proportion than others, and that the rapidity and extent of the outbreak in institutions corresponded with the massing together of the inmates.

These conclusions, based upon the 1889-1890 epidemic, have been confirmed by subsequent experience, especially in regard to the complete independence of season and weather shown by influenza. It has appeared and disappeared at all seasons and in all weathers and only popular ignorance continues to ascribe its behaviour to atmospheric conditions. In Europe, however, it has prevailed more often in winter than in summer, which may be due to the greater susceptibility of persons in winter, or, more probably, to the fact that they congregate more in buildings and are less in the open air during that part of the year. No doubt is any longer entertained of its infectious character, though the degree of infectivity appears to vary considerably. Many cases have been recorded of individuals introducing it into houses, and of all or most of the other inmates then taking it from the first case. Difficulties in preventing the spread of infection are due to (1) the shortness of the period of incubation, (2) the disease being infectious in the earliest stages before the nature of the illness is recognized, (3) the milder varieties being equally infectious with the severe attacks, and the patient going to work and spreading the infection, (4) the diagnosis often being difficult, influenza being possibly confused with ordinary catarrhal attacks, typhoid fever and other diseases. Domestic animals seem to be free from any suspicion of being liable to human influenza. Sanitary conditions, other than overcrowding, do not appear to exercise any influence on the spread of influenza.

Influenza has been shown to be an acute specific fever having nothing whatever to do with a “bad cold.” There may be some inflammation of the respiratory passages, and then symptoms of catarrh are present, but that is not necessarily the case, and in some epidemics such symptoms are quite exceptional. This had been recognized by various writers before the 1889 visitation, but it had not been generally realized, as it has been since, and some medical authorities, who persisted in regarding influenza as essentially a “catarrhal” affection, were chiefly to blame for a widespread and tenacious popular fallacy.

Leichtenstern, in his masterly article in Nothnagel’s *Handbuch*, divides the disease as follows:—(1) Epidemic influenza vera caused by Pfeiffer’s bacillus; (2) Endemic-epidemic influenza vera, which occurs several years after a pandemic and is caused by the same bacillus; (3) Endemic influenza nostras or eatarrhal fever, called *la grippe*, and bearing the same relation to true influenza as cholera nostras does to Asiatic cholera.

The “period of incubation” is one to four days. Susceptibility varies greatly, but the conditions that influence it are matters of conjecture only. It appears that the inhabitants of Great Britain are less susceptible than those of many other countries. Dr Parsons gives the following list, showing the proportion of the population estimated to have been attacked in the 1889-1890 epidemic in different localities:—

Place.	Per cent.	Place.	Per cent.
St Petersburg	50	Portugal	90
Berlin	33	Vienna	30-40
Nuremberg	67	Belgrade	33
Grand-Duchy of Hesse	25-30	Antwerp	33
Grand-Duchy, other Districts	50-75	Gaeta	50-77
		Massachusetts	39
Heligoland	50	Peking	50
Budapest	50	St Louis (Mauritius)	67

In and about London he reckoned roughly from a number of returns that the proportion was about 12 1/2% among those employed out of doors and 25% among those in offices, &c. The proportion among the troops in the Home District was 9.3%. The General Post Office made the highest return with 33.6%, which is accounted for partly by the enormous number of persons massed together in the same room in more than one department, and partly by the facilities for obtaining medical advice, which would tend to bring very light cases, unnoticed elsewhere, upon the record. No public service was seriously disorganized in England by sickness in the same manner as on the continent of Europe. Some individuals appear to be totally immune; others take the disease over and over again, deriving no immunity, but apparently greater susceptibility from previous attacks.

The symptoms were thus described by Dr Bruce Low from observations made in St Thomas’s Hospital, London, in January 1890:—

> The invasion is sudden; the patients can generally tell the time when they developed the disease; *e.g.* acute pains in the back and loins came on quite suddenly while they were at work or walking in the street, or in the case of a medical student, while playing cards, rendering him unable to continue the game. A workman wheeling a barrow had to put it down and leave it; and an omnibus driver was unable to pull up his horses. This sudden onset is often accompanied by vertigo and nausea, and sometimes actual vomiting of bilious matter. There are pains in the limbs and general sense of aching all over; frontal headache of special severity; pains in the eyeballs, increased by the slightest movement of the eyes; shivering; general feeling of misery and weakness, and great depression of spirits, many patients, both men and women, giving way to weeping; nervous restlessness; inability to sleep, and occasionally delirium. In some cases catarrhal symptoms develop, such as running at the eyes, which are sometimes injected on the second day; sneezing and sore throat; and epistaxis, swelling of the parotid and submaxillary glands, tonsilitis, and spitting of bright blood from the pharynx may occur. There is a hard, dry cough of a paroxysmal kind, worst at night. There is often tenderness of the spleen, which is almost always found enlarged, and this persists after the acute symptoms have passed. The temperature is high at the onset of the disease. In the first twenty-four hours its range is from 100° F. in mild cases to 105° in severe cases.

Dr J. S. Bristowe gave the following description of the illness during the same epidemic:—

> The chief symptoms of influenza are, coldness along the back, with shivering, which may continue off and on for two or three days; severe pain in the head and eyes, often with tenderness in the eyes and pain in moving them; pains in the ears; pains in the small of the back; pains in the limbs, for the most part in the fleshy portions, but also in the bones and joints, and even in the fingers and toes; and febrile temperature, which may in the early period rise to 104° or 105° F. At the same time the patient feels excessively ill and prostrate, is apt to suffer from nausea or sickness and diarrhoea, and is for the most part restless, though often (and especially in the case of children and those advanced in age) drowsy.... In ordinary mild cases the above symptoms are the only important ones which present themselves, and the

patient may recover in the course of three or four days. He may even have it so mildly that, although feeling very ill, he is able to go about his ordinary work. In some cases the patients have additionally some dryness or soreness of the throat, or some stiffness and discharge from the nose, which may be accompanied by slight bleeding. And in some cases, for the most part in the course of a few days, and at a time when the patient seems to be convalescent, he begins to suffer from wheezing in the chest, cough, and perhaps a little shortness of breath, and before long spits mucus in which are contained pellets streaked or tinged with blood.... Another complication is diarrhoea. Another is a roseolous spotty rash.... Influenza is by no means necessarily attended with the catarrhal symptoms which the general public have been taught to regard as its distinctive signs, and in a very large proportion of cases no catarrhal condition whatever becomes developed at any time.

Several writers have distinguished four main varieties of the disease—namely, (1) nervous, (2)gastro-intestinal, (3)respiratory, (4) febrile, a form chiefly found in children. Clifford Allbutt says, “Influenza simulates other diseases.” Many forms are of typhoid or comatose types. Cardiac attacks are common, not from organic disease but from the direct poisoning of the heart muscle by influenza.

Perhaps the most marked feature of influenza, and certainly the one which victims have learned to dread most, is the prolonged debility and nervous depression that frequently follow an attack. It was remarked by Nothnagel that “Influenza produces a specific nervous toxin which by its action on the cortex produces psychoses.” In the Paris epidemic of 1890 the suicides increased 25%, a large proportion of the excess being attributed to nervous prostration caused by the disease. Dr Rawes, medical superintendent of St Luke’s hospital, says that of insanities traceable to influenza melancholia is twice as frequent as all other forms of insanity put together. Other common after-effects are neuralgia, dyspepsia, insomnia, weakness or loss of the special senses, particularly taste and smell, abdominal pains, sore throat, rheumatism and muscular weakness. The feature most dangerous to life is the special liability of patients to inflammation of the lungs. This affection must be regarded as a complication rather than an integral part of the illness. The following diagram gives the annual death-rate per million in England and Wales, and is taken from an article by Dr Arthur Newsholme in *The Practitioner* (January 1907).

The deaths directly attributed to influenza are few in proportion to the number of cases. In the milder forms it offers hardly any danger to life if reasonable care be taken, but in the severer forms it is a fairly fatal disease. In eight London hospitals the case-mortality among in-patients in the 1890 outbreak was 34.5 per 1000; among all patients treated it was 1.6 per 1000. In the army it was rather less.

The infectious character of influenza having been determined, suggestions were made for its administrative control on the familiar lines of notification, isolation and disinfection, but this has not hitherto been found practicable. In March 1895, however, the Local Government Board issued a memorandum recommending the adoption of the following precautions wherever they can be carried out:—

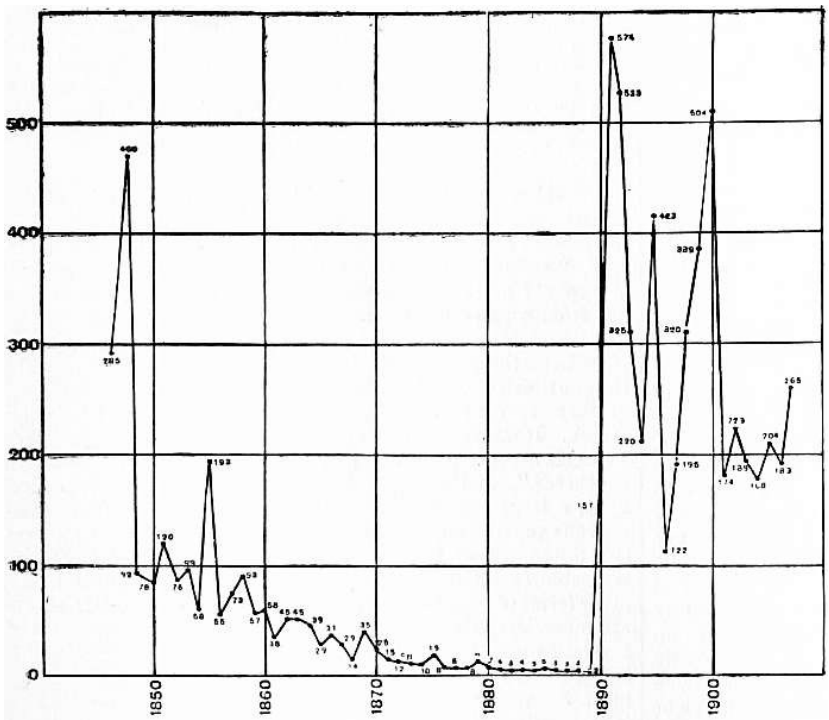
1. The sick should be separated from the healthy. This is especially important in the case of first attacks in a locality or a household.

2. The sputa of the sick should, especially in the acute stage of the disease, be received into vessels containing disinfectants. Infected articles and rooms should be cleansed and disinfected.

3. When influenza threatens, unnecessary assemblages of persons should be avoided.

4. Buildings and rooms in which many people necessarily congregate should be efficiently aerated and cleansed during the intervals of occupation.

There is no routine treatment for influenza except bed. In all cases bed is advisable, because of the danger of lung complications, and in mild ones it is sufficient. Severer ones must be treated according to the symptoms. Quinine has been much used. Modern “anti-pyretic” drugs have also been extensively employed, and when applied with discretion they may be useful, but patients are not advised to prescribe them for themselves.



Sir Wm. Broadbent in a note on the prophylaxis of influenza recommends quinine in a dose of two grains every morning, and remarks: “I have had opportunities of obtaining extraordinary evidence of its protective power. In a large public school it was ordered to be taken every morning. Some of the boys in the school were home boarders, and it was found that while the boarders at the school took the quinine in the presence of a master every morning, there were scarcely any cases of influenza among them, although the home boarders suffered nearly as much as before.” He

continues, “In a large girls’ school near London the same thing was ordered, and the girls and mistresses took their morning dose but the servants were forgotten. The result was that scarcely any girl or mistress suffered while the servants were all down with influenza.”

The liability to contract influenza, and the danger of an attack if contracted, are increased by depressing conditions, such as exposure to cold and to fatigue, whether mental or physical. Attention should, therefore, be paid to all measures tending to the maintenance of health. Persons who are attacked by influenza should at once seek rest, warmth and medical treatment, and they should bear in mind that the risk of relapse, with serious complications, constitutes a chief danger of the disease.

In addition to the ordinary text-books, see the series of articles by experts on different aspects in *The Practitioner* (London) for January 1907.

IN FORMÂ PAUPERIS (Latin, “in the character of pauper”), the legal phrase for a method of bringing or defending a case in court on the part of persons without means. By an English statute of 1495 (11 Hen. VII. c. 12), any poor person having cause of action was entitled to have a writ according to the nature of the case, without paying the fees thereon. The statute of 1495 was repealed by the Statute Law Revision and Civil Procedure Act 1883, but its provisions, as well as the chancery practice were incorporated into one code and embodied in the rules of the Supreme Court (O. xvi. rr. 22-31). Now any person may be admitted to sue as a pauper, on proof that he is not worth £25, his wearing apparel and the subject matter of the cause or matter excepted. He must lay his case before counsel for opinion, and counsel’s opinion thereon, with an affidavit of the party suing that the case contains a full and true statement of all the material facts to the best of his knowledge and belief, must be produced before the proper officers to whom the application is made. A person who desires to defend as a pauper must enter an appearance to a writ in the ordinary way and afterwards apply for an order to defend as a pauper. Where a person is admitted to sue or defend as a pauper, counsel and solicitor may be assigned to him, and such counsel and solicitor are not at liberty to refuse assistance unless there is some good reason for refusing. If any person admitted to sue or defend as a pauper agrees to pay fees to any person for the conduct of his business he will be dispaupered. Costs ordered to be paid to a pauper are taxed as in other cases. Appeals to the House of Lords *in formâ pauperis* were regulated by the Appeal (Formâ Pauperis) Act 1893, which gave the House of Lords power to refuse a petition for leave to sue.

INFORMATION (from Lat. *informare*, to give shape or form to, to represent, describe), the communication of knowledge; in English law, a proceeding on behalf of the crown against a subject otherwise than by indictment. A criminal information is a proceeding in the King’s bench by the attorney-general without the intervention of a grand jury. The attorney-general, or, in his absence, the solicitor-general, has a right *ex officio* to file a criminal information in respect of any indictments, but not for treason, felonies or misprision of treason. It is, however, seldom exercised, except in cases which might be described as “enormous misdemeanours,” such as those peculiarly tending to disturb or endanger the king’s government, *e.g.* seditions, obstructing the king’s officers in the execution of their duties, &c. In the form of the proceedings the attorney-general is said to “come into the court of our lord the king before the king himself at Westminster, and gives the court there to understand and be informed that, &c.” Then follows the statement of the offence as in an indictment. The information is filed in the crown office without the leave of the court. An information may also be filed at the instance of a private prosecutor for misdemeanours not affecting the government, but being peculiarly flagrant and pernicious. Thus criminal informations have been granted for bribing or attempting to bribe public functionaries, and for aggravated libels on public or private persons. Leave to file an information is obtained after an application to show cause, founded on a sworn statement of the material facts of the case.

Certain suits might also be filed in Chancery by way of information in the name of the attorney-general, but this species of information was superseded by Order 1, rule 1 of the Rules of the Supreme Court, 1883, under which they are instituted in the ordinary way. Informations in the Court of Exchequer in revenue cases, also filed by the attorney-general, are still resorted to (see *A.-G.* v. *Williamson*, 1889, 60 L.T. 930).

INFORMER, in a general sense, one who communicates information. The term is applied to a person who prosecutes in any of the courts of law those who break any law or penal statute. Such a person is called a common informer when he furnishes evidence on criminal trials or prosecutes for breaches of penal laws solely for the purpose of obtaining the penalty recovered, or a share of it. An action by a common informer is termed a *popular* or *qui tam* action, because it is brought by a person *qui tam pro domino rege quam pro se ipso sequitur*. A suit by an informer must be brought within a year of the offence, unless a specific time is prescribed by the statute. The term informer is also used of an accomplice in crime who turns what is called “king’s evidence” (see Accomplice). In Scotland, informer is the term applied to the party who, in criminal proceedings, sets the lord advocate in motion.

INFUSORIA, the name given by Bütschli (following O.F. Ledermüller, 1763) to a group of Protozoa. The name arose from the procedure adopted by the older microscopists to obtain animalcules. Infusions of most varied organic substances were prepared (hay and pepper being perhaps the favourite ones), the method of obtaining them including maceration and decoction, as well as infusion in the strict sense; they were then allowed to decompose in the air, so that various living beings developed therein. As classified by C. G. Ehrenberg in his monumental *Infusionstierchen als volkommene Organismen*, they included (1) Desmids, Diatoms and Schizomycetes, now regarded as essentially Plant

Protista or Protophytes; (2) Sarcodina (excluding Foraminifera, as well as Radiolaria, which were only as yet known by their skeletons, and termed Polycystina), and (3) Rotifers, as well as (4) Flagellates and Infusoria in our present sense. F. Dujardin in his *Histoire des zoophytes* (1841) gave nearly as liberal an interpretation to the name; while C. T. Van Siebold (1845) narrowed it to its present limits save for the admission of several Flagellate families. O. Bütschli limited the group by removing the Flagellata, Dinoflagellata and Cystoflagellata (*q.v.*) under the name of "Mastigophora" proposed earlier by R. M. Diesing (1865). We now define it thus:—Protozoa bounded by a permanent plasmic pellicle and consequently of definite form, never using pseudopodia for locomotion or ingestion, provided (at least in the young state) with numerous cilia or organs derived from cilia and equipped with a double nuclear apparatus: the larger (mega-) nucleus usually dividing by constriction, and disappearing during conjugation: the smaller (micro-) nucleus (sometimes multiple) dividing by mitosis, and entering into conjugation and giving rise to the cycle of nuclei both large and small of the race succeeding conjugation.

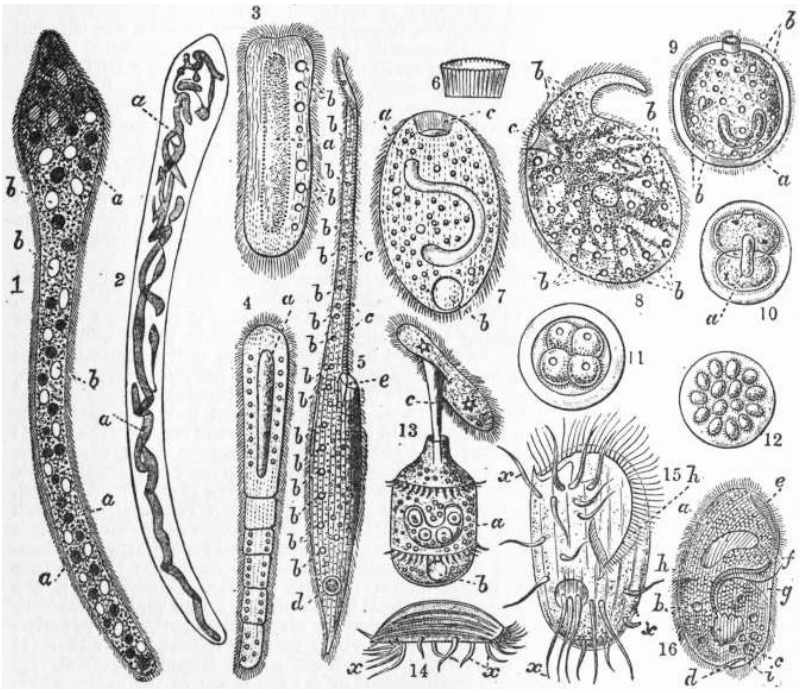


FIG. i. Ciliata.

1. *Opalinopsis sepiolae*, Foett.: a parasitic Holotrichous mouthless Ciliate from the liver of the Squid. *a*, branched meganucleus; *b*, vacuoles (non-contractile).
2. A similar specimen treated with picrocarmine, showing a remarkably branched and twisted meganucleus (*a*), in place of several nuclei.
3. *Anoplophrya naidos*, Duj.; a mouthless Holotrichous Ciliate parasitic in the worm Nais. *a*, the large axial meganucleus; *b*, contractile vacuoles.
4. *Anoplophrya prolifera*, C. and L.; from the intestine of *Clitellio*. Remarkable for the adhesion of incomplete fission-products in a metameric series. *a*, meganucleus.
5. *Amphileptus gigas*, C. and L. (Gymnostomaceae). *b*, contractile vacuoles; *c*, trichocysts (see fig. 2); *d*, meganucleus; *e*. pharynx.
6, 7. *Prorodon niveus*, Ehr. (Gymnostomaceae). *a*, meganucleus; *b*, contractile vacuole; *c*, pharynx with horny cuticular lining.
6. The fasciculate cuticle of the pharynx isolated.
8. *Trachelius ovum*, Ehr. (Gymnostomaceae); showing the reticulate arrangement of the endosarc, *b*, contractile vacuoles; *c*, the cuticle-lined pharynx.
9, 10, 11, 12. *Icthyophthirius multifilius*, Fouquet (Gymnostomaceae). Free individual and successive stages of division to form spores. *a*, meganucleus; *b*, contractile vacuoles.
13. *Didinium nasutum*, Müll. (Gymnostomaceae). The pharynx is everted and has seized a *Paramecium* as food. *a*, meganucleus; *b*, contractile vacuole; *c*, everted pharynx.
14. *Euplotes charon*, Müll. (Hypotrichaceae); lateral view of the animal when using its great cirrhi, *x*, as ambulatory organs.
15. *Euplotes harpa*, Stein (Hypotrichaceae); *h*, mouth; *x*, cirrhi.
16. *Nyctotherus cordiformis*, Stein (a Heterotriceae), parasitic in the intestine of the Frog; *a*, meganucleus; *b*, contractile vacuole; *c*, food particle; *d*, anus; *e*, heterotrichous band of membranelles; *f*, *g*, mouth; *h*, pharynx; *i*, small cilia.

Thus defined, the Infusoria fall into two groups:—(1) *Ciliata*, with cilia or organs derived from cilia throughout their lives, provided with a single permanent mouth (absent in the parasitic *Opalinopsidae*) flush with the body or at the base of an oral depression, and taking in food by active swallowing or by ciliary action: (2) *Suctoria*, rarely ciliated except in the young state, and taking in their food by suction through protrusible hollow tentacles, usually numerous.

The pellicle of the Infusoria is stronger and more permanent than in many Protozoa, and sometimes assumes the character of a mail of hard plates, closely fitting; but even in this case it undergoes solution soon after death. It is continuous with a firm ectosarc, highly differentiated in the Ciliata, and in both groups free from coarse movable granules. The endosarc is semifluid and rich in granules mostly "reserve" in nature, often showing proteid or fat reactions. One or more contractile vacuoles are present in some of the marine and all the freshwater species, and open to the surface by pores of permanent position: a system of canals in the deeper layers of the ectoplasm is sometimes connected with the vacucle. The body is often provided with not-living external formations "stalk" and "theca" (or "lorica").

The character of the nuclear apparatus excludes two groups both parasitic and mouthless: (1) the Trichonymphidae, with a single nucleus of Leidy, parasitic in Insects, especially Termites; (2) the Opalinidae, with several (often numerous) uniform nuclei, parasitic in the gut of Batrachia, &c., and producing 1-nuclear zoospores which conjugate.

Both these families we unite into a group of Pseudociliata, which may be referred to the *Flagellata* (*q.v.*). Lankester in the last edition of this Encyclopaedia called attention to the doubtful position of *Opalina*, and Delage and Hérouard placed Trichonymphidae among Flagellates.

The theca or shell is present in some pelagic species (fig. iii. 3, 5) and in many of the attached species, notably among the Peritricha (fig. iii. 21, 22, 25, 26) and Suctoria (fig. viii. 11); and is found in some free-swimming forms (fig. iii. 3, 5): it is usually chitinous, and forms a cup into which the animal, protruded when at its utmost elongation, can retract itself. In *Metacineta mystacina* it has several distinct slits (pylomes) for the passage of tufts of tentacles. In *Stentor* it is gelatinous; and in the Dictyocystids it is beautifully latticed.

The stalk is usually solid, and expanded at the base into a disk in Suctoria. In Peritrichaceae (fig. iii. 8-22, 25, 26), the only ciliate group with a stalk, it grows for some time after its formation, and on fission two new stalks continue the old one, so as to form a branched colony (fig. iii. 18). In *Vorticella* (fig. iii. 11, 12, 14, &c.) the stalk is hollow and elastic, and attached to it along a spiral is a prolongation of the ectosarc containing a bundle of myonemes, so that by the contractions of the bundle the stalk is pulled down into a corkscrew spiral, and on the relaxation of the muscle the elasticity of the hollow stalk straightens it out.

On fission the stalk may become branched, as the solid one of *Epistylis* and *Opercularia* (fig. iii. 20); and the myoneme also in the tubular stem of *Zoothaminum*; or the branch-myoneme for the one offspring may be inserted laterally on that for the other in *Carchesium* (fig. iii. 18). In several tubicolous Peritrichaceae there is some arrangement for closing their tubes. In *Thuricola* (fig. iii. 25-26) there is a valve which opens by the pressure of the animal on its protrusion, and closes automatically by elasticity on retraction. In *Lagenophrys* the animal adheres to the cup a little below the opening, so that its withdrawal closes the cup: at the adherent part the body mass is hardened, and so differentiated as to suggest the frame of the mouth of a purse. In *Pyxicola* (fig. iii. 21-22) the animal bears some way down the body a hardened shield (“operculum”) which closes the mouth of the shell on retraction.

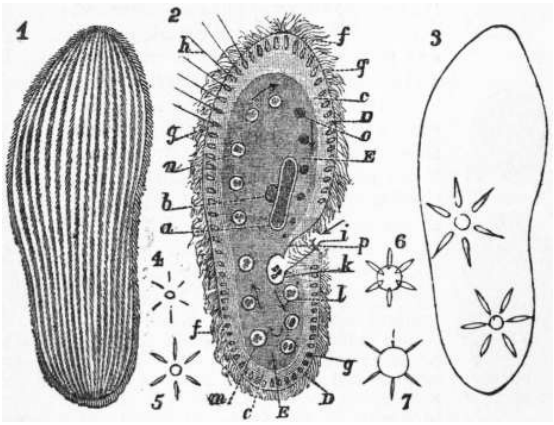


Fig. ii.

1, Surface view of *Paramecium*, showing the disposition of the cilia in longitudinal rows.

2, *a*, mega-; *b*, micronucleus; *c*, junction of ecto- and endosarc; *D*, pellicle; *E*, endosarc; *f*, cilia (much too numerous and crowded); *g*, trichocysts; *g′*, same with thread; *h*, discharged; *i*, pharynx, its undulating membrane not shown; *k*, food granules collecting into a bolus; *l*, *m*, *n*, *o*, food vacuoles, their contents being digested as they pass in the endosarc along the path indicated by the arrows.

3, Outline showing contractile vacuoles in commencing diastole, surrounded by five afferent canals.

4-7 Successive stages of diastole of contractile vacuole.

The cytoplasm of the Infusoria is very susceptible to injuries; and when cut or torn, unless the pellicle contracts rapidly to enclose the wounded surface, the substance of the body swells up, becoming frothy, with bubbles which rapidly enlarge and finally burst; the cell thus disintegrates, leaving only a few granules to mark where it was. This phenomenon, observed by Dujardin, is called “diffluence.” The contractile vacuole appears to be one of the means by which diffluence is avoided in cells with no strong wall to resist the absorption of water in excess; for after growing in size for some time, its walls contract suddenly, and its contents are expelled to the outside by a pore, which is, like the anus, usually invisible, but permanent in position. The contractile vacuole may be single or multiple; it may receive the contents of a canal, or of a system of canals, which only become visible at the moment of the contraction of the vacuole (fig. ii. 4-7), giving liquid time to accumulate in them, or when the vacuole is acting sluggishly or imperfectly, as in the approach of asphyxia (fig. ii. 3). Besides this function, since the system passes a large quantity of water from without through the substance of the cell, it must needs act as a means of respiration and excretion. In all Peritrichaceae it opens to the vestibule, and in some of them it discharges through an intervening reservoir, curiously recalling the arrangements in the Flagellate Euglenaceae.

The nuclear apparatus consists of two parts, the meganucleus, and the micronucleus or micronuclei (fig. iii. 17*d*, iv. 1). The meganucleus alone regarded and described as “the nucleus” by older observers is always single, subject to a few reservations. It is most frequently oval, and then is indented by the micronucleus; but it may be lobed, the lobes lying far apart and connected by a slender bridge or moniliform, or horseshoe-shaped (Peritrichaceae). It often contains darker inclusions, like nucleoles.

It has been shown, more especially by Gruber, that many Ciliata are multinucleate, and do not possess merely a single meganucleus and a micronucleus. In *Oxytricha* the nuclei are large and numerous (about forty), scattered through the protoplasm, whilst in other cases the nucleus is so finely divided as to appear like a powder diffused uniformly through the medullary protoplasm (*Trachelocerca*). Carmine staining, after treatment with absolute alcohol, has led to this

remarkable discovery. The condition described by Foettinger in his *Opalinopsis* (fig. i. 1, 2) is an example of this pulverization of the nucleus. The condition of pulverization had led in some cases to a total failure to detect any nucleus in the living animal, and it was only by the use of reagents that the actual state of the case was revealed. Before fission, whatever be its habitual character, it condenses, becomes oval, and divides by constriction; and though it usually is then fibrillated, only in a few cases does it approach the typical mitotic condition. The micronucleus described by older writers as the “nucleolus” or “paranucleus” (“endoplastule” of Huxley), may be single or multiple. When the meganucleus is bilobed there are always two micronuclei, and at least one is found next to every enlargement of the moniliform meganucleus. In the fission of the Infusoria, every micronucleus divides by a true mitotic process, during which, however, its wall remains intact. From their relative sizes the meganucleus would appear to discharge during cell-life, exclusively, the functions of the nucleus in ordinary cells. Since in conjugation, however, the meganucleus degenerates and is in great part either digested or excreted as waste matter, while the new nuclear apparatus in both exconjugates arises, as we shall see, from a conjugation-nucleus of exclusively micronuclear origin, we infer that the micronucleus has for its function the carrying on of the nuclear functions of the race from one fission cycle to the next from which the meganucleus is excluded.

Fission is the ordinary mode of reproduction in the Infusoria, and is usually transverse, but oblique in *Stentor*, &., as in Flagellata, longitudinal in Peritrichaceae; in some cases it is always more or less unequal owing to the differentiation of the body, and consequently it must be followed by a regeneration of the missing organs in either daughter-cell. In some cases it becomes very uneven, affording every transition to budding, which process assumes especial importance in the Suctoria. Multiple fission (brood-formation or sporulation) is exceptional in Infusoria, and when it occurs the broods rarely exceed four or eight—another difference from Flagellata. The nuclear processes during conjugation suggest the phylogenetic loss of a process of multiple fission into active gametes. As noted, in fission the meganucleus divides by direct constriction; each micronucleus by a mode of mitosis. The process of fission is subject in its activity to the influences of nutrition and temperature, slackening as the food supply becomes inadequate or as the temperature recedes from the optimum for the process. Moreover, if the descendants of a single animal be raised, it is found that the rapidity of fission, other conditions being the same, varies periodically, undergoing periods of depression, which may be followed by either (1) spontaneous recovery, (2) recovery under stimulating food, (3) recovery through conjugation, or (4) the death of the cycle, which would have ensued if 2 or 3 had been omitted at an earlier stage, but which ultimately seems inevitable, even the induction of conjugation failing to restore it. These physiological conditions were first studied by E. Maupas, librarian to the city of Algiers, in his pioneering work in the later ’eighties, and have been confirmed and extended by later observers, among whom we may especially cite G. N. Calkins.

Syngamy, usually termed conjugation or “karyogamy,” is of exceptional character in the majority of this group—the Peritrichaceae alone evincing an approximation to the usual typical process of the permanent fusion of two cells (pairing-cells or gametes), cytoplasm to cytoplasm, nucleus to nucleus, to form a new cell (coupled cell, zygote).

This process was elucidated by E. Maupas in 1889, and his results, eagerly questioned and repeatedly tested, have been confirmed in every fact and in every generalization of importance.

Previously all that had been definitely made out was that under certain undetermined conditions a fit of pairing two and two occurred among the animals of the same species in a culture or in a locality in the open; that after a union prolonged over hours, and sometimes even days, the mates separated; that during the union the meganucleus underwent changes of a degenerative character; and that the micronucleus underwent repeated divisions, and that from the offspring of the micronuclei the new nuclear apparatus was evolved for each mate. Maupas discovered the biological conditions leading to conjugation: (1) the presence of individuals belonging to distinct stocks; (2) their belonging to a generation sufficiently removed from previous conjugation, but not too far removed therefrom; (3) a deficiency of food. He also showed that during conjugation a “migratory” nucleus, the offspring of the divisions of the micronucleus, passes from either mate to the other, while its sister nucleus remains “stationary”; and that reciprocal fusion of the migratory nucleus of the one mate with the stationary nucleus of the other takes place to form a zygote nucleus in either mate; and that from these zygote nuclei in each by division, at least two nuclei are formed, the one of which enlarges to form a meganucleus, while the other remains small as the first micronucleus of the new reorganized animal, which now separates as an “exconjugate” (fig. iv). Moreover, if pairing be prevented, or be not induced, the individuals produced by successive fissions become gradually weaker, their nuclear apparatus degenerates, and finally they cannot be induced under suitable conditions to pair normally, so that the cycle becomes extinct by senile decay. In Peritrichaceae the gametes are of unequal sizes (fig. iii. 11, 12), the smaller being formed by brood fissions (4 or 8); syngamy is here permanent, not temporary, the smaller (male) being absorbed into the body of the larger (female); and there are only two nuclei that pair. Thus we have a derived binary sexual process, comparable to that of ordinary bisexual organisms.

FIG. iii.— Ciliata: 1, 2, Heterotrichaceae; 3-7, 23-24, Oligotrichaceae; 8-22, 25, 26, Peritrichaceae.

1, *Spirostomum ambiguum*, Ehr.; on its left side oral groove and wreath of membranellae; a, moniliform meganucleus; b, position of contractile vacuole.

2, Group of *Stentor polymorphus*, O. F. Müller; the twisted end of the peristome indicating the position of the mouth.

3, *Tintinnus lagenula*, Cl. and L., in free shell.

4, *Strombidium claparedii*, S. Kent.

5, Shell of *Codonella campanella*, Haeck.

6, 7, *Torquatella typica*, Lank. (= *Strombidium* according to Bütschli); *p*, oral tube seen through peristomial wreath of apparently coalescent membranellae.

8. Basal, and 9, side (inverted) views of *Trichodina pediculus*, Ehr.; *a*, meganucleus; *c*, basal collar and ring of hooks; *d*, mouth; contractile vacuole and oral tube seen by transparency in 8.

10, *Spirochona gammipara*, Stein; *a*, meganucleus; *g*, bud.

11, 12, *Vorticella microstoma*, Ehr.; *d*, formation of a brood

14, *V. nebulifera*, Ehr.; bud swimming away by posterior wreath, peristome contracted; e, peristomial disk; f, oral tube.

15, *V. microstoma*; *b*, contr. vacuole; *c*, *d*, two microgametes seeking to conjugate.

16, *V. nebulifera*, contracted, with body encysted.

17, Same sp. enlarged; *c*, myonemes converging posteriorly to muscle of stalk; *d*, micronucleus.

18, *Carchesium spectabile*, Ehr.; (×50).

19, Nematocysts of *Epistylis flavicans*. Ehr. (after Greeff).

20, *Opercularia stenostoma*, St.; (×200); a small colony showing upstanding ("opercular") peristomial disk, protruded oral undulating membranejand cilia in oral tube.

21, 22, *Pyxicola affinis*, S.K., with stalk and theca; *x*, chitinous disk, or true "operculum" closing theca in retracted state.

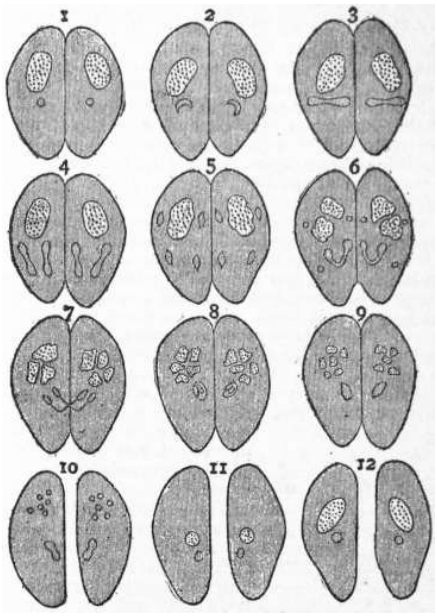
23, 24, *Caenomorpha medusula*, Perty, (×250), with spiral peristomial wreath.

25, 26, *Thuricola valvata*, Str.

of 8 microgametes *c* by multiple fission; *b*, contr. vacuole.

13, Same sp. in binary fission; *a*, meganucleus.

Wright, in sessile theca, with internal valve (*v*) to close tube, as in gastropod *Clausilia*; owing to recent fission two animals occupy one tube.



From Lankester's *Treatise on Zoology*.

FIG. iv.—Diagrammatic Sketch of Changes during Conjugation in Ciliata. (From Hickson after Delage and Maupas.)

1, Two individuals at commencement of conjugation showing meganucleus (dotted) and micronucleus; successive stages of the disintegration of the meganucleus shown in all figures up to 9.

2, 3, First mitotic division of micronuclei.

4, 5, Second ditto.

6, One of the four nuclei resulting from the second division again dividing to form the pairing-nuclei in either mate, while the other 3 nuclei degenerate.

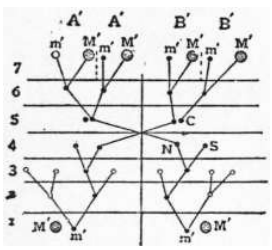
7, Migration of the migratory nuclei.

8, 9, Fusion of the incoming migratory with the stationary nucleus in either mate.

10, Fission of Zygote nucleus into two, the new mega- and micronucleus whose differentiation is shown in 11, 12. The vertical dotted line indicates the separation of the mates.

CILIATA.—The *Ciliate* Infusoria represent the highest type of Protozoa. They are distinctly animal in function, and the Gymnostomaceae are active predaceous beings preying on other Infusoria or Flagellates. Some possess shells (fig. iii. 3, 5, 21, 22, 25, 26), most have a distinct swallowing apparatus, and in *Dysteria* there is a complex jaw—or tooth-apparatus, which needs new investigation. In the active Ciliata we find locomotive organs of most varied kinds: tail-springs, cirrhi for crawling and darting, cilia and membranellae for continuous swimming in the open or gliding over surfaces or waltzing on the substratum (*Trichodina*, fig. iii. 8) or for eddying in wild turns through the water (*Strombidium*, *Tintinnus*, *Halteria*). Their forms offer a most interesting variety, and the flexibility of many adds to their easy grace of movement, especially where the front of the body is produced and elongated like the neck of a swan (*Amphileptus*, fig. iii. 5; *Lacrymaria*).

The cytoplasm is very highly differentiated: especially the ectoplasm or ectosarc. This has always a distinct elastic "pellicle" or limiting layer, in a few cases hard, or even with local hardenings that affect the disposition of a coat of mail (*Coleps*) or a pair of valves (*Dysteria*); but is usually only marked into a rhomboidal network by intersecting depressions, with the cilia occupying the centres of the areas or meshes defined. The cytoplasm within is distinctly alveolated, and frequently contains tubular alveoli running along the length of the animal. Between these are dense fibrous thickenings, which from their double refraction, from their arrangement, and from their shortening in contracted animals are regarded as of muscular function and termed "myonemes." Other threads running alongside of these, and not shortening but becoming wavy in the general contraction have been described in a few species as "neuronemes" and as possessing a *nervous*, conducting character. On this level, too, lie the dot-like granules at the bases of the cilia, which form definite groups in the case of such organs as are composed of fused cilia; in the deeper part of the ectoplasm the vacuoles or alveoli are more numerous, and reserve granules are also found; here too exist the canals, sometimes developed into a complex



From Lankester's *Treatise on Zoology*.

FIG. v.—Diagram 1 illustrating changes during conjugation of *Colpidium colpoda*. (From Hickson, after Maupas.)

network, which open into the contractile vacuole.

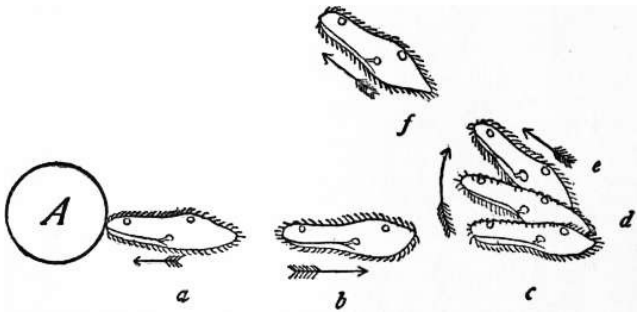
The cilia themselves have a stiffer basal part, probably strengthened by an axial rod, and a distal flexible lash; when cilia are united by the outer plasmatic layer, they form (1) “Cirrhi,” stiff and either hook-like and pointed at the end, or brush-like, with a frayed apex; (2) membranelles, flattened organs composed of a number of cilia fused side by side, sometimes on a single row, sometimes on two rows approximated at either end so as to form a narrow oval, the membranelle thus being hollow; (3) the oral “undulating membrane,” merely a very elongated membranelle whose base may extend over a length nearly equal to the length of the animal; such membranes are present in the mouth oral depression and pharynx of all but Gymnostomaceae, and aid in ingestion; a second or third may be present, and behave like active lips; (4) in Peritrichaceae the cilia of the peristomial wreath are united below into a continuous undulating membrane, forming a spiral of more than one turn, and fray out distally into a fringe; (5) the dorsal cilia of Hypotrichaceae are slender and motionless, probably sensory.

M, Old meganucleus undergoing disintegration.
m, Micronucleus.
N, migratory, and
S, Stationary pairing-nucleus.
M′, M′, the new meganuclei, and
m′, The new micronuclei in the products of the first fission of each of the exconjugates; the continuous vertical line indicates period of fusion, its cessation, separation; dotted lines indicate fission; the spaces lettered 1-7 successive stages in the process; the clear circles indicate functionless nuclei which degenerate.

Embedded in the ectosarc of many Ciliates are trichocysts, little elongated sacs at right angles to the surface, with a fine hair-like process projecting. On irritation these elongate into strong prominent threads, often with a more or less barb-like head, and may be ejected altogether from the body. Those over the surface of the body appear to be protective; but in the Gymnostomaceae specially strong ones surround the mouth. They can be injected into the prey pursued, and appear to have a distinctly poisonous effect on it. They are combined also into defensive batteries in the Gymnostome *Loxophyllum*. They are absent from most Heterotrichaceae and Hypotrichaceae, and from Peritrichaceae, except for a zone round the collar of the peristome.

The openings of the body are the *mouth*, absent in a few parasital species (*Opalinopsis*, fig. i. 1, 2), the *anus* and the *pore* of the contractile vacuole. The *mouth* is easily recognizable; in the most primitive forms of the Gymnostomaceae and some other groups, it is terminal, but it passes further and further back in more modified species, thereby defining a ventral, and correspondingly a dorsal surface; it usually lies on the left side. The anus is usually only visible during excretion, though its position is permanent; in a few genera it is always visible (*e.g. Nyctotherus*, fig. i. 16). The pore of the contractile vacuole might be described in the same terms.

The endoplasm has also an alveolar structure, and contains besides large food-vacuoles or digestive vacuoles, and shows movements of rotation within the ectoplasm, from which, however, it is not usually distinctly bounded. In *Ophryoscolex* and *Didinium* (fig. i. 13) a permanent cavity traverses it from mouth to anus.



From Calkins’ *Protozoa*, by permission of the Macmillan Company, N.Y.

Fig. vi.—Diagrammatic view of behaviour of the motile reaction of Paramecium after meeting a mechanical obstruction at A. (From G. N. Calkins after H. S. Jennings.) For clearness and simplicity the normal motion is supposed to be straight instead of spiral.

Ingestion of food is of the same character in all the Hymenostomata. The ciliary current drives a powerful stream into the mouth, which impinges against the endosarc, carrying with it the food particles; these adhere and accumulate to form a pellet, which ultimately is pushed by an apparently sudden action into the substance of the endosarc which closes behind it (fig. ii. 2). In some of the Aspirotrichaceae accessory undulating membranes play the part of lips, and there is a closer approximation to true deglutition. The mouth is rarely terminal, more frequently at the bottom of a depression, the “vestibule,” which may be prolonged into a slender canal, sometimes called the “pharynx” or “oral tube,” ciliated as well as provided with a membrane, and extending deep down into the body in many Peritrichaceae.

In Spirostomaceae the “adoral wreath” of membranelles encloses more or less completely an anterior part of the body, the “peristome,” within which lies the vestibule. This area may be depressed, truncate, convex or produced into a short obconical disk or into one or more lobes, or finally form a funnel, or a twisted spiral like a paper cone. In most Peritrichaceae a collar-like rim surrounds the peristome, and marks out a gutter from which the vestibule opens; the peristome can be retracted, and the collar close over it. This rim forms a deep permanent spiral funnel in *Spirochona* (fig. iii. 10).

Movements of Ciliata.—H. S. Jennings has made a very detailed study of these movements, which resemble those of most minute free-swimming organisms. The following account applies practically to all active “Infusoria” in the widest sense.

The position of the free-swimming Infusoria, like that of Rotifers and other small swimming animals, is with the front end of the body inclined outward to the axis of advance, constantly changing its azimuth while preserving its angle constant or nearly so; if advance were ignored the body would thus rotate so as to trace out a cone, with the hinder end at the apex, and the front describing the base. On any irritation, (1) the motion is arrested, (2) the animal reverses its cilia and swims backwards, (3) it swerves outwards away from the axis so as to make a larger angle with it, and (4) then swims forwards along a new axis of progression, to which it is inclined at the same angle as to the previous axis (figs. vi., vii.). In this way it alters its axis of progression when it finds itself under conditions of stimulation. Thus a *Paramecium* coming into a region relatively too cold, too hot, or too poor in CO_2 or in nutriment, alters its direction of swimming; in this way individuals come to assemble in crowds where food is abundant, or even where there is a slight

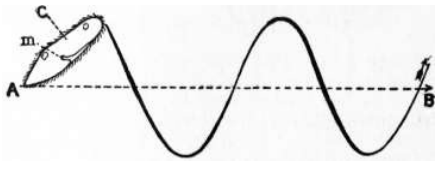


Fig. vii.—Diagram of a mode of progression of a Ciliate like *Paramecium*; *m*, mouth and pharynx; the straight line A, B, represents the axis of progression described by the posterior end, and the spiral line the curve described by the anterior end; the clear circles are the contractile vacuoles on the dorsal side.

excess of CO_2. This reaction may lead to fatal results; if a solution of corrosive sublimate (Mercuric chloride) diffuses towards the hinder end of the animal faster than it progresses, the stimulus affecting the hinder end first, the axis of progression is altered so as to bring the animal after a few changes into a region where the solution is strong enough to kill it. This "motile reaction," first noted by H. S. Jennings, is the explanation of the general reactions of minute swimming animals to most stimuli of whatever character, including light; the practical working out is, as he terms it, a method of "trial and error." The action, however, of a current of electricity is distinctly and immediately directive; but such a stimulus is not to be found in nature. The motile reaction in the Hypotrichaceae which crawl or dart in a straight line is somewhat different, the swerve being a simple turn to the right hand—*i.e.* away from the mouth.

Parasitism in the Infusoria is by no means so important as among Flagellates. *Ichthyophthirius* alone causes epidemics among Fishes, and *Balantidium coli* has been observed in intestinal disease in Man. The Isotricheae, among Aspirotrichaceae and the Ophryoscolecidae among Heterotrichaceae are found in abundance in the stomachs of Ruminants, and are believed to play a part in the digestion of cellulose, and thus to be rather commensals than parasites. A large number of attached species are epizoic commensals, some very indifferent in choice of their host, others particular not only in the species they infest, but also in the special organs to which they adhere. This is notably the case with the shelled Peritrichaceae. *Lichnophora* and *Trichodina* (fig. iii. 8, 9) among Peritrichaceae are capable of locomotion by their permanent posterior wreath or of attaching themselves by the sucker which surrounds it; *Kerona polyporum* glides habitually over the body of Hydra, as does *Trichodina pediculus*.

Several Suctoria are endoparasitic in Ciliata, and their occurrence led to the view that they represented stages in the life-history of these. Again, we find in the endosarc of certain Ciliates green nucleated cells, which have a cellulose envelope and multiply by fission inside or outside the animal. They are symbiotic Algae, or possibly the resting state of a Chlamydomonadine Flagellate (*Carteria*?), and have received the name *Zoochlorella*. They are of constant occurrence in *Paramecium bursaria*, frequent in *Stentor polymorphus* and *S. igneus*, and *Ophrydium versatile*, and a few other species, which become infected by swallowing them.

Classification.

Order I.—Section A.—Gymnostomaceae. Mouth habitually closed; swallowing an active process; cilia (or membranelles) uniform, usually distributed evenly over the body; form variable, sometimes of circular transverse section.

Section B.—Trichostomata. Mouth permanently open against the endosarc, provided with 1 or 2 undulating membranes often prolonged into an inturned pharynx; ingestion by action of oral ciliary apparatus.

Order 2.—Subsection (*a*).—Aspirotrichaceae. Cilia nearly uniform, not associated with cirrhi or membranelles, nor forming a peristomial wreath. Form usually flattened, mouth unilateral. (N.B.—Orders 1, 2 are sometimes united into the single order Holotrichaceae.)

Subsection (*b*).—Spirotricha. Wreath of distinct membranelles—or of cilia fused at the base—enclosing a peristomial area and leading into the mouth.

§§ i.—Wreath of separate membranelles.

Order 3.—Heterotrichaceae; body covered with fine uniform cilia, usually circular in transverse section.

Order 4.—Oligotrichaceae; body covering partial or wholly absent; transverse section usually circular.

Order 5.—Hypotrichaceae; body flattened; body cilia represented chiefly by stiff cirrhi in ventral rows, and fine motionless dorsal sensory hairs.

Order 6.—§§ ii.—Peritrichaceae. Peristomial ciliary wreath, spiral, of cilia united at the base; posterior wreath circular of long membranelles; body circular in section, cylindrical, taper, or bell-shaped.

Illustrative Genera (*selected*).

1. Gymnostomaceae. (*a*) Ciliation general or not confined to one surface. *Coleps* Ehr., with pellicle locally hardened into mailed plates; *Trachelocerca* Ehr.; *Prorodon* Ehr. (fig. i. 6, 7); *Trachelius* Ehr., with branching endosarc (fig. i. 8); *Lacrymaria* Ehr. (fig. i. 5), body produced into a long neck with terminal mouth surrounded by offensive trichocysts; *Dileptus* Duj., of similar form, but anterior process, blind, preoral; *Ichthyophthirius* Fouquet (fig. i. 9-12), cilia represented by two girdles of membranellae; *Didinium* St. (fig. i. 13), cilia in tufts, surface with numerous tentacles each with a strong terminal trichocyst; *Actinobolus* Stein, body with one adoral tentacle; Ileonema Stokes. (*b*) Cilia confined to dorsal surface. *Chilodon* Ehr.; *Loxodes* Ehr., body flattened, ciliated on one side only, endosarc as in *Trachelius*; *Dysteria* Huxley, with the dorsal surface hardened and hinged along the median line into a bivalve shell, ciliated only on ventral surface, with a protrusible foot-like process, and a complex pharyngeal armature. (*c*) Cilia restricted to a single equatorial girdle, strong (probably membranelles); *Mesodinium*, mouth 4-lobed.

2. Aspirotrichaceae. *Paramecium* Hill (fig. ii. 1-3); *Ophryoglena* Ehr.; *Colpoda* O. F. Müller; *Colpidium* St.; *Lembus* Cohn, with posterior strong cilium for springing; *Leucophrys* St.; *Urocentrum* Nitsch, bare, with polar and equatorial zones and a posterior tuft of long cilia; *Opalinopsis* Foetlinger (fig. i. 1, 2); *Anoplophyra* St. (fig. i. 3, 4). (The last two parasitic mouthless genera are placed here doubtfully.)

3. Heterotrichaceae. (*a*) Wreath spiral; *Stentor* Oken. (fig. iii. 2), oval when free, trumpet-shaped when attached by pseudopods at apex, and then often secreting a gelatinous tube; *Blepharisma* Perty, sometimes parasitic in Heliozoa; *Spirostomum* Ehr., cylindrical, up to 1″ in length; (*b*) Wreath straight, often oblique; *Nyctotherus* Leidy, parasitic anus always visible; *Balantidium* Cl. and L., parasitic (*B. coli* in man); *Bursaria*, O.F.M., hollowed into an oval pouch, with the wreath inside.

4. Oligotrichaeceae. *Tintinnus* Schranck (fig. iii. 3); *Trichodinopsis* Cl. and L.; *Codonella* Haeck. (fig. iii. 5); *Strombidium* Cl. and L. (fig. iii. 4), including *Torquatella* Lank. (fig. iii. 6, 7), according to Bütschli; *Halteria* Duj., with an equatorial girdle of stiff bristle-like cilia; *Caenomorpha* Perty (fig. iii. 23, 24); *Ophryoscolex* St., with straight digestive cavity, and visible anus, parasitic in Ruminants.

5. Hypotrichaceae. *Stylonychia* Ehr.; *Oxytricha* Ehr.; *Euplotes* Ehr. (fig. i. 14, 15); *Kerona* Ehr. (epizoic on *Hydra*).

6. Peritrichaceae. 1. Peristomial wreath projecting when expanded above a circular contractile collar-like rim.

(*a*) Fam. Urceolaridae: posterior wreath permanently present around sucker-like base. *Trichodina* Ehr. (fig. iii. 8, 9), epizoic on Hydra; *Lichnophora* Cl. and L.; *Cyclochaeta* Hatchett Jackson; *Gerda* Cl. and L.; *Scyphidia* Duj.

(*b*) Fam. Vorticellidae = Bell Animalcules: posterior wreath temporarily present, shed after fixation.

Subfam. 1. Vorticellinae animals naked. (i.) Solitary; *Vorticella* Linn. (fig. iii. 11-17), stalk hollow with spiral muscle; *Pyxidium* S. Kent, stalk non-contractile. (ii.) Forming colonies by budding on a branched stalk: *Carchesium* Ehr., hollow branches and muscles discontinuous; *Zoothamnium*. Ehr., branched hollow stem and muscle continuous through colony;

Epistylis Ehr., stalk rigid—(the animal body in these three genera has the same characters as *Vorticella*)—*Campanella* Goldf., stalked like *Epistylis*, wreath of many turns (nematocysts sometimes present) (fig. iii. 19); *Opercularia*, stalk of *Epistylis*, disk supporting wreath obconical, collar very high (fig. iii. 20).

Subfam. 2. Vaginicolinae; body enclosed in a firm theca: *Vaginicola* Lam., shell simple, sessile; *Thuricola* St. Wright, shell sessile, with a valve opening inwards (fig. iii. 25-26); *Cothurnia* Ehr., shell stalked, simple; *Pyxicola* S. Kent, shell stalked, closed by an infraperistomial opercular thickening on the body (fig. iii. 21-22).

Subfam. 3. Shells gelatinous; those of the colony aggregated into a floating spheroidal mass several inches in diameter *Ophrydium* Bory, *O. versatile* contains *Zoochlorella*, which secretes oxygen, and the gas-bubbles float the colonies like green lumps of jelly.

2. Peristomial wreath, not protrusible, surrounded by a very high usually spiral collar.

Fam. Spirochonina. *Spirochona* St. (fig. iii. 10); *Kentrochona* Rompel; both genera epizoic on gills, &c., of small Crustacea.

Suctoria.—These are distinguished from Ciliata by their possession of hollow tentacles (one only in *Rhyncheta*, fig. viii. 1, and *Urnula*) through which they ingest food, and by not possessing cilia, except in the young stage. Fission approximately equal is very rare. Usually it is unequal, or if nearly equal one of the halves remains attached, and the other, as an embryo or gemmule, develops cilia and swims off to attach itself elsewhere; *Sphaerophrya* (fig. viii. 2-6) alone, often occurring as an endoparasite in Ciliata, may be free, tentaculate and unattached.

The ectosarc is usually provided with a firm pellicle which shows a peculiar radiate “milling” in optical section, so fine that its true nature is difficult to make out; it may be due to radial rods, regularly imbedded, or may be the expression of radial vacuoles. The tentacles vary in many respects, but are always retractile. They are tubes covered by an extension of the pellicle; this is invaginated into the body round the base of the tentacle as a sheath, and then evaginated to form the outer layer of the tentacle itself, over which it is frequently raised into a spiral ridge, which may be traced down into the part sunk and ensheathed within the body: in *Choanophrya*, where the tentacles are largest, the pellicle is further continued into the interior of the tentacle. The tentacles are always pierced by a central canal opening at the apex, which may be (1) enlarged into a terminal capitate sucker, (2) slightly flared, (3) truncate and closed in the resting state to become widely opened into a funnel, or (4) pointed. The tentacles are always capable of being waved from side to side, or turned in a definite direction for the reception or prehension of food; in *Rhyncheta*, the movements of the long single tentacle recall those of an elephant’s trunk, only they are more extensive and more varied. In the majority of cases the food consists of Ciliata; and the contents of the prey may be seen passing down the canal of the sucker beyond where it becomes free from the general surface. In *Choanophrya* the food appears to consist of the débris of the prey of the carnivorous host (*Cyclops*), which is sucked into the wide funnel-shaped mouths of the tentacles—by what mechanism is unknown. The endosarc is full of food-granules and reserve-granules (oil, colouring matter and proteid).

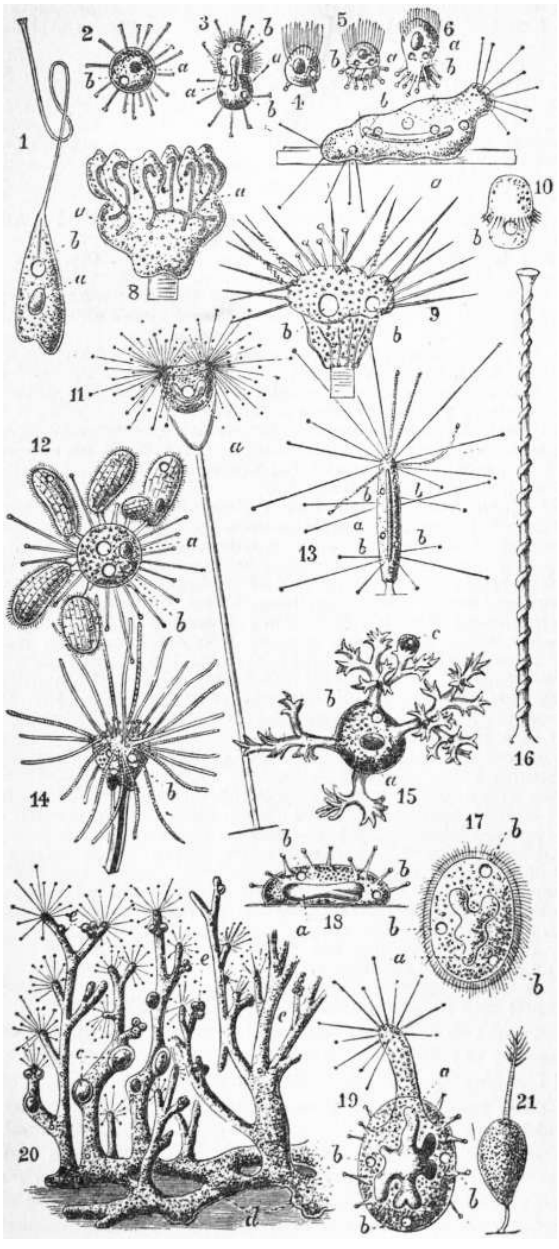
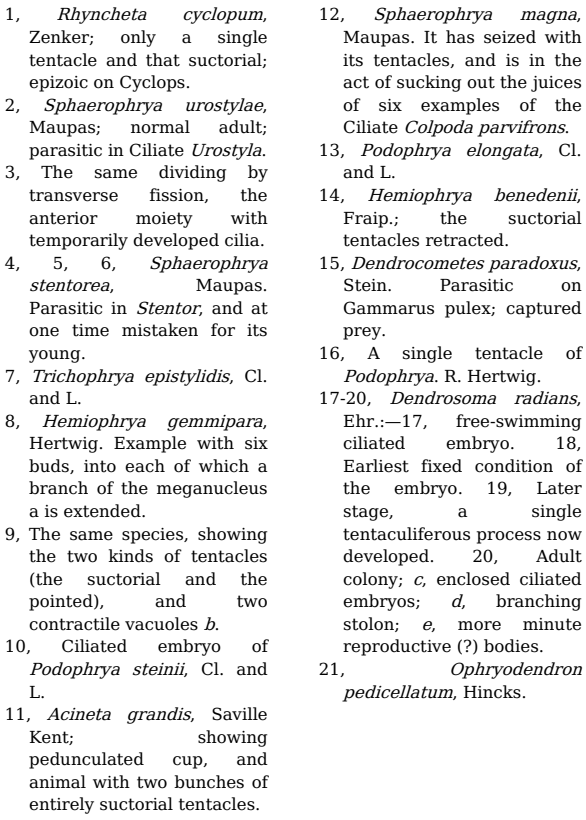


FIG. viii.—Suctoria (in all *a*, meganucleus; *b*, contractile vacuole).



1, *Rhyncheta cyclopum*, Zenker; only a single tentacle and that suctorial; epizoic on Cyclops.
2, *Sphaerophrya urostylae*, Maupas; normal adult; parasitic in Ciliate *Urostyla*.
3, The same dividing by transverse fission, the anterior moiety with temporarily developed cilia.
4, 5, 6, *Sphaerophrya stentorea*, Maupas. Parasitic in *Stentor*, and at one time mistaken for its young.
7, *Trichophrya epistylidis*, Cl. and L.
8, *Hemiophrya gemmipara*, Hertwig. Example with six buds, into each of which a branch of the meganucleus a is extended.
9, The same species, showing the two kinds of tentacles (the suctorial and the pointed), and two contractile vacuoles *b*.
10, Ciliated embryo of *Podophrya steinii*, Cl. and L.
11, *Acineta grandis*, Saville Kent; showing pedunculated cup, and animal with two bunches of entirely suctorial tentacles.
12, *Sphaerophrya magna*, Maupas. It has seized with its tentacles, and is in the act of sucking out the juices of six examples of the Ciliate *Colpoda parvifrons*.
13, *Podophrya elongata*, Cl. and L.
14, *Hemiophrya benedenii*, Fraip.; the suctorial tentacles retracted.
15, *Dendrocometes paradoxus*, Stein. Parasitic on Gammarus pulex; captured prey.
16, A single tentacle of *Podophrya*. R. Hertwig.
17-20, *Dendrosoma radians*, Ehr.:—17, free-swimming ciliated embryo. 18, Earliest fixed condition of the embryo. 19, Later stage, a single tentaculiferous process now developed. 20, Adult colony; *c*, enclosed ciliated embryos; *d*, branching stolon; *e*, more minute reproductive (?) bodies.
21, *Ophryodendron pedicellatum*, Hincks.

The meganucleus and the micronucleus are both usually single, but in *Dendrosoma* (fig. viii. 20), of which the body is branched, and the meganucleus with it, there are numerous micronuclei. In most cases the micronucleus has not been recorded, though from the similarity of conjugation, and its presence in most cases of fission and budding that have been accurately described, we may infer that it is always present. In unequal fission the meganucleus sends a process into the bud, while the micronucleus divides as in Ciliata. The bud may be nearly equal to the remains of the original animal, or much smaller, and in that case a depression surrounds it which may deepen so as to form a brood-cavity, either communicating by a mere "birth-pore" with the outside or entirely closed. In some cases the budding is multiple (fig. viii. 8), and a large number of buds are formed and liberated at the same time. In all cases the bud escapes without tentacles, and possesses a characteristic supply of cilia, whose arrangement is constant for the species.

In some cases an adult may withdraw its tentacles, moult its pellicle and develop an equipment of cilia and swim away: this is the case with *Dendrocometes*, parasitic on *Gammarus*, when its host moults.

The numerous species of Suctoria, often so abundant on various species of *Cyclops*, are not found on the other freshwater Copepoda, *Diaptomus* and *Canthocamptus*, belonging indeed to other families. Again, these Suctoria affect different positions, those found on the antennae not being present on the mouth parts; the ventral part of the thorax has another set; and the inside of the pleural fold another. *Rhyncheta* occupies the front of the "couplers" or median downgrowths uniting the coxopodites of the swimming legs, and *Choanophrya* settles in the immediate neighbourhood of the mouth, preferably on the epistoma, labrum and metastomatic region, but also on the adoral appendages and in rare cases extends, when the settlement is extensive, to the bases of the two pairs of antennae; while distinct species of *Podophrya* settle on the antennae, the front of the thorax and the inside of the pleural folds. *Dendrocometes* is common on the gills of the freshwater shrimp (Amphipod) *Gammarus* and *Stylocometes* on the gills and gill-covers of the Isopod Asellus, the water-slater. The independence of the Acinetaria was threatened by the erroneous view of Stein that they were phases in the life-history of Vorticellidae. Small parasitic forms (*Sphaerophrya*) were also regarded erroneously as the "acinetiform young" of Ciliata. They now must be regarded as an extreme modification of the Protozoon series, in which the differentiation of organs in a unicellular animal reaches its highest point.

Principal Genera.

1. Unstalked simple forms. *Urnula* Cl. and L., permanently ciliate; *Rhyncheta* Zenker (fig. viii. 1), on the limb couplers of *Cyclops*; *Sphaerophrya* Cl. and L. (fig. viii. 2-6, 12), endoparasitic in Ciliata and formerly taken for embryos thereof, never attached; *Trichophrya* Cl. and L. (fig. viii. 7), of similar habits, but temporarily attached, sessile.

2. Stalked simple forms; *Podophrya* Ehr. (fig. viii. 10, 13, 16), tentacles all knobbed or flared; *Ephelota* Strethill Wright, tentacles all pointed; *Hemiophrya* S. Kent (fig. viii. 8, 9, 14), tentacles of both kinds; *Choanophrya* Hartog, tentacles thick, truncate, very retractile, when expanded opening into funnels for aspiration of floating prey, never for attachment—epizoic on antero-ventral parts of *Cyclops*.

3. Cupped forms; *Solenophrya* Cl. and L., cup sessile; *Acineta* Ehr., cup stalked; *Acinetopsis* Bütschli, like *Acineta*, but the cup flattened, closed distally with only slit-like apertures ("pylomes") for the bundles of tentacles; *Podocyathus*, like *Acineta*, but with pointed as well as knobbed tentacles.

4. Tentacles in bundles at the tips of one or more processes or branches of the body. *Ophryodendron* Cl. and L., tentaculiferous process single (fig. viii. 21); *Dendrocometes* Stein (fig. viii. 15), body rounded, processes repeatedly branched, epizoic on gills of *Gammarus pulex*; *Dendrosoma* Ehr. (fig. viii. 17-20), body freely branched from a basal attached stolon, meganucleus branching with the body.

BIBLIOGRAPHY.—(*a*) Infusoria in the widest sense: C. E. Ehrenberg. *Die Infusionstierchen als vollkommene Organismen* (1838); F. Dujardin, *Zoophytes infusoires* (1841). (*b*) Infusoria, including Mastigophora: M. Perty, *Zur Kenntniss Kleinster Lebensformen* (1852); E. Claparède and J. Lachmann, *Études sur les infusoires et les Rhizopodes* (1858-1861); F. von Stein, *Der Organismus der Infusionstiere* (1859-1883); W. Saville Kent, *A Manual of the Infusoria*, including a description of all known Flagellate, Ciliate and Tentaculiferous Protozoa (1880-1882). (*c*) Infusoria, as limited by Bütschli. O. Bütschli, *Bronn's Tierreich*, vol. i. *Protozoa*, pt. 3 *Infusoria* (1887-1889), the most complete work existing,

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(M. Ha.)

INGEBORG [Ingeburge, Ingelburge, Ingelborg, Isemburge, Dan. Ingibjörg] (*c.* 1176-1237 or 1238), queen of France, was the daughter of Valdemar I., king of Denmark. She married in 1193 Philip II. Augustus, king of France, but on the day after his marriage the king took a sudden aversion to her, and wished to obtain a separation. During almost twenty years he strained every effort to obtain from the church the declaration of nullity of his marriage. The council of Compiègne acceded to his wish on the 5th of November 1193, but the popes Celestine III. and Innocent III. successively took up the defence of the unfortunate queen. Philip, having married Agnes of Meran in June 1196, was excommunicated, and as he remained obdurate, the kingdom was placed under an interdict. Agnes was finally sent away, but Ingeborg, shut up in the château of Étampes, had to undergo all sorts of privations and vexations. The king attempted to induce her to solicit a divorce herself, or to enter a convent. At last, however (1213), hoping perhaps to justify by his wife's claims his pretensions to England, Philip was reconciled with Ingeborg, whose life from henceforth was devoted to religion. She survived him more than fourteen years, passing the greater part of the time in the priory of St Jean at Corbeil, which she had founded.

See Robert Davidson, *Philip II. August von Frankreich und Ingeborg* (Stuttgart, 1888); and E. Michael, "Zur Geschichte der Königin Ingelborg" in the *Zeitschrift für Katholische Theologie* (1890).

INGELHEIM (Ober-Ingelheim and Nieder-Ingelheim), the name of two contiguous market-towns of Germany, in the grand-duchy of Hesse-Darmstadt, on the Selz, near its confluence with the Rhine, 9 m. W.N.W. of Mainz on the railway to Coblenz. Ober-Ingelheim, formerly an imperial town, is still surrounded by walls. It has an Evangelical church with painted windows representing scenes in the life of Charlemagne, a Roman Catholic church and a synagogue. Its chief industry is the manufacture of red wine. Pop. (1900) 3402. Nieder-Ingelheim has an Evangelical and a Roman Catholic church, and, in addition to wine, manufactories of paper, chemicals, cement and malt. Pop. 3435.

Nieder-Ingelheim is, according to one tradition, the birthplace of Charlemagne, and it possesses the ruins of an old palace built by that emperor between 768 and 774. The building contained one hundred marble pillars, and was also adorned with sculptures and mosaics sent from Ravenna by Pope Adrian I. It was extended by Frederick Barbarossa, and was burned down in 1270, being restored by the emperor Charles IV. in 1354. Having passed into the possession of the elector palatine of the Rhine, the building suffered much damage during a war in 1462, the Thirty Years' War, and the French invasion in 1689. Only few remains of it are now standing; but of the pillars, several are in Paris, one is in the museum at Wiesbaden and another on the Schillerplatz in Mainz. Inside its boundaries there is the restored Remigius Kirche, apparently dating from the time of Frederick I.

See Hilz, *Der Reichspalast zu Ingelheim* (Ober-Ingelheim, 1868); and Clemen, "Der Karolingische Kaiserpalast zu Ingelheim," in *Westdeutsche Zeitschrift*, Band ix. (Trier, 1890).

INGELOW, JEAN (1820-1897), English poet and novelist, was born at Boston, in Lincolnshire, on the 17th of March 1820. She was the daughter of William Ingelow, a banker of that town. As a girl she contributed verses and tales to the magazines under the pseudonym of "Orris," but her first (anonymous) volume, *A Rhyming Chronicle of Incidents and Feelings*, did not appear until her thirtieth year. This Tennyson said had "very charming things" in it, and he declared he should "like to know" the author, who was later admitted to his friendship. Miss Ingelow followed this book of verse in 1851 with a story, *Allerton and Dreux*, but it was the publication of her *Poems* in 1863 which suddenly raised her to the rank of a popular writer. They ran rapidly through numerous editions, were set to music, and sung in every drawing-room, and in America obtained an even greater hold upon public estimation. In 1867 she published *The Story of Doom and other Poems*, and then gave up verse for a while and became industrious as a novelist. *Off the Skelligs* appeared in 1872, *Fated to be Free* in 1873, *Sarah de Berenger* in 1880, and *John Jerome* in 1886. She also wrote *Studies for Stories* (1864), *Stories told to a Child* (1865), *Mopsa the Fairy* (1869), and other excellent stories for children. Her third series of *Poems* was published in 1885. She resided for the last years of her life in Kensington, and somewhat outlived her popularity as a poet. She died on the 20th of July 1897. Her poems, which were collected in one volume in 1898, have often the genuine ballad note, and as a writer of songs she was exceedingly successful. "Sailing beyond Seas" and "When Sparrows build" in *Supper at the Mill* were deservedly among the most popular songs of the day; but they share, with the rest of her work, the faults of affectation and stilted phraseology. Her best-known poem was the "High Tide on the Coast of Lincolnshire," which reached the highest level of excellence. The blemishes of her style were cleverly indicated in a well-known parody of Calverley's; a false archaism and a deliberate assumption of unfamiliar and unnecessary synonyms for simple objects were among the most vicious of her mannerisms. She wrote, however, in verse with a sweetness which her sentiment and her heart inspired, and in prose she displayed feeling for character and the gift of narrative; while a delicate underlying tenderness is never wanting in either medium to her sometimes tortured expression. Miss Ingelow was a woman of frank and hospitable manners, with a look of the Lady

Bountiful of a country parish. She had nothing of the professional authoress or the “literary lady” about her, and, as with characteristic simplicity she was accustomed to say, was no great reader. Her temperament was rather that of the improvisatore than of the professional author or artist.

INGEMANN, BERNHARD SEVERIN (1789-1862), Danish poet and novelist, was born at Torkildstrup, in the island of Falster, on the 28th of May 1789. He was educated at the grammar school at Slagelse, and entered the university of Copenhagen in 1806. His studies were interrupted by the English invasion, and on the first night of the bombardment of the city Ingemann stood with the young poet Blicher on the walls, while the shells whistled past them, and comrades were killed on either side. All his early and unpublished writings were destroyed when the English burned the town. In 1811 he published his first volume of poems, and in 1812 his second, followed in 1813 by a book of lyrics entitled *Procne* and in 1814 the verse romance, *The Black Knights*. In 1815 he published two tragedies, *Masaniello and Blanca*, followed by *The Voice in the Desert*, *The Shepherd of Tolosa*, and other romantic plays. After a variety of publications, all very successful, he travelled in 1818 to Italy. At Rome he wrote *The Liberation of Tasso*, and returned in 1819 to Copenhagen. In 1820 he began to display his real power in a volume of delightful tales. In 1821 his dramatic career closed with the production of an unsuccessful comedy, *Magnetism in a Barber’s Shop*. In 1822 the poet was nominated lector in Danish language and literature at Sorö College, and he now married. *Valdemar the Great and his Men*, an historical epic, appeared in 1824. The next few years were occupied with his best and most durable work, his four great national and historical novels of *Valdemar Seier*, 1826; *Erik Menved’s Childhood*, 1828; *King Erik*, 1833; and *Prince Otto of Denmark*, 1835. He then returned to epic poetry in *Queen Margaret*, 1836, and in a cycle of romances, *Holger Danske*, 1837. His later writings consist of religious and sentimental lyrics, epic poems, novels, short stories in prose, and fairy tales. His last publication was *The Apple of Gold*, 1856. In 1846 Ingemann was nominated director of Sorö College, a post from which he retired in 1849. He died on the 24th of February 1862. Ingemann enjoyed during his lifetime a popularity unapproached even by that of Öhlenschläger. His boundless facility and fecundity, his sentimentality, his religious melancholy, his direct appeal to the domestic affections, gave him instant access to the ear of the public. His novels are better than his poems; of the former the best are those which are directly modelled on the manner of Sir Walter Scott. As a dramatist he outlived his reputation, and his unwieldy epics are now little read.

Ingemann’s works were collected in 41 vols. at Copenhagen (1843-1865). His autobiography was edited by Galskjöt in 1862; his correspondence by V. Heise (1879-1881); and his letters to Grundtvig by S. Grundtvig (1882). See also H. Schwanenflügel, *Ingemanns Liv og Digtning* (1886); and Georg Brandes, *Essays* (1889).

INGERSOLL, ROBERT GREEN (1833-1899), American lawyer and lecturer, was born in Dresden, New York, on the 11th of August 1833. His father was a Congregational minister, who removed to Wisconsin in 1843 and to Illinois in 1845. Robert, who had received a good common-school education, was admitted to the bar in 1854, and practised law with success in Illinois. Late in 1861, during the Civil War, he organized a cavalry regiment, of which he was colonel, until captured at Lexington, Tennessee, on the 18th of December 1862, by the Confederate cavalry under General N. B. Forrest. He was paroled, waited in vain to be exchanged, and in June 1863 resigned from the service. He was attorney-general of Illinois in 1867-1869, and in 1876 his speech in the Republican National Convention, naming James G. Blaine for the Presidential candidate, won him a national reputation as a public speaker. As a lawyer he distinguished himself particularly as counsel for the defendants in the “Star-Route Fraud” trials. He was most widely known, however, for his public lectures attacking the Bible, and his anti-Christian views were an obstacle to his political advancement. Ingersoll was an eloquent rhetorician rather than a logical reasoner. He died at Dobbs Ferry, N.Y., on the 21st of July 1899.

His principal lectures and speeches were published under the titles: *The Gods and Other Lectures* (1876); *Some Mistakes of Moses* (1879); *Prose Poems* (1884); *Great Speeches* (1887). His lectures, entitled “The Bible,” “Ghosts,” and “Foundations of Faith,” attracted particular attention. His complete works were published in 12 vols. in New York in 1900.

INGERSOLL, a town and port of entry of Oxford county, Ontario, Canada, 19 m. E. of London, on the river Thames and the Grand Trunk and Canadian Pacific railways. Pop. (1901) 4572. The principal manufactures are agricultural implements, furniture, pianos and screws. There is a large export trade in cheese and farm produce.

INGHAM, CHARLES CROMWELL (1796-1863), American artist, was born in Dublin, Ireland. He was a pupil of the Dublin Academy, emigrated to the United States at the age of twenty-one, and immediately became identified with the art life of that country, being one of the founders of the National Academy of New York in 1826 and its vice-president from 1845 to 1850. He painted portraits of the reigning beauties of New York and acquired considerable reputation, continuing to practise his profession until his death, in New York, on the 10th of December 1863.

INGHIRAMI, the name of an Italian noble family of Volterra. The following are its most important members:

Tommaso Inghirami (1470-1516), a humanist, is best known for his Latin orations, seven of which were published in 1777. His success in the part of Phaedra in a presentation of Seneca's *Hippolytus* (or *Phaedra*) led to his being generally known as *Fedra*. He received high honours from Alexander VI., Leo X. and Maximilian I.

Francesco Inghirami (1772-1846), a distinguished archaeologist, fought in the French wars (1799), and afterwards devoted himself especially to the study of Etruscan antiquities. He founded a college at Fiesole and collected, though without critical insight, a mass of valuable material in his *Monumenti etruschi* (10 vols., 1820-1827), *Galleria omerica* (3 vols., 1829-1851), *Pitture di vasi fittili* (1831-1837), *Museo etrusco chiusino* (2 vols., 1833), and the incomplete *Storia della Toscana* (1841-1845): these works were elaborately illustrated.

His brother, Giovanni Inghirami (1779-1851), was an astronomer of repute. He was professor of astronomy at the Institute founded by Ximenes in Florence and published beside a number of text-books *Effemeridi dell' occultazione delle piccole stelle sotto la luna* (1809-1830); *Effemeridi di Venese e Giove all' uso de' naviganti* (1821-1824); *Tavole astronomichi universali portatili* (1811); *Base trigonometrica misurata in Toscana* (1818); *Carta topografica e geometrica della Toscana* (1830).

INGLEBY, CLEMENT MANSFIELD (1823-1886), English Shakespearian scholar, was born at Edgbaston, Birmingham, on the 29th of October 1823, the son of a solicitor. After taking his degree at Trinity College, Cambridge, he entered his father's office, eventually becoming a partner. In 1859 he abandoned the law and left Birmingham to live near London. He contributed articles on literary, scientific and other subjects to various magazines, but from 1874 devoted himself almost entirely to Shakespearian literature. His first work in this field had been an exposure of the manipulations of John Payne Collier, entitled *The Shakespeare Fabrications* (1859); his work as a commentator began with *The Still Lion* (1874), enlarged in the following year into *Shakespeare Hermeneutics*. In this book many of the then existing difficulties of Shakespeare's text were explained. In the same year (1875) he published the *Centurie of Prayse*, a collection of references to Shakespeare and his works between 1592 and 1692. His *Shakespeare: the Man and the Book* was published in 1877-1881; he also wrote *Shakespeare's Bones* (1882), in which he suggested the disinterment of Shakespeare's bones and an examination of his skull. This suggestion, though not due to vulgar curiosity, was regarded, however, by public opinion as sacrilegious. He died on the 26th of September 1886, at Ilford, Essex. Although Ingleby's reputation now rests solely on his works on Shakespeare, he wrote on many other subjects. He was the author of hand-books on metaphysic and logic, and made some contributions to the study of natural science. He was at one time vice-president of the New Shakspere Society, and one of the original trustees of the "Birthplace."

INGLEFIELD, SIR EDWARD AUGUSTUS (1820-1894), British admiral and explorer, was born at Cheltenham, on the 27th of March 1820, and educated at the Royal Naval College, Portsmouth. His father was Rear-Admiral Samuel Hood Inglefield (1783-1848), and his grandfather Captain John Nicholson Inglefield (1748-1828), who served with Lord Hood against the French. The boy went to sea when fourteen, took part in the naval operations on the Syrian Coast in 1840, and in 1845 was promoted to the rank of commander for gallant conduct at Obligado. In 1852 he commanded Lady Franklin's yacht "Isabel" on her cruise to Smith Sound, and his narrative of the expedition was published under the title of *A Summer Search for Sir John Franklin* (1853). He received the gold medal of the Royal Geographical Society on his return and was given command of the "Phoenix," in which he made three trips to the Arctic, bringing home part of the Belcher Arctic expedition in 1854. In that year he was again sent out on the last attempt made by the Admirally to find Sir John Franklin.

In the Crimean War Captain Inglefield took part in the siege of Sevastopol. He was knighted in 1877, and nominated a Knight Commander of the Bath ten years later. He was promoted admiral in 1879. Besides being an excellent marine artist, he was the inventor of the hydraulic steering gear and the Inglefield anchor. He died on the 5th of September 1894. His son, Captain Edward Fitzmaurice Inglefield (b. 1861), became secretary of Lloyds in 1906. Sir Edward Inglefield's brother, Rear-Admiral V. O. Inglefield, was the father of Rear-Admiral Frederick Samuel Inglefield (b. 1854), director of naval intelligence in 1902-1904, and of two other sons distinguished as soldiers.

INGLE-NOOK (from Lat. *igniculus*, dim. of *ignis*, fire), a corner or seat by the fireside, within the chimney-breast. The open Tudor or Jacobean fire-place was often wide enough to admit of a wooden settle being placed at each end of the embrasure of which it occupied the centre, and yet far enough away not to be inconveniently hot. This was one of the means by which the builder sought to avoid the draughts which must have been extremely frequent in old houses. English literature is full of references, appreciatory or regretful, to the cosy ingle-nook that was killed by the adoption of small grates. Modern English and American architects are, however, fond of devising them in houses designed on ancient models, and owners of old buildings frequently remove the modern grates and restore the original arrangement.

INGLIS, SIR JOHN EARDLEY WILMOT (1814-1862), British major-general, was born in Nova Scotia on the 15th of November 1814. His father was the third, and his grandfather the first, bishop of that colony. In 1833 he joined the 32nd Foot, in which all his regimental service was passed. In 1837 he saw active service in Canada, and in 1848-1849 in the Punjab, being in command at the storming of Mooltan and at the battle of Gujrat. In 1857, on the outbreak of the Indian Mutiny, he was in command of his regiment at Lucknow. Sir Henry Lawrence being mortally wounded during the

siege of the residency, Inglis took command of the garrison, and maintained a successful defence for 87 days against an overwhelming force. He was promoted to major-general and made K.C.B. After further active service in India, he was, in 1860, given command of the British troops in the Ionian Islands. He died at Hamburg on the 27th of September 1862.

INGLIS, SIR WILLIAM (1764-1835), British soldier, was born in 1764, a member of an old Roxburghshire family. He entered the army in 1781. After ten years in America he served in Flanders, and in 1796 took part in the capture of St Lucia. In 1809 he commanded a brigade in the Peninsula, taking part in the battle of Busaco (1810) and the first siege of Badajoz. At Albuera his regiment, the 57th, occupied a most important position, and was exposed to a deadly fire. "Die hard! Fifty-Seventh," cried Inglis, "Die hard!" The regiment's answer has gone down to history. Out of a total strength of 579, 23 officers and 415 rank and file were killed and wounded. Inglis himself was wounded. On recovering, he saw further Peninsular service. In two engagements his horse was shot under him. His services were rewarded by the thanks of parliament and in 1825 he became lieutenant-general, and was made a K.C.B. After holding the governorships of Kinsale and Cork, he was, in 1830, appointed colonel of the 57th. He died at Ramsgate on the 29th of November 1835.

INGOLSTADT, a fortified town of Germany, in the kingdom of Bavaria, on the left bank of the Danube at its confluence with the Schutter, 52 m. north of Munich, at the junction of the main lines of railway, Munich, Bamberg and Regensburg-Augsburg. Pop. (1900) 22,207. The principal buildings are the old palace of the dukes of Bavaria-Ingolstadt, now used as an arsenal; the new palace on the Danube; the remains of the earliest Jesuits' college in Germany, founded in 1555; the former university buildings, now a school; the theatre; the large Gothic Frauenkirche, founded in 1425, with two massive towers, containing several interesting monuments, among them the tomb of Dr Eck, Luther's opponent; the Franciscan convent and nunnery; and several other churches and hospitals. Ingolstadt possesses several technical and other schools. In 1472 a university was founded in the town by the Bavarian duke, Louis the Rich, which at the end of the 16th century was attended by 4000 students. In 1800 it was removed to Landshut, whence it was transferred to Munich in 1826. Its newer public buildings include an Evangelical church, a civil hospital, an arsenal and an orphanage. The industries are cannon-founding, manufacture of gunpowder and cloth, and brewing.

Ingolstadt, known as *Aureatum* or *Chrysopolis*, was a royal villa in the beginning of the 9th century, and received its charter of civic incorporation before 1255. After that date it grew in importance, and became the capital of a dukedom which merged in that of Bavaria-Munich. The fortifications, erected in 1539, were put to the test during the contests of the Reformation period and in the Thirty Years' War. Gustavus Adolphus vainly besieged Ingolstadt in 1632, when Tilly, to whom there is a monument in the Frauenkirche, lay mortally wounded within the walls. In the War of the Spanish Succession it was besieged by the margrave of Baden in 1704. In 1743 it was surrendered by the French to the Austrians, and in 1800, after three months' siege, the French, under General Moreau, took the town, and dismantled the fortifications. They were rebuilt on a much larger scale under King Louis I., and since 1870 Ingolstadt has ranked as a fortress of the first class. In 1872 even more important fortifications were constructed, which include têtes-de-pont with round towers of massive masonry, and the redoubt Tilly on the right bank of the river.

See Gerstner, *Geschichte der Stadt Ingolstadt* (Munich, 1853); and Prantl, *Geschichte der Ludwig Maximilians Universität* (Munich, 1872).

INGOT, originally a mould for the casting of metals, but now a mass of metal cast in a mould, and particularly the small bars of the precious metals, cast in the shape of an oblong brick or wedge with slightly sloping sides, in which form gold and silver are handled as bullion at the Bank of England and the Mint. Ingots of varying sizes and shapes are cast of other metals, and "ingot-steel" and "ingot-iron" are technical terms in the manufacture of iron and steel (see Iron and Steel). The word is obscure in origin. It occurs in Chaucer ("The Canon's Yeoman's Tale") as a term of alchemy, in the original sense of a mould for casting metal, and, as the *New English Dictionary* points out, an English origin for such a term is unlikely. It may, however, be derived from *in* and the O. Eng. *géotan* to pour; cf. Ger. *giessen* and *Einguss*, a mould. The Fr. *lingot*, with the second English meaning only, has been taken as the origin of "ingot" and derived from the Lat. *lingua*, tongue—with a supposed reference to the shape. This derivation is wrong, and French etymologists have now accepted the English origin for the word, *lingot* having coalesced from *l'ingot*.

INGRAM, JAMES (1774-1850), English antiquarian and Anglo-Saxon scholar, was born near Salisbury on the 21st of December 1774. He was educated at Warminster and Winchester schools and at Trinity College, Oxford, of which he became a fellow in 1803. From 1803 to 1808 he was Rawlinsonian professor of Anglo-Saxon at Oxford, and in 1824 was made President of Trinity College and D.D. His time, however, was principally spent in antiquarian research, and especially in the study of Anglo-Saxon, in which field he was the pre-eminent scholar of his time. He published in 1823 an edition of the *Saxon Chronicle*. His other works include admirable *Memorials of Oxford* (1832-1837), and *The Church in the Middle Centuries* (1842). He died on the 5th of September 1850.

INGRAM, JOHN KELLS (1823-1907), Irish scholar and economist, was born in Co. Donegal, Ireland, on the 7th of July 1823. Educated at Newry School and Trinity College, Dublin, he was elected a fellow of his college in 1846. He held the professorship of Oratory and English Literature in Dublin University from 1852 to 1866, when he became regius professor of Greek. In 1879 he was appointed librarian. Ingram was remarkable for his versatility. In his undergraduate days he had written the well-known poem "Who fears to speak of Ninety-eight?" and his *Sonnets and other Poems* (1900) reveal the poetic sense. He contributed many important papers to mathematical societies on geometrical analysis, and did much useful work in advancing the science of classical etymology, notably in his *Greek and Latin Etymology in England*, *The Etymology of Liddell and Scott*. His philosophical works include *Outlines of the History of Religion* (1900), *Human Nature and Morals according to A. Comte* (1901), *Practical Morals* (1904), and the *Final Transition* (1905). He contributed to the 9th edition of the *Encyclopaedia Britannica* an historical and biographical article on political economy, which was translated into nearly every European language. His *History of Slavery and Serfdom* was also written for the 9th edition of the *Encyclopaedia Britannica*. He died in Dublin on the 18th of May 1907.

INGRES, JEAN AUGUSTE DOMINIQUE (1780-1867), French painter, was born at Montauban, on the 29th of August 1780. His father, for whom he entertained the most tender and respectful affection, has described himself as *sculpteur en plâtre*; he was, however, equally ready to execute every other kind of decorative work, and now and again eked out his living by taking portraits or obtained an engagement as a violin-player. He brought up his son to command the same varied resources, but in consequence of certain early successes—the lad's performance of a concerto of Viotti's was applauded at the theatre of Toulouse—his attention was directed chiefly to the study of music. At Toulouse, to which place his father had removed from Montauban in 1792, Ingres had, however, received lessons from Joseph Roques, a painter whom he quitted at the end of a few months to become a pupil of M. Vigan, professor at the academy of fine arts in the same town. From Vigan, Ingres, whose vocation became day by day more distinctly evident, passed to M. Briant, a landscape-painter who insisted that his pupil was specially gifted by nature to follow the same line as himself. For a while Ingres obeyed, but he had been thoroughly aroused and enlightened as to his own objects and desires by the sight of a copy of Raphael's "Madonna della Sedia," and, having ended his connexion with Briant, he started for Paris, where he arrived about the close of 1796. He was then admitted to the studio of David, for whose lofty standard and severe principles he always retained a profound appreciation. Ingres, after four years of devoted study, during which (1800) he obtained the second place in the yearly competition, finally carried off the Grand Prix (1801). The work thus rewarded—the "Ambassadors of Agamemnon in the Tent of Achilles" (École des Beaux Arts)—was admired by Flaxman so much as to give umbrage to David, and was succeeded in the following year (1802) by the execution of a "Girl after Bathing," and a woman's portrait; in 1804 Ingres exhibited "Portrait of the First Consul" (Musée de Liége), and portraits of his father and himself; these were followed in 1806 by "Portrait of the Emperor" (Invalides), and portraits of M, Mme, and Mlle Rivière (the first two now in the Louvre). These and various minor works were executed in Paris (for it was not until 1809 that the state of public affairs admitted of the re-establishment of the Academy of France at Rome), and they produced a disturbing impression on the public. It was clear that the artist was some one who must be counted with; his talent, the purity of his line, and his power of literal rendering were generally acknowledged; but he was reproached with a desire to be singular and extraordinary. "Ingres," writes Frau v. Hastfer (*Leben und Kunst in Paris*, 1806) "wird nach Italien gehen, und dort wird er vielleicht vergessen dass er zu etwas Grossem geboren ist, und wird eben darum ein hohes Ziel erreichen." In this spirit, also, Chaussard violently attacked his "Portrait of the Emperor" (*Pausanias Français*, 1806), nor did the portraits of the Rivière family escape. The points on which Chaussard justly lays stress are the strange discordances of colour—such as the blue of the cushion against which Mme Rivière leans, and the want of the relief and warmth of life, but he omits to touch on that grasp of his subject as a whole, shown in the portraits of both husband and wife, which already evidences the strength and sincerity of the passionless point of view which marks all Ingres's best productions. The very year after his arrival in Rome (1808) Ingres produced "Oedipus and the Sphinx" (Louvre; lithographed by Sudre, engraved by Gaillard), a work which proved him in the full possession of his mature powers, and began the "Venus Anadyomene" (Collection Rieset; engraving by Pollet), completed forty years later, and exhibited in 1855. These works were followed by some of his best portraits, that of M. Bochet (Louvre), and that of Mme la Comtesse de Tournon, mother of the prefect of the department of the Tiber; in 1811 he finished "Jupiter and Thetis," an immense canvas now in the Musée of Aix; in 1812 "Romulus and Acron" (École des Beaux Arts), and "Virgil reading the *Aeneid*"—a composition very different from the version of it which has become popular through the engraving executed by Pradier in 1832. The original work, executed for a bedchamber in the Villa Aldobrandini-Miollis, contained neither the figures of Maecenas and Agrippa nor the statue of Marcellus; and Ingres, who had obtained possession of it during his second stay in Rome, intended to complete it with the additions made for engraving. But he never got beyond the stage of preparation, and the picture left by him, together with various other studies and sketches, to the Musée of his native town, remains half destroyed by the process meant for its regeneration. The "Virgil" was followed by the "Betrothal of Raphael," a small painting, now lost, executed for Queen Caroline of Naples; "Don Pedro of Toledo Kissing the Sword of Henry IV." (Collection Deymié; Montauban), exhibited at the Salon of 1814, together with the "Chapelle Sistine" (Collection Legentil; lithographed by Sudre), and the "Grande Odalisque" (Collection Seillière; lithographed by Sudre). In 1815 Ingres executed "Raphael and the Fornarina" (Collection Mme N. de Rothschild; engraved by Pradier); in 1816 "Aretin" and the "Envoy of Charles V." (Collection Schroth), and "Aretin and Tintoret" (Collection Schroth); in 1817 the "Death of Leonardo" (engraved by Richomme) and "Henry IV. Playing with his Children" (engraved by Richomme), both of which works were commissions from M. le Comte de Blacas, then ambassador of France at the Vatican. "Roger and Angelique" (Louvre; lithographed by Sudre), and "Francesca di Rimini" (Musée of Angers; lithographed by Aubry Lecomte), were completed in 1819, and followed in 1820 by "Christ giving the Keys to Peter" (Louvre). In 1815, also, Ingres had made many projects for treating a subject from the life of the celebrated duke of Alva, a commission from the family, but a loathing for "cet horrible homme" grew upon him, and finally he abandoned the task and entered in his diary—"J'étais forcé par la nécessité de peindre un pareil tableau; Dieu a voulu qu'il restât en ébauche." During all these years Ingres's reputation in France did not increase. The interest which his "Chapelle Sistine" had aroused at the Salon of 1814 soon died away; not only was the public indifferent, but amongst his brother artists Ingres found scant recognition. The strict classicists looked upon him as a renegade, and strangely enough Delacroix and other pupils of Guérin—the leaders of that romantic movement for which Ingres, throughout his long life, always expressed the deepest abhorrence—alone seem to have been sensible of his merits. The weight of poverty, too, was hard to bear. In 1813 Ingres had married; his marriage had been arranged for him with a young woman who came in a business-like way from Montauban, on the strength of the representations of her friends in Rome. Mme Ingres speedily acquired a faith in her husband which enabled her to combat with heroic courage and patience the difficulties which beset their common existence, and which were increased by their removal to Florence. There Bartolini, an old friend, had hoped that Ingres might have

materially bettered his position, and that he might have aroused the Florentine school—a weak offshoot from that of David—to a sense of its own shortcomings. These expectations were disappointed. The good offices of Bartolini, and of one or two other persons, could only alleviate the miseries of this stay in a town where Ingres was all but deprived of the means of gaining daily bread by the making of those small portraits for the execution of which, in Rome, his pencil had been constantly in request. Before his departure he had, however, been commissioned to paint for M. de Pastoret the "Entry of Charles V. into Paris," and M. de Pastoret now obtained an order for Ingres from the Administration of Fine Arts; he was directed to treat the "Vœu de Louis XIII." for the cathedral of Montauban. This work, exhibited at the Salon of 1824, met with universal approbation: even those sworn to observe the unadulterated precepts of David found only admiration for the "Vœu de Louis XIII." On his return Ingres was received at Montauban with enthusiastic homage, and found himself celebrated throughout France. In the following year (1825) he was elected to the Institute, and his fame was further extended in 1826 by the publication of Sudre's lithograph of the "Grande Odalisque," which, having been scorned by artists and critics alike in 1819, now became widely popular. A second commission from the government called forth the "Apotheosis of Homer," which, replaced by a copy in the decoration of the ceiling for which it was designed, now hangs in the galleries of the second storey of the Louvre. From this date up till 1834 the studio of Ingres was thronged, as once had been thronged the studio of David, and he was a recognized *chef d'école*. Whilst he taught with despotic authority and admirable wisdom, he steadily worked; and when in 1834 he produced his great canvas of the "Martyrdom of Saint Symphorien" (cathedral of Autun; lithographed by Trichot-Garneri), it was with angry disgust and resentment that he found his work received with the same doubt and indifference, if not the same hostility, as had met his earlier ventures. The suffrages of his pupils, and of one or two men—like Decamps—of undoubted ability, could not soften the sense of injury. Ingres resolved to work no longer for the public, and gladly availed himself of the opportunity to return to Rome, as director of the École de France, in the room of Horace Vernet. There he executed "La Vierge à l'Hostie" (Imperial collections, St Petersburg), "Stratonice," "Portrait of Cherubini" (Louvre), and the "Petite Odalisque" for M. Marcotte, the faithful admirer for whom, in 1814, Ingres had painted the "Chapelle Sistine." The "Stratonice," executed for the duke of Orleans, had been exhibited at the Palais Royal for several days after its arrival in France, and the beauty of the composition produced so favourable an impression that, on his return to Paris in 1841, Ingres found himself received with all the deference that he felt to be his due. A portrait of the purchaser of "Stratonice" was one of the first works executed after his return; and Ingres shortly afterwards began the decorations of the great hall in the Château de Dampierre, which, unfortunately for the reputation of the painter, were begun with an ardour which gradually slackened, until in 1849 Ingres, having been further discouraged by the loss of his faithful and courageous wife, abandoned all hope of their completion, and the contract with the duc de Luynes was finally cancelled. A minor work, "Jupiter and Antiope," marks the year 1851, but Ingres's next considerable undertaking (1853) was the "Apotheosis of Napoleon I.," painted for the ceiling of a hall in the Hôtel de Ville; "Jeanne d'Arc" (Louvre) appeared in 1854; and in 1855 Ingres consented to rescind the resolution, more or less strictly kept since 1834, in favour of the International Exhibition, where a room was reserved for his works. Prince Napoleon, president of the jury, proposed an exceptional recompense for their author, and obtained from the emperor Ingres's nomination as grand officer of the Legion of Honour. With renewed confidence Ingres now took up and completed one of his most charming productions—"La Source" (Louvre), a figure of which he had painted the torso in 1823, and which seen with other works in London (1862) there renewed the general sentiment of admiration, and procured him, from the imperial government, the dignity of senator. After the completion of "La Source," the principal works produced by Ingres were with one or two exceptions ("Molière" and "Louis XIV.," presented to the Théâtre Français, 1858; "Le Bain Turc," 1859), of a religious character; "La Vierge de l'Adoption," 1858 (painted for Mlle Roland-Gosselin), was followed by "La Vierge Couronnée" (painted for Mme la Baronne de Larinthie) and "La Vierge aux Enfans" (Collection Blanc); in 1859 these were followed by repetitions of "La Vierge à l'Hostie"; and in 1862 Ingres completed "Christ and the Doctors" (Musée Montauban), a work commissioned many years before by Queen Marie Amélie for the chapel of Bizy.

On the 17th of January 1867 Ingres died in his eighty-eighth year, having preserved his faculties in wonderful perfection to the last. For a moment only—at the time of the execution of the "Bain Turc," which Prince Napoleon was fain to exchange for an early portrait of the master by himself—Ingres's powers had seemed to fail, but he recovered, and showed in his last years the vigour which marked his early maturity. It is, however, to be noted that the "Saint Symphorien" exhibited in 1834 closes the list of the works on which his reputation will chiefly rest; for "La Source," which at first sight seems to be an exception, was painted, all but the head and the extremities, in 1821; and from those who knew the work well in its incomplete state we learn that the after-painting, necessary to fuse new and old, lacked the vigour, the precision, and the something like touch which distinguished the original execution of the torso. Touch was not, indeed, at any time a means of expression on which Ingres seriously calculated; his constant employment of local tint, in mass but faintly modelled in light by half tones, forbade recourse to the shifting effects of colour and light on which the Romantic school depended in indicating those fleeting aspects of things which they rejoiced to put on canvas;—their methods would have disturbed the calculations of an art wholly based on form and line. Except in his "Sistine Chapel," and one or two slighter pieces, Ingres kept himself free from any preoccupation as to depth and force of colour and tone; driven, probably by the excesses of the Romantic movement into an attitude of stricter protest, "ce que l'on sait" he would repeat, "il faut le savoir l'épée à la main." Ingres left himself therefore, in dealing with crowded compositions, such as the "Apotheosis of Homer" and the "Martyrdom of Saint Symphorien," without the means of producing the necessary unity of effect which had been employed in due measure—as the Stanze of the Vatican bear witness—by the very master whom he most deeply reverenced. Thus it came to pass that in subjects of one or two figures Ingres showed to the greatest advantage: in "Oedipus," in the "Girl after Bathing," the "Odalisque" and "La Source"—subjects only animated by the consciousness of perfect physical well-being—we find Ingres at his best. One hesitates to put "Roger and Angelique" upon this list, for though the female figure shows the finest qualities of Ingres's work,—deep study of nature in her purest forms, perfect sincerity of intention and power of mastering an ideal conception—yet side by side with these the effigy of Roger on his hippogriff bears witness that from the passionless point of view, which was Ingres's birthright, the weird creatures of the fancy cannot be seen.

A graphic account of "Ingres, sa vie et ses travaux," and a complete catalogue of his works, were published by M. Delaborde in 1870, and dedicated to Mme Ingres, *née* Ramel, Ingres's devoted second wife, whom he married in 1852. Allusions to the painter's early days will be found in Delécluze's *Louis David*; and amongst less important notices may be cited that by Théophile Silvestre in his series of living artists. Most of Ingres's important works are engraved in the collection brought out by Magimel.

(E. F. S. D.)

INGRESS (Lat. *ingressus*, going in), entrance as opposed to exit or egress; in astronomy, the apparent entrance of a smaller body upon the disk of a larger one, as it passes between the latter and the observer; in this sense it is applied especially to the beginning of a transit of a satellite of Jupiter over the disk of the planet.

INHAMBANE, a seaport of Portuguese East Africa in 23° 50′ S., 35° 25′ E. The town, which enjoys a reputation for healthiness, is finely situated on the bank of a river of the same name which empties into a bay also called Inhambane. Next to Mozambique Inhambane, which dates from the middle of the 16th century, is architecturally the most important town in Portuguese East Africa. The chief buildings are the fort, churches and mosque. The principal church is built with stone and marble brought from Portugal. The population, about 4000 in 1909, is of a motley character: Portuguese and other Europeans, Arabs, Banyans, half-castes and negroes. Its commerce was formerly mostly in ivory and slaves. In 1834 Inhambane was taken and all its inhabitants save ten killed by a Zulu horde under Manikusa (see GAZALAND). It was not until towards the close of the 19th century that the trade of the town revived. The value of exports and imports in 1907 was about £150,000. The chief exports are wax, rubber, mafureira and other nuts, mealies and sugar. Cotton goods and cheap wines (for consumption by natives) are the principal imports. The harbour, about 9 m. long by 5 wide, accommodates vessels drawing 10 to 12 ft. of water. The depth of water over the bar varies from 17 to 28 ft., and large vessels discharge into and load from lighters. Inhambane is the natural port for the extensive and fertile district between the Limpopo and Sabi rivers. This region is the best recruiting ground for labourers in the Rand gold mines. Mineral oils have been found within a short distance of the port.

INHERITANCE. In English law, inheritance, heir and other kindred words have a meaning very different from that of the Latin *haeres*, from which they are derived. In Roman law the heir or heirs represented the entire legal personality of the deceased—his *universum jus*. In English law the heir is simply the person on whom the real property of the deceased devolves by operation of law if he dies intestate. He has nothing to do as heir with the personal property; he is not appointed by will; and except in the case of coparceners he is a single individual. The Roman *haeres* takes the whole estate; his appointment may or may not be by testament; and more persons than one may be associated together as heirs.

The devolution of an inheritance in England is now regulated by the rules of descent, as altered by the Inheritance Act 1833, amended by the Law of Property Amendment Act 1859.

1. The first rule is that inheritance shall descend to the issue of the last "purchaser." A purchaser in law means one who acquires an estate otherwise than by descent, *e.g.* by will, by gratuitous gift, or by purchase in the ordinary meaning of the word. This rule is one of the changes introduced by the Inheritance Act, which further provides that "the person last entitled to the land shall be considered the purchaser thereof unless it be proved that he inherited the same." Under the earlier law descent was traced from the last person who had "seisin" or feudal possession, and it was occasionally a troublesome question whether the heir or person entitled had ever, in fact, acquired such possession. Now the only inquiry is into title, and each person entitled is presumed to be in by purchase unless he is proved to be in by descent, so that the stock of descent is the last person entitled who cannot be shown to have inherited. 2. The male is admitted before the female. 3. Among males of equal degree in consanguinity to the purchaser, the elder excludes the younger; but females of the same degree take together as "coparceners." 4. Lineal descendants take the place of their ancestor. Thus an eldest son dying and leaving issue would be represented by such issue, who would exclude their father's brothers and sisters. 5. If there are no lineal descendants of the purchaser, the next to inherit is his nearest lineal ancestor. This is a rule introduced by the Inheritance Act. Under the former law inheritance never went to an ancestor—collaterals, however remote of the person last seized being preferred even to his father. Various explanations have been given of this seemingly anomalous rule—Bracton and Blackstone being content to say that it rests on the law of nature, by which heavy bodies gravitate downwards. Another explanation is that estates were granted to be descendible in the same way as an ancient inheritance, which having passed from father to son *ex necessitate* went to collaterals on failure of issue of the person last seized. 6. The sixth rule is thus expressed by Joshua Williams in his treatise on *The Law of Real Property*:—

> "The father and all the male paternal ancestors of the purchaser and their descendants shall be admitted before any of the female paternal ancestors or their heirs; all the female paternal ancestors and their heirs before the mother or any of the maternal ancestors or her or their descendants; and the mother and all the male maternal ancestors and her and their descendants before any of the female maternal ancestors or their heirs."

7. Kinsmen of the half-blood may be heirs; such kinsmen shall inherit next after a kinsman in the same degree of the whole blood, and after the issue of such kinsman where the common ancestor is a male and next after the common ancestor where such ancestor is a female. The admission of kinsmen of the half-blood into the chain of descent is an alteration made by the Inheritance Act. Formerly a relative, however nearly connected in blood with the purchaser through one only and not both parents, could never inherit—a half-brother for example. 8. In the admission of female paternal ancestors, the mother of the more remote male paternal ancestor and her heirs shall be preferred to the mother of the less remote male paternal and her heirs; and, in the case of female maternal ancestors, the mother of the more remote male maternal ancestor shall be preferred to the mother of a less remote male maternal ancestor. This rule, following the opinion of Blackstone, settles a point much disputed by text-writers, although its importance was little more than theoretical. 9. When there shall be a total failure of heirs of the purchaser, or when any lands shall be descendible as if an ancestor had been the purchaser thereof, and there shall be a total failure of the heirs of such ancestor, then and in every such case the descent shall be traced from the person last entitled to the land as if he had been the purchaser thereof. This rule is enacted by the Law of Property Amendment Act 1859. It would apply to such a case as the following: Purchaser dies intestate, leaving a son and no other relations, and the son in turn dies intestate; the son's relations through his mother are now admitted by this rule. If the purchaser is illegitimate, his only relations must necessarily be his own issue. Failing heirs of all kinds, the lands of an intestate purchaser, not alienated by him, would revert by "escheat" to the next immediate lord of the fee, who would generally be the crown. If an intermediate lordship could be proved to exist between the crown and the tenant in fee simple, such intermediate lord would have the escheat. But escheat is a matter of rare occurrence.

The above rules apply to all freehold land whether the estate therein of the intestate is legal or equitable. Before 1884, if a sole trustee had the legal estate in realty, and his *cestui que trust* died intestate and without heirs, the land escheated to the trustee. This distinction was abolished by the Intestate Estates Act 1884.

The descent of an estate in tail would be ascertained by such of the foregoing rules as are not inapplicable to it. By the form of the entail the estate descends to the "issue" of the person to whom the estate was given in tail—in other

words, the last purchaser. The preceding rules after the fourth, being intended for the ascertainment of heirs other than those by lineal descent, would therefore not apply; and a special limitation in the entail, such as to heirs male or female only, would render unnecessary some of the others. When the entail has been barred, the estate descends according to these rules. In copyhold estates descent, like other incidents thereof, is regulated by the custom of each particular manor; *e.g.* the youngest son may exclude the elder sons. How far the Inheritance Act applies to such estates has been seriously disputed. It has been held in one case (*Muggleton* v. *Barnett*) that the Inheritance Act, which orders descent to be traced from the last purchaser, does not override a manorial custom to trace descent from the person last seized, but this position has been controverted on the ground that the act itself includes the case of customary holdings.

Husband and wife do not stand in the rank of heir to each other. Their interests in each other's real property are secured by courtesy and dower.

The personal property of a person dying intestate devolves according to an entirely different set of rules (see INTESTACY).

In Scotland the rules of descent differ from the above in several particulars. Descent is traced, as in England before the Inheritance Act, to the person last seized. The first to succeed are the lineal descendants of the deceased, and the rules of primogeniture, preference of males to females, equal succession of females (heirs-portioners), and representation of ancestors are generally the same as in English law. Next to the lineal descendants, and failing them, come the brothers and sisters, and their issue as collaterals. Failing collaterals, the inheritance ascends to the father and his relations, to the entire exclusion of the mother and her relations. Even when the estate has descended from mother to son, it can never revert to the maternal line. As to succession of brothers, a distinction must be taken between an estate of heritage and an estate of conquest. Conquest is where the deceased has acquired the land otherwise than as heir, and corresponds to the English term purchase in the technical sense explained. Heritage is land acquired by deceased as heir. The distinction is important only in the case when the heir of the deceased is to be sought among his brothers; when the descent is lineal, conquest and heritage go to the same person. And when the brothers are younger than the deceased, both conquest and heritage go to the brother (or his issue) next in order of age. But when the deceased leaves an elder and a younger brother (or their issues), the elder brother takes the conquest, the younger takes the heritage. Again, when there are several elder brothers, the one next in age to the deceased takes the conquest before the more remote, and when there are several younger brothers, the one next to the deceased takes the heritage before the more remote. When heritage of the deceased goes to an elder brother (as might happen in certain eventualities), the younger of the elder brothers is preferred. The position of the father, after the brothers and sisters of the deceased, will be noticed as an important point of difference from the English axioms; so also is the total exclusion of the mother and the maternal line. As between brothers and sisters the half-blood only succeeds after the full blood. Half-blood is either consanguinean, as between children by the same father, or uterine, as between children having the same mother. The half-blood uterine is excluded altogether. Half-blood consanguinean succeeds thus: if the issue is by a former marriage, the youngest brother (being nearest to the deceased of the consanguinean) succeeds first; if by a later marriage than that from which the deceased has sprung, the eldest succeeds first.

United States.—American law has borrowed its rules of descent considerably more from the civil law than the common law. "The 118 novel of Justinian has a striking resemblance to American law in giving the succession of estates to all legitimate children without distinction and disregarding all considerations of primogeniture. There is one particular in which the American law differs from that of Justinian, that while generally in this country lineal descendants if they stand in an equal degree from the common ancestor share equally *per capita*, under the Roman law regard was had to the right of representation, each lineal branch of descendants taking only the portion which their parent would have taken had he been living, the division being *per stirpes* and not *per capita*. But in some of the states the rule of the Roman law in this respect has been adopted and retained. Among these are Rhode Island, New Jersey, North and South Carolina, Alabama and Louisiana" (3 Washburn's *Real Property*, pp. 408, 409; 4 Kent's *Comm.* p. 375). When such lineal descendants stand in unequal degrees of consanguinity the inheritance is *per stirpes* and not *per capita* (*In re Prote*, 1907; 104, N.Y. Supplement 581). This is the rule in practically all the states. But as in no two states or territories are the rules of descent identical, the only safe guides are the statutes and decisions of the particular state in which the land to be inherited is situated. The law of primogeniture as understood in England is generally abolished throughout the United States, and male and female relatives inherit equally. In some states, as in Massachusetts, relatives of the half-blood inherit equally with chose of the whole-blood of the same degree; in others, like Maryland, they can inherit only in case none of whole-blood exist. In some of the states the English rule that natural children have no inheritable blood has been greatly modified. In Louisiana, if duly acknowledged, they may inherit from both father and mother in the absence of lawful issue. Degrees of kindred in the United States generally are computed according to the civil law, *i.e.* by adding together the number of degrees between each of the two persons whose relationship is to be ascertained and the common ancestor. Thus, relationship between two brothers is in the second degree; between uncle and nephew in the third degree; between cousins, in the fourth, &c.

In a few states such degrees are computed according to the common law, *i.e.* by counting from the common ancestor to the most remote descendant of the two from him—thus, brothers would be related in the first degree, uncle and nephew in the second, &c. In most states representation amongst collaterals is restricted—in some to the descendants of brothers and sisters, in others to their children only.

In some states, *e.g.* in California, Louisiana and Texas, the law of "community property" of husband and wife prevails. This is derived from the French and Spanish law existing in the territories out of which those states were formed, as the result of the conquest of Mexico by Spain and the colonizing of Louisiana by France. The foundation idea is an equal division at death of either party of all property acquired during their marriage except by gift, devise or descent. In general the husband has the control and management thereof during the marriage, and either survivor has the administration of the moiety of the one deceased. There is a conflict in the laws in such states as to the exact definition and as to whether or not the gains or profits of such property are to be deemed separate property or community property [Succession of Dielman (Louisiana, 1907), 43 Southern Rep. 972].

INHIBITION (from Lat. *inhibere*, to restrain, prevent), an act of restraint or prohibition, an English legal term, particularly used in ecclesiastical law, for a writ from a superior to an inferior court, suspending proceedings in a case under appeal, also for the suspension of a jurisdiction of a bishop's court on the visitation of an archbishop, and for that of an archdeacon on the visitation of a bishop. It is more particularly applied to a form of ecclesiastical *censure*, suspending an offending clergyman from the performance of any service of the Church, or other spiritual duty, for the purpose of enforcing obedience to a monition or order of the bishop or judge. Such inhibitions are at the discretion of the ordinary if he considers that scandal might arise from the performance of spiritual duties by the offender (Church Discipline Act 1860, re-enacted by the Clergy Discipline Act 1892, sect. 10). By the Sequestration Act 1871, sect. 5,

similar powers of inhibition are given where a sequestration remains in force for more than six months, and also, by the Benefices Act 1898, in cases where a commission reports that the ecclesiastical duties of a benefice are inadequately performed through the negligence of the incumbent.

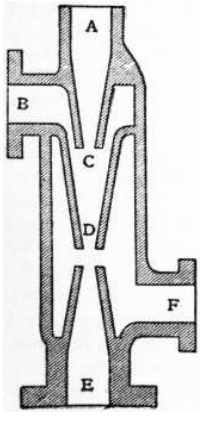
INISFAIL, a poetical name for Ireland. It is derived from *Faul* or *Lia-fail*, the celebrated stone, identified in Irish legend with the stone on which the patriarch Jacob slept when he dreamed of the heavenly ladder. The Lia-fail was supposed to have been brought to Ireland by the Dedannans and set up at Tara as the "inauguration stone" of the Irish kings; it was subsequently removed to Scone where it became the coronation stone of the Scottish kings, until it was taken by James VI. of Scotland to Westminster and placed under the coronation chair in the Abbey, where it has since remained. Inisfail was thus the island of the Fail, the island whose monarchs were crowned at Tara on the sacred inauguration stone.

INITIALS (Lat. *initialis*, of or belonging to a beginning, *initium*), the first letters of names. In legal and formal documents it is usually the practice in appending a signature to write the name in full. But this is by no means necessary, even in cases where a signature is expressly required by statute. It has been held that it is sufficient if a person affixes to a document the usual form in which he signs his name, with the intent that it shall be treated as his signature. So, signature by initials is a good signature within the Statute of Frauds (*Phillimore* v. *Barry*, 1818, I Camp. 513), and also under the Wills Act 1837 (*In re Blewitt*, 1880, 5 P.D. 116).

INITIATION (Lat. *initium*, beginning, entrance, from *inire*, to go in), the process of formally entering, and especially the rite of admission into, some office, or religious or secret society, &c. Among nearly all primitive races initiatory rites of a bloody character were and are common. The savage pays homage to strength, and the purpose of his initiatory rites is to test physical vigour, self-control and the power of enduring pain. Initiation is sometimes religious, sometimes social, but in primitive society it has always the same character. Thus, in Whydah (West Africa) the young girls consecrated to the worship of the serpent, "the brides of the Serpent," had figures of flowers and animals burnt into their skins with hot irons; while in the neighbouring Yorubaland the power of enduring a sound thrashing is the qualification for the throne. In no country was the practice of initiatory rites more general than in the Americas. The Colombian Indians compelled their would-be chief to submit to terrible tests. He had first to bear severe beatings without a murmur. Then, placed in a hammock with his hands tied, venomous ants were placed on his naked body. 570 Finally a fire was lit beneath him. All this he had to bear without flinching. In ancient Mexico there were several orders of chivalry, entry into which was only permitted after brutal initiation. The nose of the candidate was pierced with an eagle's talon or a pointed bone, and he was expected to dig knives into his body. In Peru the young Inca princes had to fast and live for weeks without sleep. Among the North American Indians initiatory rites were universal. The Mandans held a feast at which the young "braves" supported the weight of their bodies on pieces of wood skewered through the muscles of shoulders, breasts and arms. With the Sioux, to become a medicine-man, it was necessary to submit to the ordeal known as "looking at the sun." The sufferer, nearly naked, was bound on the earth by cords passed through holes made in the pectoral muscles. With bow and arrow in hand, he lay in this position all day gazing at the sun. Around him his friends gathered to applaud his courage.

Religious brotherhoods of antiquity, too, were to be entered only after long and complicated initiation. But here the character of the ordeal is rather moral than physical. Such were the rites of admission to the Mysteries of Isis and Eleusis. Secret societies of all ages have been characterized by more or less elaborate initiation. That of the Femgerichte, the famous medieval German secret tribunal, took place at night in a cave, the neophyte kneeling and making oath of blind obedience. Imitations of such tests are perpetuated to-day in freemasonry; while the Mafia, the Camorra, the Clan-na-Gael, the Molly Maguires, the Ku-Klux Klan, are among more recent secret associations which have maintained the old idea of initiation.

INJECTOR (from Lat. *injicere*, to throw in), an appliance for supplying steam-boilers with water, and especially used with locomotive boilers. It was invented by the French engineer H. V. Giffard in 1858, and presents the paradox that by the pressure of the steam in the boiler, or even, as in the case of the exhaust steam injector, by steam at a much lower pressure, water is forced into the boiler against that pressure. A diagrammatic section illustrating its construction is shown in figure. Steam enters at A and blows through the annular orifice C, the size of which can be regulated by a valve not shown in the figure. The feed water flows in at B and meeting the steam at C causes it to condense. Hence a vacuum is produced at C, and consequently the water rushes in with great velocity and streams down the combining cone D, its velocity being augmented by the impact of steam on the back of the column. In the lower part of the nozzle E the stream expands; it therefore loses velocity and, by a well-known hydrodynamic principle, gains pressure, until at the bottom the pressure is so great that it is able to enter the boiler through a check valve which opens only in the direction of the stream. An overflow pipe F, by providing a channel through which steam and water may escape before the stream has acquired sufficient energy to force its way into the boiler, allows the injector to start into action. Means are also provided for regulating the amount of water admitted between D and C. In the *exhaust-steam* injector, which works with steam from



the exhaust of non-condensing engines, the steam orifice is larger in proportion to other parts than in injectors working with boiler steam, and the steam supply more liberal. In *self-starting* injectors an arrangement is provided which permits free overflow until the injector starts into action, when the openings are automatically adjusted to suit delivery into the boiler.

INJUNCTION (from Lat. *injungere*, to fasten, or attach to, to lay a burden or charge on, to enjoin), a term-meaning generally a command, and in English law the name for a judicial process whereby a party is required to refrain from doing a particular thing according to the exigency of the writ. Formerly it was a remedy peculiar to the court of chancery, and was one of the instruments by which the jurisdiction of that court was established in cases over which the courts of common law were entitled to exercise control. The court of chancery did not presume to interfere with the action of the courts, but, by directing an injunction to the person whom it wished to restrain from following a particular remedy at common law, it effected the same purpose indirectly. Under the present constitution of the judicature, the injunction is now equally available in all the divisions of the high court of justice, and it can no longer be used to prevent an action in any of them from proceeding in the ordinary course.

Although an injunction is properly a restraining order, there are instances in which, under the form of a prohibition, a positive order to do something is virtually expressed. Thus in a case of nuisance an injunction was obtained to restrain the defendant from preventing water from flowing in such regular quantities as it had ordinarily done before the day on which the nuisance commenced. But generally, if the relief prayed for is to compel something to be done, it cannot be obtained by injunction, although it may be expressed in the form of a prohibition—as in the case in which it was sought to prevent a person from discontinuing to keep a house as an inn. The injunction was used to stay proceedings in other courts "wherever a party by fraud, accident, mistake or otherwise had obtained an advantage in proceeding in a court of ordinary jurisdiction, which must necessarily make that court an instrument of injustice." As the injunction operates personally on the defendant, it may be used to prevent applications to foreign judicatures; but it is not used to prevent applications to parliament, or to the legislature of any foreign country, unless such applications be in breach of some agreement, and relate to matters of private interest. In so far as an injunction is used to prohibit acts, it may be founded either on an alleged contract or on a right independent of contract. The jurisdiction of the court to prevent breaches of contract has been described as supplemental to its power of compelling specific performance; *i.e.* if the court has power to compel a person to perform a contract, it will interfere to prevent him from doing anything in violation of it. But even when it is not within the power of the court to compel specific performance, it may interfere by injunction; thus, *e.g.* in the case of an agreement of a singer to perform at the plaintiff's theatre and at no other, the court, although it could not compel her to sing, could by injunction prevent her from singing elsewhere in breach of her agreement.

An injunction may as a general rule be obtained to prevent acts which are violations of legal rights, except when the same may be adequately remedied by an action for damages at law. Thus the court will interfere by injunction to prevent waste, or the destruction by a limited owner, such as a tenant for life, of things forming part of the inheritance. Injunctions may also be obtained to prevent the continuance of nuisances, public or private, the infringement of patents, copyrights and trade marks. Trespass might also in certain cases be prevented by injunction. Under the Common Law Procedure Act of 1854, and by other statutes in special cases, a limited power of injunction was conferred on the courts of common law. But the Judicature Act, by which all the superior courts of common law and chancery were consolidated, enacts that an injunction may be granted by an interlocutory order of the court in all cases in which it shall appear to be just or convenient; ... and, if an injunction is asked either before or at or after the hearing of any cause or matter, to prevent any threatened or apprehended waste or trespass, such injunction may be granted whether the person against whom it is sought is or is not in possession under any claim of title or otherwise, or if not in possession does or does not claim to do the act sought to be restrained under colour of any title, and whether the estates claimed are legal or equitable.

An injunction obtained on interlocutory application during the progress of an action is superseded by the trial. It may be continued either provisionally or permanently. In the latter case the injunction is said to be perpetual. The distinction between "special" and "common" injunctions—the latter being obtained as of course—is now abolished in English law.

In the courts of the United States the writ of injunction remains purely an equitable remedy. It may be issued at the instance of the president to prevent any organized obstruction to inter-state commerce or to the passage of the mails (*in re* Debs, 158 United States Reports, 564). Temporary restraining orders may be issued, *ex parte*, pending an application for a temporary injunction. In the state courts temporary injunctions are often issued, *ex parte*, subject to the defendant's right to move immediately for their dissolution. Generally, however, notice of an application for a temporary injunction is required.

For the analogous practice in Scots law see INTERDICT.

INK (from Late Lat. *encaustum*, Gr. ἔγκαυστον, the purple ink used by Greek and Roman emperors, from ἐγκαίειν, to burn in), in its widest signification, a substance employed for producing graphic tracings, inscriptions, or impressions on paper or similar materials. The term includes two distinct conditions of pigment or colouring matter: the one fluid, and prepared for use with a pen or brush, as writing ink; the other a glutinous adhesive mass, printing ink, used for transferring to paper impressions from types, engraved plates and similar surfaces.

The ancient Egyptians prepared and used inks (Flinders Petrie discovered a papyrus bearing written characters as old as 2500 B.C.), and in China the invention of an ink is assigned to Tien-Tcheu, who lived between 2697 B.C. and 2597 B.C. These early inks were prepared from charcoal or soot mixed with gum, glue or varnish. Sepia (*q.v.*), the black pigment secreted by the cuttle-fish, was used as a writing fluid by the Romans. The iron-gall ink, *i.e.* an ink prepared from an iron salt and tannin, appears to have been first described by the monk Theophilus, who lived in the 11th century A.D., although Pliny, in the 1st century A.D., was acquainted with the blackening of paper containing green vitriol by immersion in an infusion of nut-galls. Iron-gall inks, prepared by mixing extracts of galls, barks, &c., with green vitriol, subsequently came into common use, and in the 16th century recipes for their preparation were given in domestic encyclopaedias. Their scientific investigation was first made by William Lewis in 1748. The earlier iron-inks were

essentially a suspension of the pigment in water. In the early part of the 19th century the firm of Stephens introduced the first of the so-called blue-black inks under the name of “Stephens’ writing fluid.” Solutions of green vitriol and tannin, coloured by indigo and logwood, were prepared, which wrote with a blue tint and blackened on exposure, this change being due to the production of the pigment within the pores of the paper. The “alizarine” inks, patented by Leonhardi in 1856, are similar inks with the addition of a little madder. The application of aniline colours to ink manufacture in England dates from Croc’s patent of 1861.

Writing Inks.—Writing inks are fluid substances which contain colouring matter either in solution or in suspension, and commonly partly in both conditions. They may be prepared in all shades of colour, and contain almost every pigment which can be dissolved or suspended in a suitable medium. The most important of all varieties is black ink, after which red and blue are most commonly employed. Apart from colour there are special qualities which recommend certain inks for limited applications, such as marking inks, ineradicable ink, sympathetic ink, &c. A good writing ink for ordinary purposes should continue limpid, and flow freely and uniformly from the pen; it should not throw down a thick sludgy deposit on exposure to the air; nor should a coating of mould form on its surface. It should yield distinctly legible characters immediately on writing, not fading with age; and the fluid ought to penetrate into the paper without spreading, so that the characters will neither wash out nor be readily removed by erasure. Further, it is desirable that ink should be non-poisonous, that it should as little as possible corrode steel pens, that characters traced in it should dry readily on the application of blotting paper without smearing, and that the writing should not present a glossy, varnished appearance.

Tannin Inks.—These inks are prepared from galls, or other sources of tannin, and a salt of iron, with the addition of some agglutinant in the case of the so-called oxidized inks, or a colouring matter in the case of unoxidized inks. Such mixtures form the staple black inks of commerce; they are essentially an insoluble iron gallate in extremely fine division held in suspension in water or a soluble compound dissolved in water.

On long exposure to air, as in inkstands, or otherwise, tannin inks gradually become thick and ropy, depositing a slimy sediment. This change on exposure is inevitable, resulting from the gradual oxidation of the ferrous compound, and it can only be retarded by permitting access of air to as small surfaces as possible. The inks also have a tendency to become mouldy, an evil which may be obviated by the use of a minute proportion of carbolic acid; or salicylic acid may be used.

The essential ingredients of ordinary black ink are—first, tannin-yielding bodies, for which Aleppo or Chinese galls are the most eligible materials; second, a salt of iron, ferrous sulphate (green vitriol) being alone employed; and third, a gummy or mucilaginous agent to keep in suspension the insoluble tinctorial matter of the ink. For ink-making the tannin has first to be transformed into gallic acid. In the case of Aleppo galls this change takes place by fermentation when the solution of the galls is exposed to the air, the tannin splitting up into gallic acid and sugar. Chinese galls do not contain the ferment necessary for inducing this change; and to induce the process yeast must be added to their solution. To prepare a solution of Aleppo galls for ink-making, the galls are coarsely powdered, and intimately mixed with chopped straw. This mixture is thrown into a narrow deep oak vat, provided with a perforated false bottom, and having a tap at the bottom for drawing off liquid. Over the mixture is poured lukewarm water, which, percolating down, extracts and carries with it the tannin of the galls. The solution is drawn off and repeatedly run through the mixture to extract the whole of the tannin, the water used being in such proportion to the galls as will produce as nearly as possible a solution having 5% of tannin. The object of using straw in the extraction process is to maintain the porosity of the mixture, as powdered galls treated alone become so slimy with mucilaginous extract that liquid fails to percolate the mass. For each litre of the 5% solution about 45 grammes of the iron salt are used, or about 100 parts of tannin for 90 parts of crystallized green vitriol. These ingredients when first mixed form a clear solution, but on their exposure to the air oxidation occurs, and an insoluble blue-black ferrosoferric gallate in extremely fine division, suspended in a coloured solution of ferrous gallate, is formed. To keep the insoluble portion suspended, a mucilaginous agent is employed, and those most available are gum senegal and gum arabic. An ink so prepared develops its intensity of colour only after some exposure; and after it has partly sunk into the paper it becomes oxidized there, and so mordanted into the fibre. As the first faintness of the characters is a disadvantage, it is a common practice to add some adventitious colouring matter to give immediate distinctness, and for that purpose either extract of logwood or a solution of indigo is used. When logwood extract is employed, a smaller proportion of extract of galls is required, logwood itself containing a large percentage of tannin. For making an unoxidized or blue-black ink indigo is dissolved in strong sulphuric acid, and the ferrous sulphate, instead of being used direct, is prepared by placing in this indigo solution a proper quantity of scrap iron. To free the solution from excess of uncombined acid, chalk or powdered limestone is added, whereby the free acid is fixed and a deposit of sulphate of lime formed. A solution so prepared, mixed with a tannin solution, yields a very limpid sea-green writing fluid, and as all the constituents remain in solution, no gum or other suspending medium is necessary. In consequence the ink flows freely, is easily dried and is free from the glossy appearance which arises through the use of gum.

China ink or *Indian ink* is the form in which ink was earliest prepared, and in which it is still used in China and Japan for writing with small brushes instead of pens. It is extensively used by architects, engineers and artists generally, and for various special uses. China ink is prepared in the form of sticks and cakes, which are rubbed down in water for use. It consists essentially of lamp-black in very fine condition, baked up with a glutinous substance; and the finer Oriental kinds are delicately perfumed. The following description of the manufacture as conducted in Japan is from a native source:—

> “The body of the ink is soot obtained from pine wood or rosin, and lamp-black from sesamum oil for the finest sort. This is mixed with liquid glue made of ox-skin. This operation is effected in a large round copper bowl, formed of two spherical vessels, placed 1 in. apart, so that the space between can be filled up with hot water to prevent the glue from hardening during the time it is being mixed by hand with the lamp-black. The cakes are formed in wooden moulds, and dried between paper and ashes. Camphor, or a peculiar mixture of scents which comes from China, and a small quantity of carthamine (the red colouring substance of safflower), are added to the best kinds for improving the colour as well as for scenting the ink. There is a great difference both in price and in quality of the various kinds of ink, the finest article being rather costly.”

It is said that the size used in Chinese kinds is of vegetable origin.

Logwood Ink.—Under the name of chrome ink a black ink was discovered by Runge, which held out the promise of cheapness combined with many excellent qualities. It is prepared by dissolving 15 parts of extract of logwood in 900 parts of water, to which 4 parts of crystallized sodium carbonate are added. A further solution of 1 part of potassium chromate (not bichromate) in 100 parts of water is prepared, and is added very gradually to the other solution with constant agitation. The ink so obtained possesses an intense blue-black colour, flows freely and dries readily, is neutral in reaction and hence does not corrode steel pens, and adheres to and sinks into paper so that manuscripts written with it may be freely washed with a sponge without danger of smearing or spreading. It forms a good copying ink, and it possesses all the qualities essential to the best ink; but on exposure to air it very readily undergoes decomposition, the

colouring matter separating in broad flakes, which swim in a clear menstruum. It is affirmed by Viedt that this drawback may be overcome by the use of soda, a method first suggested by Böttger.

Logwood forms the principal ingredient in various other black inks used, especially as copying ink. A very strong decoction of logwood or a strong solution of the extract with ammonium-alum yields a violet ink which darkens slowly on exposure. Such an ink is costly, on account of the concentrated condition in which the logwood must be used. If, however, a metallic salt is introduced, a serviceable ink is obtained with the expenditure of much less logwood. Either sulphate of copper or sulphate of iron may be used, but the former, which produces a pleasing blue-black colour, is to be preferred. The following is the formula most highly recommended for this ink. A clear solution of 20 kilos of extract of logwood in 200 litres of water is obtained, to which is added, with agitation, 10 kilos of ammonium-alum dissolved in 20 litres of boiling water. The solution is acidified with 0.2 kilo of sulphuric acid, which has the effect of preventing any deposit, and finally there is added a solution of 1.5 kilos of sulphate of copper dissolved in 20 litres of water. This compound is exposed to the air for a few days to allow the colour to develop by oxidation, after which it is stored in well-corked bottles. The acid condition of this ink has a corrosive influence on steel pens; in all other respects it is a most valuable writing fluid.

Aniline Inks.—Solutions of aniline dye-stuffs in water are widely used as inks, especially coloured varieties. They are usually fugitive. Nigrosine is a black ink, which, although not producing a black so intense as common ink, possesses various advantages. Being perfectly neutral, it does not attack pens; it can easily be kept of a proper consistency by making up with water; and its colour is not injuriously affected by the action of acids. Its ready flow from stylographic pens led to the name “stylographic ink.” Other aniline inks are mentioned below.

Copying Ink.—Ink which yields by means of pressure an impression, on a sheet of damped tissue paper, of characters written in it is called copying ink. Any ink soluble in water, or which retains a certain degree of solubility, may be used as copying ink. Runge’s chrome ink, being a soluble compound, is, therefore, so available; and the other logwood inks as well as the ordinary ferrous gallate inks contain also soluble constituents, and are essentially soluble till they are oxidized in and on the paper after exposure to the air. To render these available as copying inks it is necessary to add to them a substance which will retard the oxidizing effect of the air for some time. For this purpose the bodies most serviceable are gum arabic or senegal, with glycerin, dextrin or sugar, which last, however, renders the ink sticky. These substances act by forming a kind of glaze or varnish over the surface of the ink which excludes the air. At the same time when the damp sheet of tissue paper is applied to the writing, they dissolve and allow a portion of the yet soluble ink to be absorbed by the moistened tissue. As copying ink has to yield two or more impressions, it is necessary that it should be made stronger, *i.e.* that it should contain more pigment or body than common ink. It, therefore, is prepared with from 30 to 40% less of water than non-copying kinds; but otherwise, except in the presence of the ingredients above mentioned, the inks are the same. Copying ink pencils consist of a base of graphite and kaolin impregnated with a very strong solution of an aniline colour, pressed into sticks and dried.

Red Ink.—The pigment most commonly employed as the basis of red ink is Brazil-wood. Such an ink is prepared by adding to a strong decoction of the wood a proportion of stannous chloride (tin spirits), and thickening the resulting fluid with gum arabic. In some instances alum and cream of tartar are used instead of the stannous chloride. Cochineal is also employed as the tinctorial basis of red ink; but, while the resulting fluid is much more brilliant than that obtained from Brazil-wood, it is not so permanent. A very brilliant red ink may be prepared by dissolving carmine in a solution of ammonia, but this preparation must be kept in closely stoppered bottles. A useful red ink may also be made by dissolving the rosein of Brook, Simpson and Spiller in water, in the proportion of 1 to from 150 to 200 parts.

Blue Ink.—For the production of blue ink the pigment principally used is Prussian blue. It is first digested for two or three days with either strong hydrochloric acid, sulphuric acid or nitric acid, the digested mass is next very largely diluted with water, and after settling the supernatant liquid is siphoned away from the sediment. This sediment is repeatedly washed, till all traces of iron and free acid disappear from the water used, after which it is dried and mixed with oxalic acid in the proportion of 8 parts of Prussian blue to 1 of the acid, and in this condition the material is ready for dissolving in water to the degree of colour intensity necessary. An aniline blue ink may be prepared by dissolving 1 part of bleu de Paris in from 200 to 250 parts of water.

Marking Ink.—The ink so called, used principally for marking linen, is composed of a salt of silver, usually the nitrate, dissolved in water and ammonia, with a little provisional colouring matter and gum for thickening. The colour resulting from the silver salt is developed by heat and light; and the stain it makes, although exceedingly obstinate, gradually becomes a faint brownish-yellow. The following yields a good marking ink. Equal parts of nitrate of silver and dry tartaric acid are triturated in a mortar, and treated with water, when a reaction takes place, resulting in the formation of tartrate of silver and the liberation of nitric acid. The acid is neutralized, and at the same time the silver tartrate is dissolved by the addition of ammonia, and this solution with colouring matter and gum forms the ink, which may be used with an ordinary steel pen.

Many vegetable juices, *e.g.* of *Coriaria thymifolia*, *Semecarpus anacardium*, *Anacardium occidentale* (Cashew), are inks of this type.

Gold and *silver inks* are writing fluids in which gold and silver, or imitations of these metals, are suspended in a state of fine division. In place of gold, Dutch leaf or mosaic gold is frequently substituted, and bronze powders are used for preparing a similar kind of ink. The metallic foil is first carefully triturated into a fine paste with honey, after which it is boiled in water containing a little alkali, and then repeatedly washed in hot water and dried at a gentle heat. A solution is prepared consisting of 1 part of pure gum arabic and 1 part of soluble potash glass in 4 parts of distilled water, into which the requisite quantity of the metallic powder prepared is introduced. Owing to the superior covering nature of pure gold, less of the metal is required than is necessary in the case of silver and other foils. In general 1 part of foil to 3 or 4 parts of solution is sufficient. The metallic lustre of writing done with this solution may be greatly heightened by gently polishing with a burnishing point. Another gold ink depends upon the formation of purple of Cassius; the linen is mordanted with stannous chloride, and the gold applied as a gummy solution of the chloride.

Indelible or *incorrodible ink* is the name given to various combinations of lamp-black or other carbonaceous material with resinous substances used for writing which is exposed to the weather or to the action of strong acids or alkaline solutions. An ink having great resisting powers may be conveniently prepared by rubbing down Indian ink in common ink till the mixture flows easily from the pen. Other combinations have more the character of coloured varnishes.

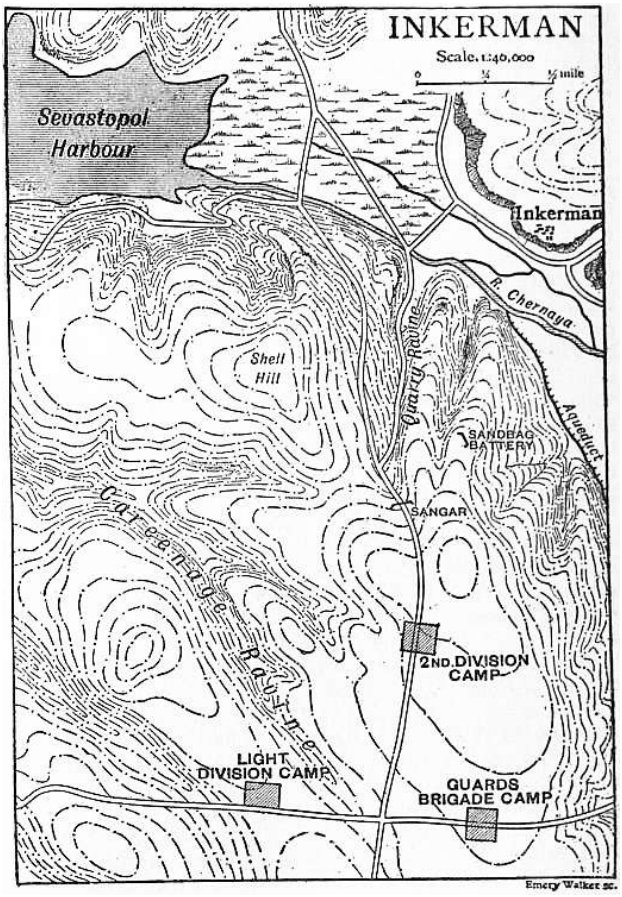
Sympathetic inks are preparations used for forming characters which only become visible on the application of heat or of some chemical reagent. Many chemicals which form in themselves colourless solutions, but which develop colour under the influence of reagents, may be used as sympathetic ink, but they are of little practical utility. Characters written in a weak solution of galls develop a dark colour on being treated with a solution of copperas; or, vice versa, the writing may be done in copperas and developed by the galls solution. Writing done in various preparations develops colour on heating which fades as the paper cools. Among such substances are solutions of the chlorides of cobalt and of nickel. Very dilute solutions of the mineral acids and of common salt and a solution of equal parts of sulphate of copper

and sal-ammoniac act similarly. Writing with rice water and developing with iodine was a device much used during the Indian Mutiny.

Printing Inks.—Printing inks are essentially mixtures of a pigment and a varnish. The varnish is prepared from linseed oil, rosin and soap; the oil must be as old as possible; the rosin may be black or amber; and the soap, which is indispensable since it causes the ink to adhere uniformly to the type and also to leave the type clean after taking an impression, is yellow, or turpentine soap for dark inks, and curd soap for light inks. The varnish is prepared as follows: The oil is carefully heated until it "strings" properly, *i.e.* a drop removed from the vessel on a rod, when placed upon a plate and the rod drawn away, forms a thread about ½ in. long. The rosin is carefully and slowly added and the mixture well stirred. The soap is then stirred in. The ink is prepared by mixing the varnish with the pigment, and grinding the mass to impalpable fineness either in a levigating mill or by a stone and muller. For black ink, lamp-black mixed with a little indigo or Prussian blue is the pigment employed; for wood engravings it may be mixed with ivory black, and for copper plates with ivory or Frankfurt black; for lithographic reproductions Paris black is used. Red inks are made with carmine or cochineal; red lead is used in cheap inks, but it rapidly blackens. Blue inks are made with indigo or Prussian blue; yellow with lead chromate or yellow ochre; green is made by mixing yellow and blue; and purple by mixing red and blue.

See C. A. Mitchell and T. C. Hepworth, *Inks, their Composition and Manufacture* (1904); S. Lehner, *Ink Manufacture* (1902); A. F. Gouillon, *Encres et cirages* (1906); L. E. Andés, *Schreib-, Kopier- und andere Tinten* (1906).

INKERMAN, BATTLE OF, fought on the 5th of November 1854 between a portion of the Allied English and French army besieging Sevastopol and a Russian army under Prince Menshikov (see Crimean War). This battle derives its name from a ruin on the northern bank of the river Tchernaya near its mouth, but it was fought some distance away, on a nameless ridge (styled Mount Inkerman after the event) between the Tchernaya and the Careenage Ravine, which latter marked the right of the siege-works directed against Sevastopol itself. Part of this ridge, called Home Ridge and culminating in a knoll, was occupied by the British, while farther to the south, facing the battleground of Balaklava, a corps under General Bosquet was posted to cover the rear of the besiegers against attacks from the direction of Traktir Bridge. The Russians arranged for a combined attack on the ridge above-mentioned by part of Menshikov's army (16,000) and a corps (19,000) that was to issue from Sevastopol. This attack was to have, beside its own field artillery, the support of fifty-four heavy guns, and the Russian left wing on the Balaklava battleground was to keep Bosquet occupied. If successful, the attack on the ridge was to be the signal for a general attack all along the line. It was apparently intended by Menshikov that the column from the field army should attack the position from the north, and that the Sevastopol column should advance along the west side of the Careenage Ravine. But he only appointed a commander to take charge of both columns at the last moment, and the want of a clear understanding as to what was to be done militated against success from the first. General Soimonov, with the Sevastopol column, after assembling his troops before dawn on the 5th, led them on to the upland east of Careenage Ravine, while the field army column, under General Pavlov, crossed the Tchernaya near its mouth, almost at right angles to Soimonov's line of advance.



The British troops on or near the ground were the 2nd Division, 3000, encamped on the ridge; Codrington's brigade of the Light Division, 1400, on the slopes west of the Careenage Ravine; and the Guards' brigade, 1350, about ¾ m. in rear of the 2nd Division camp. No other forces, French or British, were within 2 m. except another part of Sir George Brown's Light Division. A mist overhung the field and the hillsides were slippery with mud. Soimonov, with his whole

force deployed in a normal attack formation (three lines of battalion columns covered by a few hundred skirmishers) pushed forward along the ridge (6 A.M.) without waiting for Pavlov or for Dannenberg, the officer appointed to command the whole force. Shell Hill, guarded only by a picquet, was seized at once. The heavy guns that had been brought from the fortress were placed in position on this hill, and opened fire (7 A.M.) on the knoll, 1400 yds. to the S., behind which the 2nd Division was encamped. The Russian infantry halted for the guns to prepare the way, and the heavy projectiles both swept the crest of the British knoll and destroyed the camp in rear. But already General Pennefather, commanding the division, had pushed forward one body of his infantry after another down the forward slope, near the foot of which they encountered the Russians in great force. On his side, Soimonov had been compelled to break up his regular lines of columns at the narrowest part of the ridge and to push his battalions forward a few at a time. This and the broken character of the ground made the battle even in the beginning a mêlée. The obscurity of the mist, which had at first allowed the big battalions to approach unobserved, now favoured the weaker side. Soimonov himself, however, formed up some 9000 men, who drove back the British left wing—for the whole of Pennefather's force at the time was no more than 3600 men. But the right wing, not as yet attacked, either by Soimonov or by Pavlov, held on to its positions on the forward slope, and a column of Russian sailors and marines, who had been placed under Soimonov's command and had moved up the Careenage Ravine to turn the British left, were caught, just as they emerged on to the plateau in rear of Pennefather's line, between two bodies of British troops hurrying to the scene of action. On the front, too, the Russian attack came to a standstill and ebbed, for Soimonov's overcrowded battalions jostled one another and dissolved on the narrow and broken plateau. Soimonov himself was killed, and the disciplined confidence and steady volleys of the defenders dominated the chaotic *élan* of the Russians. Thus 3300 defenders were able to repulse and even to "expunge from the battlefield" the whole of the Sevastopol column, except that portion of it which drifted away to its left and joined Pavlov. This stage of the battle had lasted about forty minutes. But, brilliant as was this overture, it is the second stage of the battle that gives it its epic interest.

The first attack made by Pavlov's advanced guard, aided by parts of Soimonov's corps, was relatively slight, but General Dannenberg now arrived on the field, and arranged for an assault on the British centre and right, to be delivered by 10,000 men (half his intact forces) chiefly by way of the Quarry Ravine, the attack to be prepared by the guns on Shell Hill. Pennefather had been reinforced by the Guards' brigade and a few smaller units. Not the least extraordinary feature of the battle that followed is the part played by a sangar of stones at the head of Quarry Ravine and a small battery, called the Sandbag Battery, made as a temporary emplacement for two heavy guns a few days before. The guns had done their work and been sent back whence they came. Nevertheless these two insignificant works, as points to hold and lines to defend on an otherwise featureless battlefield, became the centres of gravity of the battle.

The sangar at first fell into the hands of the Russians, but they were soon ejected, and small British detachments reoccupied and held it, while the various Russian attacks flowed up and past it and ebbed back into the Quarry Ravine. Possession of the Sandbag Battery was far more fiercely contested. The right wing was defended by some 700 men of the 2nd Division, who were reinforced by 1300 of the Guards. The line of defence adjacent to the battery looked downhill for about 300 yds., giving a clear field of fire for the new Enfield rifle the English carried; but a sharp break in the slope beyond that range gave the assailants plenty of "dead ground" on which to form up. For a time, therefore, the battle was a series of attacks, delivered with great fierceness by the main body of Pavlov's corps, the repulse of each being followed by the disappearance of the assailants. But the arrival of part of the British 4th Division under Sir George Cathcart gave the impulse for a counter-attack. Most of the division indeed had to be used to patch up the weaker parts of the line, but Cathcart himself with about 400 men worked his way along the lower and steeper part of the eastern slope so as to take the assailants of the battery in flank. He had not proceeded far, however, when a body of Russians moving higher up descended upon the small British corps and scattered it, Cathcart himself being killed. Other counterstrokes that his arrival had inspired were at the same time made from different parts of the defensive front, and had the effect of breaking up what was a solid line into a number of disconnected bands, each fighting for its life in the midst of the enemy. The crest of the position was laid open and parts of the Russian right wing seized it. But they were flung back to the lower slopes of the Quarry Ravine by the leading French regiment sent by Bosquet. This regiment was quickly followed by others. The last great assault was delivered with more precision, if with less fury than the others, and had Dannenberg chosen to employ the 9000 bayonets of his reserve, who stood idle throughout the day, to support the 6000 half-spent troops who made the attack, it would probably have been successful.

As it was, supported by the heavy guns on Shell Hill, the assailants, though no longer more than slightly superior in numbers, carried not only the sangar, but part of the crest line of the allied position. But they were driven back into the Quarry Ravine, and, relieving the exhausted British, the French took up the defence along the edge of the ravine, which, though still not without severe fighting, they maintained till the close of the battle. Inkerman, however, was not a drawn battle. The allied field artillery, reinforced by two long 18-pr. guns of the British siege train and assisted by the bold advance of two French horse-artillery batteries which galloped down the forward slope and engaged the Russians at close range, gained the upper hand. Last of all, the dominant guns on Shell Hill thus silenced, the resolute advance of a handful of British infantry decided the day, and the Russians retreated. The final shots were fired about 1.30 P.M.

The total British force engaged was 8500, of whom 2357 were killed and wounded. The French lost 939 out of about 7000 who came on to the field, though not all these were engaged. The Russians are said to have lost 11,000 out of about 42,000 present. The percentage (27.7) of loss sustained by the British is sufficient evidence of the intensity of the conflict, and provides a convincing answer to certain writers who have represented the battle as chiefly a French affair. On the other hand, the reproaches addressed by some British writers to General Bosquet for not promptly supporting the troops at Inkerman with his whole strength are equally unjustifiable, for apparently Sir George Brown and Sir George Cathcart both declined his first offers of support, and he had Prince Gorchakov with at least 20,000 Russians in his own immediate front. He would therefore have risked the failure of his own mission in order to take part in a battle where his intervention was not, so far as he could tell, of vital importance. When Lord Raglan definitely asked him for support, he gave it willingly and eagerly, sending his troops up at the double, and it must be remembered that several British divisions took no part in the action for the same reason that actuated Bosquet. But, in spite of the seemingly inevitable controversies attendant on an "allied" battle, it is now generally admitted that, as a "soldiers' battle," Inkerman is scarcely to be surpassed in modern history.

INLAYING, a method of ornamentation, by incrusting or otherwise inserting in one material a substance or substances differing therefrom in colour or nature. The art is practised in the fabrication of furniture and artistic objects in all varieties of wood, metal, shell, ivory and coloured, and hard stone, and in compound substances; and the combinations, styles and varieties of effect are exceedingly numerous. Several special classes of inlaying may be here enumerated and defined, details regarding most of which will be found under their separate headings. In the

ornamental treatment of metal surfaces *Niello* decoration, applied to silver and gold, is an ancient and much-practised species of inlaying. It consists in filling up engraved designs with a composition of silver, copper, lead and sulphur incorporated by heat. The composition is black, and the finished work has the appearance of a drawing in black on a metallic plate. An art, analogous in effect, called *bidri*, from Bider in the Deccan, is practised in India. In bidri work the ground is an alloy of zinc, with small proportions of copper and lead, in which shallow patterns and devices are traced, and filled up with thin plates of silver. When the surface has been evened and smoothed, the bidri ground is stained a permanent black by a paste the chief ingredients of which are sal-ammoniac and nitre, leaving a pleasing contrast of bright metallic silver in a dead black ground. The inlaying of gold wire in iron or steel is known as Damascening (*q.v.*). It has been very largely practised in Persia and India for the ornamentation of arms and armour, being known in the latter country as Kuft work or Kuftgari. In Kashmir, vessels of copper and brass are very effectively inlaid with tin—an art which, like many other decorative arts, appears to have originated in Persia. In the ornamental inlaying of metal surfaces the Japanese display the most extraordinary skill and perfection of workmanship. In the inlaying of their fine bronzes they use principally gold and silver, but for large articles and also for common cast hollow ware commoner metals and alloys are employed. In inlaying bronzes they generally hollow out and somewhat undercut the design, into which the ornamenting metal, usually in the form of wire, is laid and hammered over. Frequently the lacquer work of the Japanese is inlaid with mother-of-pearl and other substances, in the same manner as is practised in ornamenting lacquered papier-mâché among Western communities. The Japanese also practise the various methods of inlaying referred to under Damascening. The term *Mosaic* (*q.v.*) is generally applied to inlaid work in hard stones, marble and glass, but the most important class of mosaics—those which consist of innumerable small separate pieces—do not properly come under the head of inlaying. Inlaid mosaics are those in which coloured designs are inserted in spaces cut in a solid ground or basis, such as the modern Florentine mosaic, which consists of thin veneers of precious coloured stones set in slabs of marble. The Taj Mahal at Agra is an example of inlaid mosaic in white marble, and the art, carried to that city by a French artist, is still practised by native workmen. *Pietra dura* is a fine variety of inlaid mosaic in which hard and expensive stones—agate, cornelian, amethyst and the like—are used in relief. Certain kinds of enamel might also be included among the varieties of inlaying. (See also Marquetry and Bombay Furniture.)

INMAN, HENRY (1801-1846), American artist, was born in Utica, New York, on the 20th of October 1801. Apprenticed to the painter John W. Jarvis at the age of fourteen, he left him after seven years and set up for himself, painting portraits, genre and landscape. He was one of the organizers of the National Academy of Design in New York and its first vice-president (from 1826 until 1832). As a portrait painter he was highly successful both in New York and Philadelphia, and going to England in 1844, he had for sitters the Lord Chancellor (Cottenham), the poet Wordsworth, Doctor Chalmers, Lord Macaulay and others. His American sitters included President Van Buren and Chief Justice Marshall. He died in New York City on the 17th of January 1846.

INN, a river of Europe, an important right bank tributary of the Danube. It rises at an elevation of 7800 ft., in a small lake under the Piz Longhino, in the Swiss canton of the Grisons. After flowing for a distance of 55 m., through the Engadine it leaves Swiss territory at Martinsbruck and enters Austria. It next plunges through the deep ravine of Finstermünz, and, continuing in the main a north-easterly direction, receives at Landeck the Rosanna. Hence its course becomes more rapid, until, after swirling through the narrow and romantic Oberinnthal, it enters the broader and pastoral Unterinnthal. It next passes Innsbruck and from Hall, a few miles lower down, begins to be navigable for barges. At Kufstein, down to which point it has still pursued a north-easterly direction, it breaks through the north Tirol limestone formation, and, now keeping a northerly course, enters at Rosenheim the Bavarian high plateau. Its bed is now broad, studded with islands and enclosed by high banks. Its chief tributaries on this last portion of its course are the Alz and the Salzach, and at Passau, 309 m. from its source, it joins the Danube, which river down to that point it equals in length and far exceeds in volume of water. Its rapid current does not permit of extensive navigation, but timber rafts are floated down from above Innsbruck.

See Greinz, *Eine Wanderung durch das Unterinntal* (Stuttgart, 1902).

INN and **INNKEEPER.** An inn is a house where travellers are fed and lodged for reward. A distinction has been drawn between tavern, inn and hotel, the tavern supplying food and drink, the hotel lodging, the inn both; but this is fanciful. “Hotel” now means “inn,” and “inn” is often applied to a mere public-house, whilst “tavern” is less used. “Inn,” still the legal and best, as it is the oldest, is a form of the word “in” or “within.” This sense is retained in the case of the English legal societies still known as Inns of Court (*q.v.*). In the Bible “inn” means “lodging-place for the night.” Hospitality has always been a sacred duty in the East. The pilgrim or the traveller claims it as a right. But some routes were crowded, as that from Bagdad to Babylon. On these, *khans* (in or near a town) and *caravanserais* (in waste places) were erected at the expense of the benevolent. They consisted of a square building surrounded by a high wall; on the roof there was a terrace and over the gateway a tower; inside, was a large court surrounded by compartments in which was some rude provision for the animals and baggage of the traveller as well as for himself. The latter purchased his own food where he chose, and had to “do for himself.” In some such place Jesus was born. Tavern is mentioned once in Scripture (Acts xxviii. 15) where it is said the brethren from Rome met Paul at “the Three Taverns.” This was a station on the Appian Way, referred to also in Cicero’s *Letters* (*Ad Att.* ii. 12). So, in modern London, stations are called “Elephant and Castle,” or “Bricklayers’ Arms,” from adjacent houses of entertainment. Among the Greeks inns and innkeepers were held in low repute. The houses were bad and those who kept them had a bad name. A self-respecting Greek entered them as seldom as possible; if he travelled he relied on the hospitality of friends. In Rome under the emperors something akin to the modern inn grew up. There is, however, scarcely any mention of such institutions in the capital as distinguished from mere wine-shops or eating-houses. Ambassadors were lodged in apartments at the expense of the state. But along the great roads that radiated from Rome there were inns. Horace’s account of his journey to Brundisium (*Sat.* i. 5), that brilliant picture of contemporary travel, tells us of their existence, and the very

name of the Three Taverns shows that there was sufficient custom to support a knot of these institutions at one place. Under the Roman law, the innkeeper was answerable for the property of his guests unless the damage was due to *damnum fatale* or *vis major*, in modern language the act of God or the king's enemies. He was also liable for damage done by his servant or his slave or other inhabitant of the house.

In the middle ages hospitality was still regarded as a duty, and provision for travellers was regularly made in the monasteries. People of rank were admitted to the house itself, others sought the guest-chamber, which sometimes stood (as at Battle Abbey) outside the precincts. It consisted of a hall, round which were sleeping-rooms, though the floor of the hall itself was often utilized. Again, hospitality was rarely denied at the castle or country house. The knight supped with his host at the daïs or upper part of the great hall, and retired with him into his own apartment. His followers, or the meaner strangers, sat lower down at meat, and after the tables had been removed stretched themselves to rest upon the floor. In desolate parts hospices were erected for the accommodation of pilgrims. Such existed in the Alps and on all the great roads to the Holy Land or to famous shrines, notably to that of Canterbury. The still impressive remains of the Travellers' Hospital at Maidstone, founded by Archbishop Boniface in 1260, give an idea of the extent of such places. The mention of Canterbury recalls two inns celebrated by Chaucer. The pilgrims started from the "Tabard" at Southwark under the charge of Harry Baily the host, and they put up at the "Checquers of the Hope," in Mercery Lane, Canterbury. It is easy to infer that, as time went on, the meagre hospitality of the monastery or the hospice was not sufficient for an increasing middle class, and that the want was met by the development of the mere ale-house into the inn. The "ale-house," to give it the old English name, was always in evidence, and even in pre-Reformation days was a favourite subject for the satirist. In Langland's *Piers the Plowman* and in Skelton's *Elynour Rummynge* we have contemporary pictures of ale-houses of the 14th and 16th centuries, but the Tabard is quite a modern inn, with a *table d'hôte* supper, a sign, a landlord ("right a mery man") and a reckoning!

It has been conjectured (Larwood and Hotten, *History of Signboards*, 1874) that the inn sign was taken or imitated from that displayed on the town houses or *inns* of noblemen and prelates. The innkeeper alone of tradesmen retains his individual sign. The inn shared with the tavern the long projecting pole garnished with branches. These poles had become of such inordinate length in London that in 1375 they were restricted to 7 ft. But the inn of those times was still a simple affair. In each room there were several beds, the price of which the prudent traveller inquired beforehand. Extortion was frequent, though it was forbidden by a statute of Edward III. The fare was simple; bread, meat and beer, with fish on Fridays. The tavern sentiment is strong in Elizabethan literature. The "Boar's Head" in Eastcheap is inseparably connected with Sir John Falstaff and Dame Quickly. "Shall I not take mine ease in mine Inn?" (1 Henry IV., Act iii. sc. 3) is well-nigh the most famous word of the famous knight. A passage in Holinshed's *Chronicle* (1587, i. 246) explains the inner meaning of this. He assures us that the inns of England are not as those of other lands. Abroad the guest is under the tyranny of the host, but in England your inn is as your own house; in your chamber you can do what you will, and the host is rather your servant than your master. The "Mermaid" in Bread Street is associated with the memory of many wits and poets—Raleigh, Shakespeare, Beaumont, Fletcher, Ben Jonson—who frequented it and praised it.

Shenstone's lines as to "the warmest welcome at an inn" vent a common but rather cheap cynicism. Doctor Johnson was a great frequenter of inns and was outspoken in praise and blame. In the time immediately preceding railways the inn, which was also a post-house where the public coach as well as that of the private traveller changed horses, was a place of much importance. We have it presented over and over again in the pages of Dickens. The "Maypole" in *Barnaby Rudge* may be singled out for mention; it survives at Chigwell, Essex, as the "King's Head."

The effect of railways was to multiply hotels in great centres and gradually increase their size till we have the huge structures so plentiful to-day. The bicycle and later the motor car, through the enormous traffic they caused on the country roads, have restored the old wayside inns to more than their former prosperity.

In Scotland a statute (1424) of James I. ordained inns for man and beast, with food and drink at reasonable prices, in each borough, and a subsequent act prohibited lodging in private houses in places where there were inns, under a penalty of 40s. But for centuries the Scots inn was a poor affair. The Clachan of Aberfoyle in *Rob Roy*, kept by the widow MacAlpine, was probably typical. In *St Ronan's Well* Scott gives the more pleasing picture of the Cleikum Inn, kept by the delightful Meg Dods, and mention should be made of St Mary's Cottage, with its hostess Tibby Shiels, the scene of one of the *Noctes Ambrosianae*, with memories not merely of Scott but of Christopher North and the Ettrick Shepherd. Burns had much to do with inns and taverns. If Poosie Nancie's, where the Jolly Beggars held wild revel, is long vanished, the Globe at Dumfries still exists, a fair sample of an inn of the period. As late as 1841 Dickens, writing to John Foster during his first visit to Scotland, describes the Highland inns as very poor affairs, "a mere knot of little outhouses" he says of one; and even in Queen Victoria's *Leaves from the Journal of Our Life in the Highlands* the inn is described as invariably small and unassuming. Thus the development of hotels in Scotland did not begin much before the middle of the 19th century.

In America the first hotel mentioned in New York is "Kriger's Tavern" about 1642, replaced in 1703 by the "King's Arms." When the town came to be English a proclamation was issued regulating the inns. Meals were not to cost more than 8d. or beer 2d. per quart.

Law Relating to Innkeepers.—Whether any special building is an inn is a question of fact. A temperance hotel is an inn, but a mere public-house is not. An innkeeper is bound to receive, lodge and feed travellers if he has accommodation, if they are able and willing to pay, and are not obviously objectionable. If he refuse he is liable at common law to indictment, or an action will lie against him at the suit of the would-be guest. Under the Army Act soldiers of all kinds may be billeted on the innkeeper, even beyond his power to provide in his own house; he must find accommodation for them elsewhere. An innkeeper must keep the goods and chattels of his guest in safety, unless they are destroyed by the act of God or the king's enemies. Under this last the king's rebellious subjects are not included. He is not liable for goods stolen or destroyed by the companion of the guest or through the guest's own negligence. There are two theories as to the origin of this common law liability of the innkeeper: (1) it was a survival of the liability of the common trader, or (2) specially imposed from the nature of his calling. Old English law held him to some extent suspect. The traveller amongst strangers seemed forlorn and unprotected, and conspiracy with thieves was dreaded. In modern times the landlord's responsibilities were cut down by the Innkeepers Liability Act 1863. He is not liable (save for horses and other live animals with their gear and carriages) to a greater extent than £30, unless the loss is caused by the default or neglect of himself or his servants, or the goods have been formally deposited with him. He must conspicuously exhibit a copy of the material parts of the act. The innkeeper may contract himself out of his common law obligation, and, apart from negligence, he is not liable for injury to the person or clothes of his guest. In return for these responsibilities the law gives him a lien over his guest's goods till his bill be paid. This is a particular and not a general lien. It attaches only to the special goods brought by the guest to the inn, and housed by the innkeeper with him. When several guests go together, the lien extends to all their goods. The innkeeper is only bound to take ordinary care of goods thus held, but he cannot use them or charge for their house-room. By the custom of London and Exeter, "when a horse eats out the price of his head," namely, when the cost of keep exceeds value, the host may have him as his own. By the Innkeepers Act 1878, if goods have been kept for six weeks they may be advertised and then sold after

the interval of a month. Although an advertisement in a London paper is directed, this act (it would seem) applies to Scotland (J. A. Fleming, in Green's *Encyclopaedia of the Law of Scotland*, vi. 363). In that country the law is generally the same as in England, though it has been held that the innkeeper is not responsible for loss by accidental fire. Nor is his refusal to receive a guest a criminal offence. In the United States the common law follows that of England, though laws of the various states have diminished the liability of the innkeeper in much the same fashion as in England. Innkeepers as retailers of intoxicating liquors are subject to the provisions of the Licensing Laws.

See Angus, *Bible Handbook* (new ed., 1904); Beckmann's *Inventions*, tr. by Johnson (1846); Jusserand, *Les Anglais au moyen âge* (1884); Liebenau, *Das Gasthof- und Wirtshauswesen der Schweiz in älterer Zeit* (1891); Kempt, *Convivial Caledonia* (1893); F. W. Hackwood, *Inns, Ales and Drinking Customs of Old England* (1909); Jelf and Hurst, *The Law of Innkeepers* (1904). English and Roman law are compared in Pymar's *Law of Innkeepers* (1892). For Scots law, see Bell's *Principles*. An American treatise is S. H. Wandell, *Law of Inns, Hotels and Boarding Houses* (1888).

(F. Wa.)

INNERLEITHEN, a police burgh and health resort of Peeblesshire, Scotland, on Leithen Water, near its junction with the Tweed, 6½ m. S.E. of Peebles by the North British railway. Pop. (1901) 2181. In olden times it seems to have been known as Hornehuntersland, and to have been mentioned as early as 1159, when a son of Malcolm IV. (the Maiden) was drowned in a pool of the Tweed, close to Leithenfoot. Its chief industry is the manufacture of tweeds and fine yarns, which, together with the fame of its medicinal springs, brought the burgh into prominence towards the end of the 18th century. The spa, alleged to be the St Ronan's well of Scott's novel of that name, has a pump-room, baths, &c. The saline waters are useful in minor cases of dyspepsia and liver complaints. The town is flanked on the W. by the hill fort of Caerlee (400 ft. long) and on the E. by that of the Pirn (350 ft. long). Farther E., close to the village of Walkerburn, are Purvis Hill terraces, a remarkable series of earthen banks, from 50 ft. to more than 100 ft. wide, and with a length varying up to 900 ft., the origin and purpose of which are unknown. Traquair House, or Palace, on the right bank of the Tweed, is believed to be the oldest inhabited house in Scotland, the most ancient portion dating from the 10th century, and including a remnant of the castle. It was largely added to by Sir John Stewart, first earl of Traquair (d. 1659) and is a good example of the Scottish Baronial mansion with high-pitched roof and turreted angles. To the west of the house was the arbour which formed the "bush aboon Traquair" of the songs by Robert Crawford (d. 1733) and John Campbell Shairp, its site being indicated by a few birch trees. James Nicol (1769-1819), the poet, was minister of Traquair, and his son James Nicol (1810-1879), the geologist and professor of natural history in Aberdeen University, was born in the manse.

INNESS, GEORGE (1825-1894), American landscape painter, was born near Newburgh, N.Y., on the 1st of May 1825. Before he was five years of age his parents had moved to New York and afterwards to Newark, N.J., in which latter city his boyhood was passed. He would not "take education" at the town academy, nor was he a success as a greengrocer's boy. He had a strong bent towards art, and his parents finally placed him with a drawing-master named Barker. At sixteen he went to New York to study engraving, but soon returned to Newark, where he continued sketching and painting after his own initiative. In 1843 he was again in New York, and is said to have passed a month in Gignoux's studio. But he was too impetuous, too independent in thought, to accept teaching; and, besides, the knowledge of his teachers must have been limited. Practically he was self-taught, and always remained a student. In 1851 he went to Europe, and in Italy got his first glimpse of real art. He was there two years, and imbibed some traditions of the classic landscape. In 1854 he went to France, and there studied the Barbizon painters, whom he greatly admired, especially Daubigny and Rousseau. After his return to America he opened a studio in New York, then went to Medfield, Mass., where he resided for five years. A pastoral landscape near this town inspired the characteristic painting "The Medfield Meadows." Again he went abroad and spent six years in Europe. He came back to New York in 1876, and lived there, or near there, until the year of his death, which took place at Bridge of Allan on the 3rd of August 1894 while he was travelling in Scotland. He was a National Academician, a member of the Society of American Artists, and had received many honours at home and abroad. He was married twice, his son, George Inness (*b.* 1854), being also a painter. Inness was emphatically a man of temperament, of moods, enthusiasms, convictions. He was fond of speculation and experiment in metaphysics and religion, as in poetry and art. Swedenborgianism, symbolism, socialism, appealed to him as they might to a mystic or an idealist. He aspired to the perfect unities, and was impatient of structural foundations. This was his attitude towards painting. He sought the sentiment, the light, air, and colour of nature, but was put out by nature's forms. How to subordinate form without causing weakness was his problem, as it was Corot's. His early education gave him no great technical facility, so that he never was satisfied with his achievement. He worked over his pictures incessantly, retouching with paint, pencil, coal, ink—anything that would give the desired effect—yet never content with them. In his latter days it was almost impossible to get a picture away from him, and after his death his studio was found to be full of experimental canvases. He was a very uneven painter, and his experiments were not always successful. His was an original—a distinctly American—mind in art. Most of his American subjects were taken from New York state, New Jersey and New England. His point of view was his own. At his best he was often excellent in poetic sentiment, and superb in light, air and colour. He had several styles: at first he was somewhat grandiloquent in Roman scenes, but sombre in colour; then under French influence his brush grew looser, as in the "Grey Lowering Day"; finally he broke out in full colour and light, as in the "Niagara" and the last "Delaware Water-Gap." Some of his pictures are in American museums, but most of them are in private hands.

(J. C. Van D.)

INNOCENT (Innocentius), the name of thirteen popes and one antipope.

Innocent I., pope from 402 to 417, was the son of Pope Anastasius I. It was during his papacy that the siege of Rome by Alaric (408) took place, when, according to a doubtful anecdote of Zosimus, the ravages of plague and famine were so frightful, and help seemed so far off, that papal permission was granted to sacrifice and pray to the heathen deities;

the pope was, however, absent from Rome on a mission to Honorius at Ravenna at the time of the sack in 410. He lost no opportunity of maintaining and extending the authority of the Roman see as the ultimate resort for the settlement of all disputes; and his still extant communications to Victricius of Rouen, Exuperius of Toulouse, Alexander of Antioch and others, as well as his action on the appeal made to him by Chrysostom against Theophilus of Alexandria, show that opportunities of the kind were numerous and varied. He took a decided view on the Pelagian controversy, confirming the decisions of the synod of the province of proconsular Africa held in Carthage in 416, which had been sent to him. He wrote in the same year in a similar sense to the fathers of the Numidian synod of Mileve who, Augustine being one of their number, had addressed him. Among his letters are one to Jerome and another to John, bishop of Jerusalem, regarding annoyances to which the first named had been subjected by the Pelagians at Bethlehem. He died on the 12th of March 417, and in the Roman Church is commemorated as a confessor along with Saints Nazarius, Celsus and Victor, martyrs, on the 28th of July. His successor was Zosimus.

Innocent II. (Gregorio Paparesci dei Guidoni), pope from 1130 to 1143, was originally a Benedictine monk. His ability, pure life and political connexions raised him rapidly to power. Made cardinal deacon of Sant Angelo in Pescheria by Paschal II. he was employed in various diplomatic missions. Calixtus II. appointed him one of the ambassadors who made peace with the Empire and drew up the Concordat of Worms (1122), and in the following year, with his later enemy Cardinal Peter Pierleoni, he was papal legate in France. On the 13th of February 1130 Honorius II. died, and on that night a minority of the Sacred College elected Paparesci, who took the name of Innocent II. After a hasty consecration he was forced to take refuge with a friendly noble by the faction of Pierleoni, who was elected pope under the name of Anacletus II. by a majority of the cardinals. Declaring that the cardinals had been intimidated, Innocent refused to recognize their choice; by June, however, he was obliged to flee to France. Here his title was recognized by a synod called by Bernard of Clairvaux at Étampes. Similar action was taken in Germany by the synod of Würzburg. In January 1131 Innocent held a personal interview with King Henry I. of England at Chartres, and in March, at Liége, with the German King Lothair, whom he induced to undertake a campaign against Anacletus. The German army invaded Italy in August 1132, and occupied Rome, all except St Peter’s church and the castle of St Angelo which held out against them. Lothair was crowned emperor at the Lateran in June 1133, and as a further reward Innocent gave him the territories of the Countess Mathilda as a fief, but refused to surrender the right of investiture. Left to himself Innocent again had to flee, this time to Pisa. Here he called a council which condemned Anacletus. A second expedition of Lothair expelled Roger of Sicily (to whom Anacletus had given the title of king in return for his support) from southern Italy, but a quarrel with Innocent prevented the emperor attacking Rome. At this crisis, in January 1138, Anacletus died, and a successor elected by his faction, as Victor IV., resigned after two months. The Lateran council of 1139 restored peace to the Church, excommunicating Roger of Sicily, against whom Innocent undertook an expedition which proved unsuccessful. In matters of doctrine the pope supported Bernard of Clairvaux in his prosecution of Abelard and Arnold of Brescia, whom he condemned as heretics. The remaining years of Innocent’s life were taken up by a quarrel with the Roman commune, which had set up an independent senate, and one with King Louis VII. of France, about an appointment. France was threatened with the interdict, but before matters came to a head Innocent died on the 22nd of September 1143.

See Herzog-Hauck, *Realencyklopädie*, “Innocenz II.,” with full references. Gregorovius, *History of Rome in the Middle Ages*, trans. by Hamilton (London, 1896), vol. iv. part ii. pp. 420-453.

(P. Sm.)

Innocent III. (Lando da Sezza), antipope (1179-1180), sprang from a noble Lombard family. Opponents of Alexander III. tried to make him pope in September 1179. Alexander, however, bribed his partisans to give him up, and imprisoned him in the cloister of La Cava in January 1180.

Innocent III. (Lotario de’ Conti di Segni), pope from 1198 to 1216, was the son of Trasimondo, count of Segni, and of Claricia, a Roman lady of the noble family of Scotti, and was born at Anagni about 1160. His early education he received at Rome, whence he went to the university of Paris and subsequently to that of Bologna. At Paris, where he attended the lectures of Peter of Corbeil, he laid the foundations of his profound knowledge of the scholastic philosophy; at Bologna he acquired an equally profound knowledge of the canon and civil law. Thus distinguished by birth, intellect and attainments, on his return to Rome he rose rapidly in the church. He at once became a canon of St Peter’s; he was made subdeacon of the Roman Church by Gregory VIII.; and in 1190 his uncle, Pope Clement III., created him cardinal-deacon of Santi Sergio e Baccho. The election of Celestine III. in the following year withdrew Lotario for a while from the active work of the Curia, the new pope belonging to the family of the Orsini, who were at feud with the Scotti. Lotario, however, employed his leisure in writing several works: *Mysteriorum evangelicae legis ac sacramenti eucharistiae libri VI.*, *De contemtu mundi, sive de miseria humanae conditionis*, and *De quadrapartita specie nuptiarum*. Of these only the two first are extant; they are written in the scholastic style, a sea of quotations balanced and compared, and they witness at once to the writer’s profound erudition and to the fact that his mind had not yet emancipated itself from the morbid tendencies characteristic of one aspect of medieval thought. Yet Lotario was destined to be above all things a man of action, and, though his activities to the end were inspired by impracticable ideals, they were in their effects intensely practical; and Innocent III. is remembered, not as a great theologian, but as a great ruler and man of affairs.

On the 8th of January 1198 Celestine III. died, and on the same day Lotario, though not even a priest, was unanimously elected pope by the assembled cardinals. He took the name of Innocent III. On the 21st of February he was ordained priest, and on the 22nd consecrated bishop. Innocent was but thirty-seven years old at this time, and the vigour of youth, guided by a master mind, was soon apparent in the policy of the papacy. His first acts were to restore the prestige of the Holy See in Italy, where it had been overshadowed by the power of the emperor Henry VI. As pope it was his object to shake off the imperial yoke, as an Italian prince to clear the land of the hated Germans. The circumstances of the time were highly favourable to him. The early death of Henry VI. (September 1197) had left Germany divided between rival candidates for the crown, Sicily torn by warring factions of native and German barons. It was, then, easy for Innocent to depose the imperial prefect in Rome itself and to oust the German feudatories who held the great Italian fiefs for the Empire. Spoleto fell; Perugia surrendered; Tuscany acknowledged the leadership of the pope; papal *rectores* once more governed the patrimony of St Peter. Finally, Henry’s widow, Constance, in despair, acknowledged the pope as overlord of the two Sicilies, and on her death (November 27, 1198) appointed him guardian of her infant son Frederick. Thus in the first year of his pontificate Innocent had established himself as the protector of the Italian nation against foreign aggression, and had consolidated in the peninsula a secure basis on which to build up his world-power.

The effective assertion of this world-power is the characteristic feature of Innocent’s pontificate. Other popes before him—from Gregory VII. onwards—had upheld the theory of the supremacy of the spiritual over the temporal authority, with various fortune; it was reserved for Innocent to make it a reality. The history of the processes by which he accomplished this is given elsewhere. Here it will suffice to deal with it in the broadest outline. In Germany his support of Otto IV. against Philip of Swabia, then of Philip against Otto and finally, after Philip’s murder (June 21, 1208), of the young Frederick II. against Otto, effectually prevented the imperial power, during his pontificate, from again becoming a danger to that of the papacy in Italy. Concessions at the cost of the Empire in Italy were in every case the price of his

support (see Germany: *History*). In his relations with the German emperors Innocent acted partly as pope, partly as an Italian prince; his victories over other and more distant potentates he won wholly in his spiritual capacity. Thus he forced the masterful Philip Augustus of France to put away Agnes of Meran and take, back his Danish wife Ingeborg, whom he had wrongfully divorced; he compelled Peter of Aragon to forgo his intended marriage with Bianca of Navarre and ultimately (1204) to receive back his kingdom as a fief of the Holy See; he forced Alphonso IX. of Leon to put away his wife Berengaria of Castile, who was related to him within the prohibited degrees, though he pronounced their children legitimate. Sancho of Portugal was compelled to pay the tribute promised by his father to Rome, and Ladislaus of Poland to cease from infringing the rights of the church. Even the distant north felt the weight of Innocent's power, and the archbishop of Trondhjem was called to order for daring to remove the ban of excommunication from the repentant King Haakon IV., as an infringement of the exclusive right of the pope to impose or remove the ban of the church in the case of sovereigns. So widespread was the prestige of the pope that Kaloyan, prince of Bulgaria, hoping to strengthen himself against internal foes and the aggressions of the Eastern Empire, submitted to Rome and, in November 1204, received the insignia of royalty from the hands of the papal legates as the vassal of the Holy See.

Meanwhile Innocent had been zealous in promoting the crusade which ultimately, under the Doge Dandolo, led to the Latin occupation of Constantinople (see Crusades). This diversion from its original object was at first severely censured by Innocent; but an event which seemed to put an end to the schism of East and West came to wear a different aspect; he was the first pope to nominate a patriarch of Constantinople, and he expressed the hope that henceforth the church would be "one fold under one shepherd." By a bull of October 12, 1204, moreover, Innocent proclaimed the same indulgences for a crusade to Livonia as the Holy Land. The result was the "conversion" of the Livonians (1206) and the Letts (1208) by the crusaders headed by the knights of the Teutonic Order. The organization of the new provinces thus won for the church Innocent kept in his own hands, instituting the new archbishopric of Riga and defining the respective jurisdictions of the archbishops and the Teutonic Knights, a process which, owing to the ignorance at Rome of the local geography, led to curious confusion.

Another crusade, horrible in its incidents and momentous in its consequences, was that proclaimed by Innocent in 1207 against the Albigenses. In this connexion all that can be said in his favour is that he acted from supreme conviction; that the heresies against which he appealed to the sword were really subversive of Christian civilization; and that he did not use force until for ten years he had tried all the arts of persuasion in vain (see Albigenses).

Of all Innocent's triumphs, however, the greatest was his victory over King John of England. The quarrel between the pope and the English king arose out of a dispute as to the election to the vacant see of Canterbury, which Innocent had settled by nominating Stephen Langton over the heads of both candidates. John refusing to submit, Innocent imposed an interdict on the kingdom and threatened him with a crusade; and, to avert a worse fate, the English king not only consented to recognize Langton but also to hold England and Ireland as fiefs of the Holy See, subject to an annual tribute (May 1213). The submission was no idle form; for years the pope virtually ruled England through his legates (see English History and John, king of England). So great had the secular power of the papacy become that a Byzantine visitor to Rome declared Innocent to be "the successor not of Peter but of Constantine."

As in the affairs of the world at large, so also in those of the church itself, Innocent's authority exceeded that of all his predecessors. Under him the centralization of the ecclesiastical administration at Rome received a great impulse, and the independent jurisdiction of metropolitans and bishops was greatly curtailed. In carrying out this policy his unrivalled knowledge of the canon law gave him a great advantage. To his desire to organize the discipline of the church was due the most questionable of his expedients: the introduction of the system of provisions and reservations, by which he sought to bring the patronage of sees and benefices into his own hands—a system which led later to intolerable abuses.

The year before Innocent's death the twelfth ecumenical council assembled at the Lateran under his presidency. It was a wonderful proof at once of the world-power of the pope and of his undisputed personal ascendancy. It was attended by the plenipotentiaries of the emperor, of kings and of princes, and by some 1500 archbishops, bishops, abbots and other dignitaries. The business before it, the disciplining of heretics and Jews, and the proclamation of a new crusade, &c., vitally concerned the states represented; yet there was virtually no debate and the function of the great assembly was little more than to listen to and endorse the decretals read by the pope (see Lateran Councils). Shortly after this crowning exhibition of his power the great pope died on the 16th of July 1216.

Innocent III. is one of the greatest historical figures, both in the grandeur of his aims and the force of character which brought him so near to their realization. An appreciation of his work and personality will be found in the article Papacy; here it will suffice to say that, whatever judgment posterity may have passed on his aims, opinion is united as to the purity of the motives that inspired them and the tireless self-devotion with which they were pursued. "I have no leisure," Innocent once sighed, "to meditate on supermundane things; scarce I can breathe. Yea, so much must I live for others, that almost I am a stranger to myself." Yet he preached frequently, both at Rome and on his journeys—many of his sermons, inspired by a high moral earnestness, have come down to us—and, towards the end of his life, he found time to write a pious exposition of the Psalms. His views on the papal supremacy are best explained in his own words. Writing to the patriarch of Constantinople (*Inn. III., lib.* ii. *ep.* 200) he says: "The Lord left to Peter the governance not of the church only but of the whole world;" and again in his letter to King John of England (*lib.* xvi. ep. 131): "The King of Kings ... so established the kingship and the priesthood in the church, that the kingship should be priestly, and the priesthood royal (*ut sacerdotale sit regnum et sacerdotium sit regale*), as is evident from the epistle of Peter and the law of Moses, setting one over all, whom he appointed his vicar on earth." In his answer to the ambassadors of Philip Augustus he states the premises from which this stupendous claim is logically developed:—

> "To princes power is given on earth, but to priests it is attributed also in heaven; to the former only over bodies, to the latter also over souls. Whence it follows that by so much as the soul is superior to the body, the priesthood is superior to the kingship.... Single rulers have single provinces, and single kings single kingdoms; but Peter, as in the plenitude, so in the extent of his power is pre-eminent over all, since he is the Vicar of Him whose is the earth and the fullness thereof, the whole wide world and all that dwell therein."

To the emperor of Constantinople, who quoted 1 Peter ii. 13, 14, to the contrary, he replied in perfect good faith that the apostle's admonition to obey "the king as supreme was addressed to lay folk and not to the clergy." The more intelligent laymen of the time were not convinced even when coerced. Even so pious a Catholic as the minnesinger Walther von der Vogelweide, giving voice to the indignation of German laymen, ascribed Innocent's claims, not to soundness of his scholastic logic, but to the fact that he was "too young" (*owê der babest ist ze junc*).

The literature on Innocent III. is very extensive; a carefully analysed bibliography will be found in Herzog-Hauck, *Realencyklopädie* (3rd ed., 1901) s. "Innocenz III." In A. Potthast, *Bibliotheca hist. med. aevi* (2nd ed., Berlin, 1896), p. 650, is a bibliography of the literature on Innocent's writings. In the *Corpus juris canonici*, ed. Aemilius Friedberg (Leipzig, 1881), vol. ii., pp. xiv.-xvii., are lists of the official documents of Innocent III. excerpted in the *Decretales Gregorii IX.* The most important later works on Innocent III. are Achille Luchaire's *Innocent III, Rome et l'Italie* (Paris, 1904), *Innocent III, la croisade des Albigeois* (*ib.* 1905), *Innocent III, la papauté et l'empire* (*ib.* 1906), *Innocent III, la*

question d'orient (*ib.* 1906); *Innocent III, les royautés vassales du Saint-Siège* (*ib.* 1908); and *Innocent III, la concile de latran et la réforme de l'église* (1908); *Innocent the Great*, by C. H. C. Pirie-Gordon (London, 1907); is the only English monograph on this pope and contains some useful documents, but is otherwise of little value. See also H. H. Milman, *History of Latin Christianity*, vol. v.; F. Gregorovius, *Rome in the Middle Ages*, translated by A. Hamilton (1896), vol. v. pp. 5-110; J. C. L. Gieseler, *Ecclesiastical Hist.*, translated by J. W. Hull, vol. iii. (Edinburgh, 1853), which contains numerous excerpts from his letters, &c. Innocent's works are found in Migne, *Patrologiae Cursus Completus, Series Latina*, vols. ccxiv.-ccxvii. For a translation of Innocent's answer to King John on the interdict, and John's surrender of England and Ireland to Innocent, see Gee and Hardy, *Documents illustrative of Church History* (London, 1896), pp. 73 et seq.

(W. A. P.)

INNOCENT IV. (Sinibaldo Fiesco), pope 1243-1254, belonged to the noble Genoese family of the counts of Lavagna. Born at Genoa, he was educated under the care of his uncle Opizo, bishop of Parma. After taking orders at Parma, when he was made canon of the cathedral, he studied jurisprudence at Bologna. His first recorded appearance in political affairs was in 1218-1219, when he was associated with Cardinal Hugolinus (afterwards Gregory IX.) in negotiating a peace between Genoa and Pisa. This led to his rapid promotion. In 1223 Pope Honorius III. gave him a benefice in Parma, and in 1226 he was established at the curia as *auditor contradictarum literarum* of the pope, a post he held also under Gregory IX., until promoted (1227) to be vice-chancellor of the Roman Church. In September of the same year he was created cardinal priest of San Lorenzo in Lucina. He was papal *rector* (governor) of the March of Ancona from 1235 to 1240. On the 25th of June 1243 he was elected pope by the cardinals assembled at Anagni.

Innocent was raised to the Holy See when it was at deadly feud with the emperor Frederick II., who lay under excommunication. Frederick at first greeted the elevation of a member of an imperialist family with joy; but it was soon clear that Innocent intended to carry on the traditions of his predecessors. Embassies and courtesies were, indeed, interchanged, and on the 31st of March 1244 a treaty was signed at Rome, whereby the emperor undertook to satisfy the pope's claims in return for his own absolution from the ban. Neither side, however, was prepared to take the first steps to carry out the agreement, and Innocent, who had ventured back to Rome, began to feel unsafe in the city, where the imperial partisans had the ascendancy. Fearing a plan to kidnap him, he left Rome, ostensibly to meet the emperor, and from Sutri fled by night on horseback, pursued by 300 of the emperor's cavalry, to Civitavecchia, whence he took ship for Genoa and thence proceeded across the Alps to Lyons, at that time a merely nominal dependence of the Empire. Thence he wrote to the French king, Louis IX., asking for an asylum in France; but this Louis cautiously refused. Innocent, therefore, remained at Lyons, whence he issued a summons to a general council, before which he cited Frederick to appear in person, or by deputy. The council, which met on the 5th of June 1245, was attended only by those prepared to support the pope's cause; and though Frederick condescended to be represented by his justiciar, Thaddeus of Suessa, the judgment was a foregone conclusion. On the 17th of July Innocent formally renewed the sentence of excommunication on the emperor, and declared him deposed from the imperial throne and that of Naples. Frederick retorted by announcing his intention of reducing "the clergy, especially the highest, to a state of apostolic poverty," and by ordaining the severest punishments for those priests who should obey the papal sentence. Innocent thereupon proclaimed a crusade against the emperor and armed his ubiquitous agents, the Franciscan and Dominican friars, with special indulgences for all those who should take up the cross against the imperial heretic. At the same time he did all in his power to undermine Frederick's authority in Germany and Italy. In Naples he fomented a conspiracy among the feudal lords, who were discontented with the centralized government established under the auspices of Frederick's chancellor, Piero della Vigna. In Germany, at his instigation, the archbishops with a few of the secular nobles in 1246 elected Henry Raspe, landgrave of Thuringia, German king; but the "priests' king," as he was contemptuously called, died in the following year, William II., count of Holland, being after some delay elected by the papal party in his stead.

Innocent's relentless war against Frederick was not supported by the lay opinion of his time. In Germany, where it wrought havoc and misery, it increased the already bitter resentment against the priests. From England the pope's legate was driven by threats of personal violence. In France not even the saintly King Louis IX., who made several vain attempts to mediate, approved the pope's attitude; and the failure of the crusade which, in 1248, he led against the Mussulmans in Egypt, was, with reason, ascribed to the deflection of money and arms from this purpose to the war against the emperor. Even the clergy were by no means altogether on Innocent's side; the council of Lyons was attended by but 150 bishops, mainly French and Spanish, and the deputation from England, headed by Robert Grossetête of Lincoln and Roger Bigod, came mainly in order to obtain the canonization of Edmund of Canterbury and to protest against papal exactions. Yet, for better or for worse, Innocent triumphed. His financial position was from the outset strong, for not only had he the revenue from the accustomed papal dues but he had also the support of the powerful religious orders; *e.g.* in November 1245 he visited the abbey of Cluny and was presented by the abbot with gifts, the value of which surprised even the papal officials. At first the war went in Frederick's favour; then came the capture of the strategically important city of Parma by papal partisans (June 16th, 1247). From this moment fortune changed. On the 18th of February 1248 Frederick's camp before Parma (the temporary town of Vittoria) was taken and sacked, the imperial insignia—of vast significance in those days—being captured. From this blow the emperor never recovered; and when on the 13th of December 1250 he died Innocent greeted the news by quoting from Psalm xcvi. 11, "Let the heavens rejoice and let the earth be glad."

On the 19th of April 1251 Innocent left Lyons, which had suffered severely from his presence, and returned to Italy. He continued the struggle vigorously with Frederick's son and successor, Conrad IV., who in 1252 descended into Italy, reduced the rebellious cities and claimed the imperial crown. Innocent, determined that the Hohenstaufen should not again dominate Italy, offered the crown of Sicily in turn to Richard of Cornwall, Charles of Anjou, and Henry III. of England, the last of whom accepted the doubtful gift for his son Edmund. Even after Conrad's capture of Naples Innocent remained inexorable; for he feared that Rome itself might fall into the hands of the German king. But fortune favoured him. On the 20th of May 1254 Conrad died, leaving his infant son Conradin, as Henry VI. had left Frederick II., under the pope's guardianship. Innocent accepted the charge and posed as the champion of the infant king. He held, indeed, to his bargain with Henry III. and, with all too characteristic nepotism, exercised his rights over the Sicilian kingdom by nominating his own relations to its most important offices. Finally, when Manfred, who by Frederick's will had been charged with the government of the two Sicilies, felt obliged to acknowledge the pope's suzerainty, Innocent threw off the mask, ignored Conradin's claims, and on the 24th of October formally asserted his own claims to Calabria and Sicily. He entered Naples on the 27th; but meanwhile Manfred had fled and had raised a considerable force; and the news of his initial successes against the papal troops reached Innocent as he lay sick and hastened his end. He died on the 7th of December 1254.

Innocent IV. is comparable to his greater predecessor Innocent III. mainly in the extreme assertion of the papal claims. "The emperor," he wrote, "doubts and denies that all men and all things are subject to the See of Rome. As if we who are judges of angels are not to give sentence on earthly things.... The ignorant assert that Constantine first gave temporal power to the See of Rome; it was already bestowed by Christ Himself, the true King and Priest, as inalienable from its nature and absolutely unconditional. Christ established not only a pontifical but a royal sovereignty

(*principatus*) and committed to blessed Peter and his successors the empire both of earth and heaven, as is sufficiently proved by the plurality of the keys" (*Codex epist. Vatic.* No. 4957, 49, quoted in Raumer, *Hohenstaufen*, iv. 78). But this language, which in the mouth of Innocent III. had been consecrated by the greatness of his character and aims, was less impressive when it served as a cloak for an unlimited personal ambition and a family pride which displayed itself in unblushing nepotism. Yet in some respects Innocent IV. carried on the high traditions of his great predecessors. Thus he admonished Sancho II. of Portugal to turn from his evil courses and, when the king disobeyed, absolved the Portuguese from their allegiance, bestowing the crown on his brother Alphonso. He also established an ecclesiastical organization in the newly converted provinces of Prussia, which he divided into four dioceses; but his attempt to govern the Baltic countries through a legate broke on the opposition of the Teutonic Order, whose rights in Prussia he had confirmed.

It was Innocent IV. who, at the council of Lyons, first bestowed the red hat on the Roman cardinals, as a symbol of their readiness to shed their blood in the cause of the church.

Innocent was a canon lawyer of some eminence. His small work *De exceptionibus* was probably written before he became pope; but the *Apparatus in quinque libros decretalium*, which displays both practical sense and a remarkable mastery of the available materials, was written at Lyons immediately after the council. His *Apologeticus*, a defence of the papal claims against the Empire, written—as is supposed—in refutation of Piero della Vigna's argument in favour of the independence of the Empire, has been lost. Innocent was also a notable patron of learning, he encouraged Alexander of Hales to write his *Summa universae theologiae*, did much for the universities, notably the Sorbonne, and founded law schools at Rome and Piacenza.

Innocent's letters, the chief source for his life, are collected by E. Berger in *Les Registres d'Innocent IV* (3 vols., Paris, 1884-1887). For English readers the account in Milman's *Latin Christianity*, vol. vi. (3rd ed., 1864) is still useful. Full references will be found in Herzog-Hauck, *Realencyklopädie*, vol. ix. (1901).

(W. A. P.)

INNOCENT V. (Pierre de Champagni or de Tarentaise), pope from the 21st of January to the 22nd of June 1276, was born about 1225 in Savoy and entered the Dominican order at an early age. He studied theology under Thomas Aquinas, Albertus Magnus and Bonaventura, and in 1262 was elected provincial of his order in France. He was made archbishop of Lyons in 1271; cardinal-bishop of Ostia and Velletri, and grand penitentiary in 1275; and, partly through the influence of Charles of Anjou, was elected to succeed Gregory X. As pope he established peace between the republics of Lucca and Pisa, and confirmed Charles of Anjou in his office of imperial vicar of Tuscany. He was seeking to carry out the Lyons agreement with the Eastern Church when he died. His successor was Adrian V. Innocent V., before he became pope, prepared, in conjunction with Albertus Magnus and Thomas Aquinas, a rule of studies for his order, which was accepted in June 1259. He was the author of several works in philosophy, theology and canon law, including commentaries on the Scriptures and on the Sentences of Peter Lombard, and is sometimes referred to as *famosissimus doctor*. He preached the funeral sermon at Lyons over St Bonaventura. His bulls are in the Turin collection (1859).

See F. Gregorovius, *Rome in the Middle Ages*, vol. 5, trans. by Mrs G. W. Hamilton (London, 1900-1902); A. Potthast, *Regesta, pontif. Roman.* vol. ii. (Berlin, 1875); E. Bourgeois, *Le Bienheureux Innocent V* (Paris, 1899); J. E. Borel, *Notice biogr. sur Pierre de Tarentaise* (Chambéry, 1890); P. J. Béthaz, *Pierre des Cours de la Salle, pape sous le nom Innocent V* (Augustae, 1891); L. Carboni, *De Innocentio V. Romano pontifice* (1894).

(C. H. HA.)

INNOCENT VI. (Étienne Aubert), pope from the 18th of December 1352 to the 12th of September 1362, was born at Mons in Limousin. He became professor of civil law at Toulouse and subsequently chief judge of the city. Having taken orders, he was raised to the see of Noyon and translated in 1340 to that of Clermont. In 1342 he was made cardinal-priest of Sti Giovanni e Paolo, and ten years later cardinal-bishop of Ostia and Velletri, grand penitentiary, and administrator of the bishopric of Avignon. On the death of Clement VI., the cardinals made a solemn agreement imposing obligations, mainly in favour of the college as a whole, on whichever of their number should be elected pope. Aubert was one of the minority who signed the agreement with the reservation that in so doing he would not violate any law, and was elected pope on this understanding; not long after his accession he declared the agreement null and void, as infringing the divinely-bestowed power of the papacy. Innocent was one of the best Avignon popes and filled with reforming zeal; he revoked the reservations and commendations of his predecessor and prohibited pluralities; urged upon the higher clergy the duty of residence in their sees, and diminished the luxury of the papal court. Largely through the influence of Petrarch, whom he called to Avignon, he released Cola di Rienzo, who had been sent a prisoner in August 1352 from Prague to Avignon, and used the latter to assist Cardinal Albornoz, vicar-general of the States of the Church, in tranquillizing Italy and restoring the papal power at Rome. Innocent caused Charles IV. to be crowned emperor at Rome in 1355, but protested against the famous "Golden Bull" of the following year, which prohibited papal interference in German royal elections. He renewed the ban against Peter the Cruel of Castile, and interfered in vain against Peter IV. of Aragon. He made peace between Venice and Genoa, and in 1360 arranged the treaty of Bretigny between France and England. In the last years of his pontificate he was busied with preparations for a crusade and for the reunion of Christendom, and sent to Constantinople the celebrated Carmelite monk, Peter Thomas, to negotiate with the claimants to the Greek throne. He instituted in 1354 the festival of the Holy Lance. Innocent was a strong and earnest man of monastic temperament, but not altogether free from nepotism. He was succeeded by Urban V.

The chief sources for the life of Innocent VI. are in Baluzius, *Vitae Pap. Avenion*, vol. i. (Paris, 1693); *Magnum bullarium Romanum*, vol. iv. (Turin, 1859); E. Werunsky, *Excerpta ex registris Clementis VI. et Innocentii VI.* (Innsbruck, 1885). See also L. Pastor *History of the Popes*, vol. i. trans. by F. I. Antrobus (London, 1899); F. Gregorovius, *Rome in the Middle Ages*, vol. 6, trans. by Mrs G. W. Hamilton (London, 1900-1902); D. Cerri, *Innocenzo Papa VI.* (Turin, 1873); J. B. Christophe, *Histoire de la papauté pendant le XIV^e siècle*, vol. 2 (Paris, 1853); M. Souchon, *Die Papstwahlen* (Brunswick, 1888); G. Daumet, *Innocent VI. et Blanche de Bourbon* (Paris, 1899); E. Werunsky, *Gesch. Kaiser Karls IV.* (Innsbruck, 1892). There is an excellent article by M. Naumann in Hauck's *Realencyklopädie*, 3rd ed.

(C. H. HA.)

INNOCENT VII. (Cosimo dei Migliorati), pope from the 17th of October 1404 to the 6th of November 1406, was born of middle-class parentage at Sulmona in the Abruzzi in 1339. On account of his knowledge of civil and canon law, he was made papal vice-chamberlain and archbishop of Ravenna by Urban VI., and appointed by Boniface IX. cardinal priest of Sta Croce in Gerusalemme, bishop of Bologna, and papal legate to England. He was unanimously chosen to succeed Boniface, after each of the cardinals had solemnly bound himself to employ all lawful means for the restoration of the church's unity in the event of his election, and even, if necessary, to resign the papal dignity. The election was opposed at Rome by a considerable party, but peace was maintained by the aid of Ladislaus of Naples, in return for which Innocent made a promise, inconsistent with his previous oath, not to come to terms with the antipope Benedict XIII., except on condition that he should recognize the claims of Ladislaus to Naples. Innocent issued at the close of 1404 a summons for a general council to heal the schism, and it was not the pope's fault that the council never assembled, for the Romans rose in arms to secure an extension of their liberties, and finally maddened by the murder of some of their leaders by the pope's nephew, Ludovico dei Migliorati, they compelled Innocent to take refuge at Viterbo (6th of August 1405). The Romans, recognizing later the pope's innocence of the outrage, made their submission to him in January

1406. He returned to Rome in March, and, by bull of the 1st of September, restored the city's decayed university. Innocent was extolled by contemporaries as a lover of peace and honesty, but he was without energy, guilty of nepotism, and showed no favour to the proposal that he as well as the antipope should resign. He died on the 6th of November 1406 and was succeeded by Gregory XII.

See L. Pastor, *History of the Popes*, vol. i., trans. by F. I. Antrobus (London, 1899); M. Creighton, *History of the Papacy*, vol. i. (London, 1899); N. Valois, *La France et le grand schisme d'occident* (Paris, 1896-1902); Louis Gayet, *Le Grand Schisme d'occident* (Paris, 1898); J. Loserth, *Geschichte des späteren Mittelalters* (1903); Theodorici de Nyem, *De schismate libri tres*, ed. by G. Erler (Leipzig, 1890); K. J. von Hefele, *Conciliengeschichte*, Bd. 6, 2nd ed.; J. von Haller, *Papsttum u. Kirchenreform* (Berlin, 1903).

(C. H. Ha.)

Innocent VIII. (Giovanni Battista Cibo), pope from the 29th of August 1484 to the 25th of July 1492, successor of Sixtus IV., was born at Genoa (1432), the son of Arano Cibo, who under Calixtus III. had been a senator of Rome. His youth, spent at the Neapolitan court, was far from blameless, and it is not certain that he was married to the mother of his numerous family. He later took orders, and, through the favour of Cardinal Calandrini, half-brother of Nicholas V., obtained from Paul II. the bishopric of Savona. Sixtus IV. translated him to the see of Molfetta, and in 1473 created him cardinal-priest of Sta Balbina, subsequently of Sta Cecilia. As pope, he addressed a fruitless summons to Christendom to unite in a crusade against the infidels, and concluded in 1489 a treaty with Bayezid II., agreeing in consideration of an annual payment of 40,000 ducats and the gift of the Holy Lance, to detain the sultan's fugitive brother Jem in close confinement in the Vatican. Innocent excommunicated and deposed Ferdinand, king of Naples, by bull of the 11th of September 1489, for refusal to pay the papal dues, and gave his kingdom to Charles VIII. of France, but in 1492 restored Ferdinand to favour. He declared (1486) Henry VII. to be lawful king of England by the threefold right of conquest, inheritance and popular choice, and approved his marriage with Elizabeth, the daughter of Edward IV. Innocent, like his predecessor, hated heresy, and in the bull *Summis desiderantes* (5th of December 1484) he instigated very severe measures against magicians and witches in Germany; he prohibited (1486) on pain of excommunication the reading of the propositions of Pico della Mirandola; he appointed (1487) T. Torquemada to be grand inquisitor of Spain; and he offered plenary indulgence to all who would engage in a crusade against the Waldenses. He took the first steps towards the canonization of Queen Margaret of Scotland, and sent missionaries under Portuguese auspices to the Congo. An important event of his pontificate was the capture of Granada (2nd of January 1492), which was celebrated at Rome with great rejoicing and for which Innocent gave to Ferdinand of Aragon the title of "Catholic Majesty." Innocent was genial, skilled in flattery, and popular with the Romans, but he lacked talent and relied on the stronger will of Cardinal della Rovere, afterwards Julius II. His Curia was notoriously corrupt, and he himself openly practised nepotism in favour of his children, concerning whom the epigram is quoted: "Octo nocens pueros genuit, totidemque puellas:—Hunc merito poterit dicere Roma patrem." Thus he gave to his undeserving son Franceschetto several towns near Rome and married him to the daughter of Lorenzo de' Medici. Innocent died on the 25th of July 1492, and was succeeded by Alexander VI.

The sources for the life of Innocent VIII. are to be found in L. Muratori, *Rerum Italicarum Scriptores*, vol. 3, and in Raynaldus, a. 1484-1492. See also L. Pastor, *History of the Popes*, vol. 5, trans. by F. I. Antrobus (London, 1898); M. Creighton, *History of the Papacy*, vol. 4 (London, 1901); F. Gregorovius, *Rome in the Middle Ages*, vol. 7, trans. by Mrs. G. W. Hamilton (London, 1900-1902); T. Hagen, *Die Papstwahlen von 1484 u. 1492* (Brizen, 1885); S. Riezler, *Die Hexenprozesse* (1896); G. Viani, *Memorie della famiglia Cybo* (Pisa, 1808); F. Serdonati, *Vita e fatti d'Innocenzo VIII.* (Milan, 1829).

(C. H. Ha.)

Innocent IX. (Giovanni Antonio Fachinetti) was born in 1519. He filled the offices of apostolic vicar of Avignon, legate at the council of Trent, nuncio to Venice, and president of the Inquisition. He became cardinal in 1583; and under the invalid Gregory XIV. assumed almost the entire conduct of affairs. His election to the papacy, on the 29th of October 1591, was brought about by Philip II., who profited little by it, however, inasmuch as Innocent soon succumbed to age and feebleness, dying on the 30th of December 1591.

See Ciaconius, *Vitae et res gestae summorum Pontiff. Rom.* (Rome, 1601-1602); Cicarella, continuator of Platina, *De Vitis Pontiff. Rom.* (both contemporaries of Innocent); Ranke, *Popes* (Eng. trans., Austin), ii. 233 sq. (all brief accounts).

(T. F. C.)

Innocent X. (Giovanni Battista Pamfili) was born in Rome on the 6th of May 1574, served successively as auditor of the Rota, nuncio to Naples, legate apostolic to Spain, was made cardinal in 1627, and succeeded Urban VIII. as pope on the 15th of September 1644. Throughout his pontificate Innocent was completely dominated by his sister-in-law, Donna Olimpia Maidalchini, a woman of masculine spirit. There is no reason to credit the scandalous reports of an illicit attachment. Nevertheless, the influence of Donna Olimpia was baneful; and she made herself thoroughly detested for her inordinate ambition and rapacity. Urban VIII. had been French in his sympathies; but the papacy now shifted to the side of the Habsburgs, and there remained for nearly fifty years. Evidences of the change were numerous: Innocent promoted pro-Spanish cardinals; attacked the Barberini, protégés of Mazarin, and sequestered their possessions; aided in quieting an insurrection in Naples, fomented by the duke of Guise; and refused to recognize the independence of Portugal, then at war with Spain. As a reward he obtained from Spain and Naples the recognition of ecclesiastical immunity. In 1649 Castro, which Urban VIII. had failed to take, was wrested from the Farnese and annexed to the Papal States. The most worthy efforts of Innocent were directed to the reform of monastic discipline (1652). His condemnation of Jansenism (1653) was met with the denial of papal infallibility in matters of *fact*, and the controversy entered upon a new phase (see Jansenism). Although the pontificate of Innocent witnessed the conversion of many Protestant princes, the most notable being Queen Christina of Sweden, the papacy had nevertheless suffered a perceptible decline in prestige; it counted for little in the negotiations at Münster, and its solemn protest against the peace of Westphalia was entirely ignored. Innocent died on the 7th of January 1655, and was succeeded by Alexander VII.

For contemporary lives of Innocent see Oldoin, continuator of Ciaconius, *Vitae et res gestae summorum Pontiff. Rom.*; and *Palazzi, Gesta Pontiff. Rom.* (Venice, 1687-1688) iv. 570 sqq.; Ciampi's *Innoc. X. Pamfili, et la sua Corte* (Rome, 1878), gives a very full account of the period. Gualdus' (pseud. of Gregorio Leti; v. bibliog. note, art. "Sixtus V.") *Vita de Donna Olimpia Maidalchina* (1666) is gossipy and untrustworthy; Capranica's *Donna Olympia Pamfili* (Milan, 1875, 3rd ed.) is fanciful and historically of no value. See also Ranke, *Popes* (Eng. trans., Austin), iii. 40 sqq.; v. Reumont, *Gesch. der Stadt Rom.* iii. 2, p. 623 sqq.; Brosch, *Gesch. des Kirchenstaates* (1880) i. 409 sqq.; and the extended bibliography in Herzog-Hauck, *Realencyklopädie*, s.v. "Innocenz X."

(T. F. C.)

Innocent XI. (Benedetto Odescalchi), pope from 1676 to 1689, was born at Como on the 16th of May 1611. He studied law in Rome and Naples, entered the Curia under Urban VIII. (his alleged military service seems to be questionable), and became successively protonotary, president of the Apostolic Chamber, governor of Macerate and commissary of Ancona. Innocent X. made him a cardinal (1647), legate to Ferrara, and, in 1650, bishop of Novara. His simple and blameless life, his conscientious discharge of duty, and his devotion to the needs of the poor had won for him such a

name that, despite the opposition of France, he was chosen to succeed Clement X. on the 21st of September 1676. He at once applied himself to moral and administrative reform; declared against nepotism, introduced economy, abolished sinecures, wiped out the deficit (at the same time reducing rents), closed the gaming-houses, and issued a number of sumptuary ordinances. He held monks strictly to the performance of their vows; took care to satisfy himself of the fitness of candidates for bishoprics; enjoined regular catechetical instruction, greater simplicity in preaching, and greater reverence in worship. The moral teaching of the Jesuits incurred his condemnation (1679) (see Liguori), an act which the society never forgave, and which it partially revenged by forcing, through the Inquisition, the condemnation of the quietistic doctrines of Molinos (1687), for which Innocent entertained some sympathy (see Molinos).

The pontificate of Innocent fell within an important period in European politics, and he himself played no insignificant rôle. His protest against Louis XIV.'s extended claim to regalian rights called forth the famous Declaration of Gallican Liberties by a subservient French synod under the lead of Bossuet (1682), which the pope met by refusing to confirm Louis's clerical appointments. His determination to restrict the ambassadorial right of asylum, which had been grossly abused, was resented by Louis, who defied him in his own capital, seized the papal territory of Avignon, and talked loudly of a schism, without, however, shaking the pope in his resolution. The preponderance of France Innocent regarded as a menace to Europe. He opposed Louis's candidate for the electorate of Cologne (1688), approved the League of Augsburg, acquiesced in the designs of the Protestant William of Orange, even in his supplanting James II., whom, although a Roman Catholic, he distrusted as a tool of Louis. The great object of Innocent's desire was the repulse of the Turks, and his unwearying efforts to that end entitled him to share in the glory of relieving Vienna (1683).

Innocent died on the 12th of August 1689, lamented by his subjects. His character and life were such as to suggest the propriety of canonization, but hostile influences have defeated every move in that direction.

The life of Innocent has been frequently written. See Guarnacci, *Vitae et res gestae Pontiff. Rom.* (Rome, 1751), i. 105 sqq.; Palazzi, *Gesta Pontiff. Rom.* (Venice, 1690); also the lives by Albrizzi (Rome, 1695); Buonamici (Rome, 1776); and Immich (Berlin, 1900). Particular phases of Innocent's activity have been treated by Michaud, *Loius XIV. et Innoc. XI.* (Paris, 1882 sqq., 4 vols.); Dubruel, *La Correspond.... du Card. Carlo Pio*, &c. (see *Rev. des quest. hist.* lxxv. (1904) 602 sqq.); and Gerin, in *Rev. des quest. hist.*, 1876, 1878, 1886. For correspondence of Innocent see Colombo, *Notizie biogr. e lettere di P. Innoc. XI.* (Turin, 1878); and Berthier, *Innoc. PP. XI. Epp. ad Principes* (Rome, 1890 sqq.). An extended bibliography may be found in Herzog-Hauck, *Realencyklopädie*, s.v. "Innocenz XI."

(T. F. C.)

Innocent XII. (Antonio Pignatelli), pope from 1691 to 1700 in succession to Alexander VIII., was born in Naples on the 13th of March 1615, was educated at the Jesuit College in Rome, entered upon his official career at the age of twenty, and became vice-legate of Urbino, governor of Perugia, and nuncio to Tuscany, to Poland and to Austria. He was made cardinal and archbishop of Naples by Innocent XI., whose pontificate he took as a model for his own, which began on the 12th of July 1691. Full of reforming zeal, he issued ordinances against begging, extravagance and gambling; forbade judges to accept presents from suitors; built new courts of justice; prohibited the sale of offices, maintaining the financial equilibrium by reducing expenses; and, an almost revolutionary step, struck at the root of nepotism, in a bull of 1692 ordaining that thenceforth no pope should grant estates, offices or revenues to any relative. Innocent likewise put an end to the strained relations that had existed between France and the Holy See for nearly fifty years. He adjusted the difficulties over the regalia, and obtained from the French bishops the virtual repudiation of the Declaration of Gallican Liberties. He confirmed the bull of Alexander VIII. against Jansenism (1696); and, in 1699, under pressure from Louis XIV., condemned certain of Fénelon's doctrines which Bossuet had denounced as quietistic (see Fénelon). When the question of the Spanish succession was being agitated he advised Charles II. to make his will in favour of the duke of Anjou. Innocent died, on the eve of the great conflict, on the 27th of September 1700. Moderate, benevolent, just, Innocent was one of the best popes of the modern age.

See Guarnacci, *Vitae et res gestae Pontiff. Rom.* (Rome, 1751), i. 389 sqq.; Ranke, *Popes* (Eng. trans., Austin), iii. 186 sqq.; v. Reumont, *Gesch. der Stadt Rom.* iii. 2, p. 640 sqq.; and the *Bullarium Innoc. XII.* (Rome, 1697).

(T. F. C.)

Innocent XIII. (Michele Angelo Conti), pope from 1721 to 1724, was the son of the duke of Poli, and a member of a family that had produced several popes, among them Innocent III., was born in Rome on the 13th of May 1655, served as nuncio in Switzerland, and, for a much longer time, in Portugal, was made cardinal and bishop of Osimo and Viterbo by Clement XI., whom he succeeded on the 8th of May 1721. One of his first acts was to invest the emperor Charles VI. with Naples (1722); but against the imperial investiture of Don Carlos with Parma and Piacenza he protested, albeit in vain. He recognized the Pretender, "James III.," and promised him subsidies conditional upon the re-establishment of Roman Catholicism in England. Moved by deep-seated distrust of the Jesuits and by their continued practice of "Accommodation," despite express papal prohibition (see Clement XI.), Innocent forbade the Order to receive new members in China, and was said to have meditated its suppression. This encouraged the French Jansenist bishops to press for the revocation of the bull *Unigenitus*; but the pope commanded its unreserved acceptance. He weakly yielded to pressure and bestowed the cardinal's hat upon the corrupt and debauched Dubois. Innocent died on the 7th of March 1724, and was succeeded by Benedict XIII.

See Guarnacci, *Vitae et res gestae Pontiff. Rom.* (Rome, 1751), ii. 137 sqq., 381 sqq.; Sandini, *Vitae Pontiff. Rom.* (Padua, 1739); M. v. Mayer, *Die Papstwahl Innocenz XIII.* (Vienna, 1874); Michaud, "La Fin du Clement XI. et le commencement du pontificat d'Innocent XIII." in the *Internat. Theol. Zeitschr.* v. 42 sqq., 304 sqq.

(T. F. C.)

INNOCENTS' DAY, or Childermas, a festival celebrated in the Latin church on the 28th of December, and in the Greek church on the 29th (O.S.) in memory of the massacre of the children by Herod. The Church early regarded these little ones as the first martyrs. It is uncertain when the day was first kept as a saint's day. At first it seems to have been absorbed into the celebration of the Epiphany, but by the 5th century it was kept as a separate festival. In Rome it was a day of fasting and mourning. In the middle ages the festival was the occasion for much indulgence to the children. The boy-bishop (*q.v.*), whose tenure of office lasted till Childermas, had his last exercise of authority then, the day being one of the series of days which were known as the Feast of Fools. Parents temporarily abdicated authority, and in nunneries and monasteries the youngest nun and monk were for the twenty-four hours allowed to masquerade as abbess and abbot. These mockeries of religion were condemned by the Council of Basel (1431); but though shorn of its extravagances the day is still observed as a feast day and merry-making for children in Catholic countries, and particularly as an occasion for practical joking like an April Fool's Day. In Spanish-America when such a joke has been played, the phrase equivalent to "You April fool!" is *Que la inocencia le valga!* May your innocence protect you! The

society of Lincoln's Inn specially celebrated Childermas, annually electing a "king of the Cockneys." Innocents' Day was ever accounted unlucky. Nothing was begun and no marriages took place then. Louis XI. prohibited all state business. The coronation of Edward IV., fixed for a Sunday, was postponed till the Monday when it was found the Sunday fell on the 28th of December. In rural England it was deemed unlucky to do housework, put on new clothes or pare the nails. At various places in Gloucestershire, Somerset and Worcestershire muffled peals were rung (*Notes and Queries*, 1st series, vol. viii. p. 617). In Northampton the festival was called "Dyzemas Day" (possibly from Gr. δυσ- "ill" and "mass"), and there is a proverb "What is begun on Dyzemas will never be finished." The Irish call the day *La Croasta na bliana*, "the cross day of the year," or *Diar dasin darg*, "blood Thursday," and many legends attach to it (*Notes and Queries*, 4th series, vol. xii. p. 185). In medieval England the children were reminded of the mournfulness of the day by being whipped in bed on Innocents' morning. This custom survived to the 17th century.

INNSBRUCK, the capital of the Austrian province of Tirol, and one of the most beautifully situated towns in Europe. In 1900 the population was 26,866 (with a garrison of about 2000 men), mainly German-speaking and Romanist. Built at a height of 1880 ft., in a wide plain formed by the middle valley of the Inn and on the right bank of that river, it is surrounded by lofty mountains that seem to overhang the town. It occupies a strong military position (its commercial and industrial importance is now but secondary) at the junction of the great highway from Germany to Italy over the Brenner Pass, by which it is by rail 109½ m. from Munich and 174½ m. from Verona, with that from Bregenz in the Vorarlberg, distant 122 m., by rail under the Arlberg Pass. It takes its name from its position, close to the chief bridge over the Inn. It is the seat of the supreme judicial court of the Tirol, the Diet of which meets in the Landhaus. The streets are broad, there are several open places and the houses are handsome, many of those in the old town dating from the 17th and 18th centuries, and being adorned with frescoes, while the arcades beneath are used as shops.

The principal monument is the Franciscan or Court church (1553-1563). In it is the magnificent 16th-century cenotaph (his body is elsewhere) of the emperor Maximilian (d. 1519), who, as count of the Tirol from 1490 onwards, was much beloved by his subjects. It represents the emperor kneeling in prayer on a gigantic marble sarcophagus, surrounded by twenty-eight colossal bronze statues of mourners, of which twenty-three figure ancestors, relatives or contemporaries of Maximilian, while five represent his favourite heroes of antiquity—among these five are the two finest statues (both by Peter Vischer of Nuremberg), those of King Arthur of Britain and of Theodoric, the Ostrogothic king. On the sides of the sarcophagus are twenty-four marble reliefs, depicting the principal events in the life of Maximilian, nearly all by Alexander Colin of Malines, while the general design of the whole monument is attributed to Gilg Sesselschreiber, the court painter. In one of the aisles of the same church is the Silver Chapel, so called from a silver Madonna and silver bas-reliefs on the altar; it contains the tombs of Archduke Ferdinand, count of the Tirol (d. 1595) and his non-royal wife, Philippine Welser of Augsburg (d. 1580), whose happy married life spent close by is one of the most romantic episodes in Tirolese history. In the other aisle are the tombs, with monuments, of the heroes of the War of Independence of 1809, Hofer, Haspinger and Speckbacher. It was in this church that Queen Christina of Sweden, daughter of Gustavus Adolphus, abjured Protestantism, in 1655. There are also several other churches and convents, among the latter the first founded (1593) in Germany by the Capuchins.

The university of Innsbruck was formally founded in 1677, and refounded (after two periods of suspension, 1782-1792 and 1810-1826) in 1826. It is attended by about 1000 students and has a large staff of professors, the theological faculty being controlled by the Jesuits. It has a library of 176,000 books, and 1049 MSS. The University or Jesuit church dates from the early 17th century. The Ferdinandeum is the provincial museum (founded in 1823, though the present building is later). The house known as the Goldne Dachl has its roof covered with gilded copper tiles; it was built about 1425, by Frederick, count of the Tirol, nicknamed "with the empty pockets," but the balcony and gilded roof were added in 1500 by the emperor Maximilian. Among the other monuments of Innsbruck may be mentioned the Pillar of St Anne, erected in 1706 to commemorate the repulse of the French and the Bavarians in 1703; the Triumphal Arch, built in 1765, on the occasion of the marriage of the future emperor Leopold II. with the Infanta Maria Louisa of Spain; and a fountain, with a bronze statue of Archduke Leopold V., set up in 1863-1877, in memory of the five-hundredth anniversary of the union of the Tirol with Austria.

The Roman station of Veldidena was succeeded by the Premonstratensian abbey of Wilten, both serving to guard the important strategical bridge over the Inn. In 1180 the count of Andechs (the local lord) moved the market-place over to the right bank of the river (where is the convent), and in 1187 we first hear of the town by its present name. Between 1233 and 1235 it was fortified, and a castle built for the lord. But it was only about 1420 that Archduke Frederick IV. ("with the empty pockets") built himself a new castle in Innsbruck, which then replaced Meran as the capital of Tirol. The county of Tirol was generally held by a cadet line of the Austrian house, the count being almost an independent ruler. But the last princeling of this kind died in 1665, since which date Innsbruck and Tirol have been governed from Vienna. In 1552 Maurice of Saxony surprised and nearly took Innsbruck, almost capturing the emperor Charles V. himself, who escaped owing to a mutiny among Maurice's troops. In the patriotic war of 1809, Innsbruck played a great part and suffered much, while in 1848, at the time of the revolution in Vienna, it joyfully received the emperor Ferdinand.

(W. A. B. C.)

INNS OF COURT. The Inns of Court and Chancery are voluntary non-corporate legal societies seated in London, having their origin about the end of the 13th and the commencement of the 14th century.

Dugdale (*Origines Juridiciales*) states that the learned in English law were anciently persons in holy orders, the justices of the king's court being bishops, abbots and the like. But in 1207 the clergy were prohibited by canon from acting in the temporal courts. The result proving prejudicial to the interests of the community, a commission of inquiry was issued by Edward I. (1290), and this was followed up (1292) by a second commission, which among other things directed that students "apt and eager" should be brought from the provinces and placed in proximity to the courts of law now fixed by Magna Carta at Westminster (see Inn). These students were accordingly located in what became known as the Inns of Court and Chancery, the latter designated by Fortescue (*De Laudibus*) as "the earliest settled places for students of the law," the germ of what Sir Edward Coke subsequently spoke of as our English juridical university. In these Inns of Court and Chancery, thus constituted, and corresponding to the ordinary college, the

students, according to Fortescue, not only studied the laws and divinity, but further learned to dance, sing and play instrumental music, "so that these hostels, being nurseries or seminaries of the court, were therefore called Inns of Court."

Stow in his *Survey* (1598) says: "There is in and about this city a whole university, as it were, of students, practisers or pleaders and judges of the laws of this realm"; and he goes on to enumerate the several societies, fourteen in number, then existing, corresponding nearly with those recognized in the present day, of which the Inns of Court, properly so-called, are and always have been four, namely *Lincoln's Inn*, the *Inner Temple*, the *Middle Temple* and *Gray's Inn*. To these were originally attached as subordinate Inns of Chancery, Furnival's Inn, Thavie's Inn (to Lincoln's Inn), Clifford's Inn, Clement's Inn (to the Inner Temple), New Inn (to the Middle Temple), Staple's Inn, Barnard's Inn (to Gray's Inn), but they were cut adrift by the older Inns and by the middle of the 18th century had ceased to have any legal character (*vide infra*). In addition to these may be specified *Serjeant's Inn*, a society composed solely of serjeants-at-law, which ceased to exist in 1877. Besides the Inns of Chancery above enumerated, there were others, such as Lyon's Inn, which was pulled down in 1868, and Scrope's Inn and Chester or Strand Inn, spoken of by Stow, which have long been removed, and the societies to which they belonged have disappeared. The four Inns of Court stand on a footing of complete equality, no priority being conceded to or claimed by one inn over another. Their jurisdictions and privileges are equal, and upon affairs of common interest the benchers of the four inns meet in conference. From the earliest times there has been an interchange of fellowship between the four houses; nevertheless the Middle Temple and Lincoln's Inn, and the Inner Temple and Gray's Inn, have maintained a closer alliance.

The members of an Inn of Court consist of benchers, barristers and students. The benchers are the senior members of the society, who are invested with the government of the body to which they belong. They are more formally designated "masters of the bench," are self-elected and unrestricted as to numbers. Usually a member of an inn, on attaining the rank of king's counsel, is invited to the bench. Other members of long standing are also occasionally chosen, but no member by becoming a king's counsel or by seniority of standing acquires the right of being nominated a bencher. The benchers vary in number from twenty in Gray's Inn to seventy and upwards in Lincoln's Inn and the Inner Temple. The powers of the benchers are practically without limit within their respective societies; their duties, however, are restricted to the superintendence and management of the concerns of the inn, the admission of candidates as students, the calling of them to the bar and the exercise of discipline generally over the members. The meetings of the benchers are variously denominated a "parliament" in the Inner and Middle Temples, a "pension" in Gray's Inn and a "council" in Lincoln's Inn. The judges of the superior courts are the visitors of the inns, and to them alone can an appeal be had when either of the societies refuses to call a member to the bar, or to reinstate in his privileges a barrister who has been disbarred for misconduct. The presiding or chief officer is the treasurer, one of the benchers, who is elected annually to that dignity. Other benchers fulfil the duties of master of the library, master of the walks or gardens, dean of the chapel and so forth, while others are readers, whose functions are referred to below.

The usages of the different inns varied somewhat formerly in regard both to the term of probationary studentship enforced and to the procedure involved in a "call" to the bar by which the student is converted into the barrister. In the present day the entrance examination, the course of study and the examinations to be passed on the completion of the curriculum are identical and common to all the inns (see English Law). When once called to the bar, no hindrance beyond professional etiquette limits a barrister's freedom of action; so also members may on application to the benchers, and on payment of arrears of dues (if any), leave the society to which they belong, and thus cease altogether to be members of the bar likewise. A member of an Inn of Court retains his name on the lists of his inn for life by means of a small annual payment varying from £1 to £5, which at one or two of the inns is compounded for by a fixed sum taken at the call to the bar.

The ceremony of the "call" varies in detail at the different inns. It takes place after dinner (before dinner at the Middle Temple, which is the only inn at which students are called in their wigs and gowns), in the "parliament," "pension" or "council" chamber of the benchers. The benchers sit at a table round which are ranged the students to be called. Each candidate being provided with a glass of wine, the treasurer or senior bencher addresses them and the senior student briefly replies. "Call Parties" are also generally held by the new barristers; at the Middle Temple they are allowed in hall.

During the reign of Edward III. the Inns of Court and Chancery, based on the collegiate principle, prospered under the supervision and protection of the crown. In 1381 Wat Tyler invaded the Temple, and in the succeeding century (1450) Jack Cade meditated pulling down the Inns of Court and killing the lawyers. It would appear, moreover, that the inmates of the inns were themselves at times disorderly and in conflict with the citizens. Fortescue (*c.* 1464) describing these societies thus speaks of them: "There belong to the law ten lesser inns, which are called the Inns of Chancery, in each of which there are one hundred students at least, and in some a far greater number, though not constantly residing. After the students have made some progress here they are admitted to the Inns of Court. Of these there are four, in the least frequented of which there are about two hundred students. The discipline is excellent, and the mode of study well adapted for proficiency." This system had probably existed for two centuries before Fortescue wrote, and continued to be enforced down to the time of Sir Thomas More (1498), of Chief Justice Dyer (1537) and of Sir Edward Coke (1571). By the time of Sir Matthew Hale (1629) the custom for law students to be first entered to an Inn of Chancery before being admitted to an Inn of Court had become obsolete, and thenceforth the Inns of Chancery have been abandoned to the attorneys. Stow in his *Survey* succinctly points out the course of reading enforced at the end of the 16th century. He says that the Inns of Court were replenished partly by students coming from the Inns of Chancery, who went thither from the universities and sometimes immediately from grammar schools; and, having spent some time in studying the first elements of the law, and having performed the exercises called "bolts," "moots" and "putting of cases," they proceeded to be admitted to, and become students in, one of the Inns of Court. Here continuing for the space of seven years or thereabouts, they frequented readings and other learned exercises, whereby, growing ripe in the knowledge of the laws, they were, by the general consent either of the benchers or of the readers, called to the degree of barrister, and so enabled to practise in chambers and at the bar. This ample provision for legal study continued with more or less vigour down to nearly the commencement of the 18th century. A languor similar to that which affected the church and the universities then gradually supervened, until the fulfilment of the merest forms sufficed to confer the dignity of advocate and pleader. This was maintained until about 1845, when steps were taken for reviving and extending the ancient discipline and course of study, bringing them into harmony with modern ideas and requirements.

The fees payable vary slightly at the different inns, but average about £150. This sum covers all expenses from admission to an inn to the call at the bar, but the addition of tutorial and other expenses may augment the cost of a barrister's legal education to £400 or £500. The period of study prior to call must not be less than twelve terms, equivalent to about three years. Solicitors, however, may be called without keeping any terms if they have been in practice for not fewer than five consecutive years.

It has been seen that the studies pursued in ancient times were conducted by means of "readings," "moots" and "bolts." The *readings* were deemed of vital importance, and were delivered in the halls with much ceremony; they were

frequently regarded as authorities and cited as such at Westminster in argument. Some statute or section of a statute was selected for analysis and explanation, and its relation to the common law pointed out. Many of these readings, dating back to Edward I., are extant, and well illustrate the importance of the subjects and the exhaustive and learned manner in which they were treated. The function of “reader” involved the holder in very weighty expenses, chiefly by reason of the profuse hospitality dispensed—a constant and splendid table being kept during the three weeks and three days over which the readings extended, to which were invited the nobility, judges, bishops, the officers of state and sometimes the king himself. In 1688 the readers were paid £200 for their reading, but by that time the office had become a sinecure. In the present day the readership is purely honorary and without duties. The privilege formerly assumed by the reader of calling to the bar was taken away in 1664 by an order of the lord chancellor and the judges. *Moots* were exercises of the nature of formal arguments on points of law raised by the students and conducted under the supervision of a bencher and two barristers sitting as judges in the halls of the inns. *Bolts* were of an analogous character, though deemed inferior to moots.

In the early history of the inns discrimination was exercised in regard to the social status of candidates for admission to them. Sir John Ferne, a writer of the 16th century, referred to by Dugdale, states that none were admitted into the houses of court except they were gentlemen of blood. So also Pliny, writing in the 1st century of the Christian era (*Letters*, ii. 14), says that before his day young men even of the highest families of Rome were not admitted to practice except upon the introduction of some man of consular rank. But he goes on to add that all barriers were then broken down, everything being open to everybody—a remark applicable to the bar of England and elsewhere in the present day. It may here be noted that no dignity or title confers any rank at the bar. A privy councillor, a peer’s son, a baronet, the speaker of the House of Commons or a knight—all rank at the bar merely according to their legal precedence. Formerly orders were frequently issued both by the benchers and by the crown on the subject of the dress, manners, morals and religious observances of students and members. Although some semblance of a collegiate discipline is still maintained, this is restricted to the dining in hall, where many ancient usages survive, and to the closing of the gates of the inns at night.

Each inn maintains a chapel, with the accompaniment of preachers and other clergy, the services being those of the Church of England. The Inner and the Middle Temple have joint use of the Temple church. The office of preacher is usually filled by an ecclesiastic chosen by the benchers. The principal ecclesiastic of the Temple church is, however, constituted by letters patent by the crown without episcopal institution or induction, enjoying, nevertheless, no authority independently of the benchers. He bears the title of Master of the Temple.

It has already been stated, on the authority of Fortescue, that the students of the Inns of Court learned to dance, sing and play instrumental music; and those accomplishments found expression in the “masques” and “revels” for which the societies formerly distinguished themselves, especially the Inner Temple and Gray’s Inn. These entertainments were of great antiquity and much magnificence, involving very considerable expense. Evelyn (*Diary*) speaks of the revels at the Middle Temple as an old and riotous custom, having relation neither to virtue nor to policy. The last revel appears to have been held at the Inner Temple in 1734, to mark the occasion of the elevation of Lord Chancellor Talbot to the woolsack. The plays and masques performed were sometimes repeated elsewhere than in the hall of the inn, especially before the sovereign at court. A master of the revels was appointed, commonly designated Lord of Misrule. There is abundant information as to the scope and nature of these entertainments: one of the festivals is minutely described by Gerard Leigh in his *Accedence of Armorie*, 1612; and a tradition ascribes the first performance of Shakespeare’s *Twelfth Night* to a revel held in the Middle Temple hall in February 1601. The hospitality of the inns now finds expression mainly in the “Grand Day,” held once in each of the four terms, when it is customary for the judges and other distinguished visitors to dine with the benchers (who sit apart from the barristers and students on a daïs in some state), and “Readers’ Feast,” on both which occasions extra commons and wine are served to the members attending. But the old customs also found some renewal in the shape of balls, concerts, garden-parties and other entertainments. In 1887 there was a revival (the first since the 17th century) of the Masque of Flowers at both the Inner Temple and Gray’s Inn. The Royal Horticultural Society’s annual exhibition of flowers and fruit is held in May in the Temple Gardens. Plays are also occasionally performed in the Temple, Robert Browning’s *Sordello* being acted in 1902 by a company of amateurs, most of whom were either members of the bar or connected with the legal profession.

The *Inner* and the *Middle Temple*, so far as their history can be traced, have always been separate societies. Fortescue, writing between 1461 and 1470, makes no allusion to a previous junction of the two inns. Dugdale (1671) speaks of the Temple as having been one society, and states that the students so increased in number that at length they divided, becoming the Inner and Middle Temple respectively. He does not, however, give any authority for this statement, or furnish the date of the division. The first trustworthy mention of the Temple as an inn of court is found in the *Paston Letters*, where, under date November 1440, the Inner Temple is spoken of as a college, as is also subsequently the Middle Temple. The Temple had been the seat in England of the Knights Templars, on whose suppression in 1312 it passed with other of their possessions to the crown, and after an interval of some years to the Knights Hospitallers of St John of Jerusalem, who in the reign of Edward III. demised the mansion and its surroundings to certain professors of the common law who came from Thavie’s Inn. Notwithstanding the destruction of the muniments of the Temple by fire or by popular commotion, sufficient testimony is attainable to show that in the reigns of Edward III. and Richard II. the Temple had become the residence of the legal communities which have since maintained there a permanent footing. The two societies continued as tenants to the Knights Hospitallers of St John until the dissolution of the order in 1539; they then became the lessees of the crown, and so remained until 1609, when James I. made a grant by letters patent of the premises in perpetuity to the benchers of the respective societies on a yearly payment by each of £10, a payment bought up in the reign of Charles II. In this grant the two inns are described as “the Inner and the Middle Temple or New Temple,” and as “being two out of those four colleges the most famous of all Europe” for the study of the law. Excepting the church, nothing remains of the edifices belonging to the Knights Templars, the present buildings having been almost wholly erected since the reign of Queen Elizabeth or since the Great Fire, in which the major part of the Inner Temple perished. The church has been in the joint occupation of the Inner and Middle Temple from time immemorial—the former taking the southern and the latter the northern half. The round portion of the church was consecrated in 1185, the nave or choir in 1240. It is the largest and most complete of the four remaining round churches in England, and is built on the plan of the church of the Holy Sepulchre at Jerusalem. Narrowly escaping the ravages of the fire of 1666, this beautiful building is one of the most perfect specimens of early Gothic architecture in England. In former times the lawyers awaited their clients for consultation in the Round Church, as similarly the serjeants-at-Law were accustomed to resort to St Paul’s Cathedral, where each serjeant had a pillar assigned him.

The *Inner Temple*, comprehending a hall, parliament chamber, library and other buildings, occupies the site of the ancient mansion of the Knights Templars, built about the year 1240, and has from time to time been more or less rebuilt and extended, the present handsome range of buildings, including a new dining hall, being completed in 1870. The library owes its existence to William Petyt, keeper of the Tower Records in the time of Queen Anne, who was also a benefactor to the library of the Middle Temple. The greatest addition by gift was made by the Baron F. Maseres in 1825. The number of volumes now in the library is 37,000. Of the Inns of Chancery belonging to the Inner Temple *Clifford’s Inn* was anciently the town residence of the Barons Clifford, and was demised in 1345 to a body of students of the law.

It was the most important of the Inns of Chancery, and numbered among its members Coke and Selden. At its dinners a table was specially set aside for the "Kentish Mess," though it is not clear what connexion there was between the Inn and the county of Kent. It was governed by a principal and twelve rulers. *Clement's Inn* was an Inn of Chancery before the reign of Edward IV., taking its name from the parish church of St Clement Danes, to which it had formerly belonged. Clement's Inn was the inn of Shakespeare's Master Shallow, and was the Shepherd's Inn of Thackeray's *Pendennis*. The buildings of Clifford's Inn survive (1910), but of Clement's Inn there are left but a few fragments.

The *Middle Temple* possesses in its hall one of the most stately of existing Elizabethan buildings. Commenced in 1562, under the auspices of Edmund Plowden, then treasurer, it was not completed until 1572, the richly carved screen at the east end in the style of the Renaissance being put up in 1575. The belief that the screen was constructed of timber taken from ships of the Spanish Armada (1588) is baseless. The hall, which has been preserved unaltered, has been the scene of numerous historic incidents, notably the entertainments given within its walls to regal and other personages from Queen Elizabeth downwards. The library, which contains about 28,000 volumes, dates from 1641, when Robert Ashley, a member of the society, bequeathed his collection of books in all classes of literature to the inn, together with a large sum of money; other benefactors were Ashmole (the antiquary), William Petyt (a benefactor of the Inner Temple) and Lord Stowell. From 1711 to 1826 the library was greatly neglected; and many of the most scarce and valuable books were lost. The present handsome library building, which stands apart from the hall, was completed in 1861, the prince of Wales (afterwards Edward VII.) attending the inauguration ceremony on October 31st of that year, and becoming a member and bencher of the society on the occasion. He afterwards held the office of treasurer (1882). The MSS. in the collection are few and of no special value. In civil, canon and international law, as also in divinity and ecclesiastical history, the library is very rich; it contains also some curious works on witchcraft and demonology. There was but one Inn of Chancery connected with the Middle Temple, that of *New Inn*, which, according to Dugdale, was formed by a society of students previously settled at St George's Inn, situated near St Sepulchre's Church without Newgate; but the date of this transfer is not known. The buildings have now been pulled down.

Lincoln's Inn stands on the site partly of an episcopal palace erected in the time of Henry III. by Ralph Nevill, bishop of Chichester and chancellor of England, and partly of a religious house, called Black Friars House, in Holborn. In the reign of Edward II., Henry Lacy, earl of Lincoln, possessed the place, which from him acquired the name of Lincoln's Inn, probably becoming an Inn of Court soon after his death (in 1310), though of its existence as a place of legal study there is little authentic record until the time of Henry VI. (1424), to which date the existing muniments reach back. The fee simple of the inn would appear to have remained vested in the see of Chichester; and it was not until 1580 that the society which for centuries had occupied the inn as tenants acquired the absolute ownership of it. The old hall, built about 1506, still remains, but has given place to a modern structure designed by Philip Hardwick, R.A., which, along with the buildings containing the library, was completed in 1845, Queen Victoria attending the inauguration ceremony (October 13). The chapel, built after the designs of Inigo Jones, was consecrated in 1623. The library—as a collection of law books the most complete in the country—owes its foundation to a bequest of John Nethersale, a member of the society, in 1497, and is the oldest of the existing libraries in London. Various entries in the records of the inn relate to the library, and notably in 1608, when an effort was made to extend the collection, and the first appointment of a master of the library (an office now held in annual rotation by each bencher) was made. The library has been much enriched by donations and by the acquisition by purchase of collections of books on special subjects. It includes also an extensive and valuable series of MSS., the whole comprehending 50,000 volumes. The prince of Wales (George V.), a bencher of the society, filled the office of treasurer in 1904. The Inns of Chancery affiliated to Lincoln's Inn were Thavie's Inn and Furnival's Inn. *Thavie's Inn* was a residence of students of the law in the time of Edward III., and is mentioned by Fortescue as having been one of the lesser houses of Lincoln's Inn for some centuries. It thus continued down to 1769, when the inn was sold by the benchers, and thenceforth it ceased to have any character as a place of legal education. *Furnival's Inn* became the resort of students about the year 1406, and was purchased by the society of Lincoln's Inn in 1547. It was governed by a principal and twelve antients. In 1817 the Inn was rebuilt, but from that date it ceased to exist as a legal community and is now demolished.

The exact date of *Gray's Inn* becoming the residence of lawyers is not known, though it was so occupied before the year 1370. The inn stands upon the site of the manor of Portpoole, belonging in ancient times to the dean and chapter of St Paul's, but subsequently the property of the family of Grey de Wilton and eventually of the crown, from which a grant of the manor or inn was obtained, many years since discharged from any rent or payment. The hall of the inn is of handsome design, similar to the Middle Temple hall in its general character and arrangements, and was completed about the year 1560. The chapel, of much earlier date than the hall, has, notwithstanding its antiquity, little to recommend it to notice, being small and insignificant, and lacking architectural features of any kind. The library, including about 13,000 volumes, contains a small but important collection of MSS. and missals, and also some valuable works on divinity. Little is known of the origin or early history of the library, though mention is incidentally made of it in the society's records in the 16th and 17th centuries. The gardens, laid out about 1597, it is believed under the auspices of the lord chancellor Bacon, at that time treasurer of the society, continue to this day as then planned, though with some curtailment owing to the erection of additional buildings. Among many curious customs maintained in this inn is that of drinking a toast on grand days "to the glorious, pious and immortal memory of Queen Elizabeth." Of the special circumstances originating this display of loyalty there is no record. The Inns of Chancery connected with Gray's Inn are Staple and Barnard's Inns. *Staple Inn* was an Inn of Chancery in the reign of Henry V., and is probably of yet earlier date. Readings and moots were observed here with regularity. Sir Simonds d'Ewes mentions attending a moot in February 1624. The Inn, with its picturesque Elizabethan front, faces Holborn. It was sold by the antients in 1884 lor £68,000. It is in a very good state of preservation, and it is the intention of the purchasers, the Prudential Assurance Company, to preserve it as a memorial of vanishing London. *Barnard's Inn*, anciently designated Mackworth Inn, was an Inn of Chancery in the reign of Henry VI. It was bequeathed by him to the dean and chapter of Lincoln. It is now the property of the Mercer's Company and is used as a school.

The *King's Inns, Dublin*, the legal school in Ireland, corresponds closely to the English Inns of Court, and is in many respects in unison with them in its regulations with regard to the admission of students into the society, and to the degree of barrister-at-law, as also in the scope of the examinations enforced. Formerly it was necessary to keep a number of terms at one of the Inns in London—the stipulation dating as far back as 1542 (33 Henry VIII. c. 3). Down to 1866 the course of education pursued at the King's Inns differed from the English Inns of Court in that candidates for admission to the legal profession as attorneys and solicitors carried on their studies with those studying for the higher grade of the bar in the same building under a professor specially appointed for this purpose,—herein following the usage anciently prevailing in the Inns of Chancery in London. This arrangement was put an end to by the Attorneys and Solicitors Act (Ireland) 1866. The origin of the King's Inns may be traced to the reign of Edward I., when a legal society designated Collett's Inn was established without the walls of the city; it was destroyed by an insurrectionary band. In the reign of Edward III. Sir Robert Preston, chief baron of the exchequer, gave up his residence within the city to the legal body, which then took the name of Preston's Inn. In 1542 the land and buildings known as Preston's Inn were restored to the family of the original donor, and in the same year Henry VIII. granted the monastery of Friars Preachers for the use of the professors of the law in Ireland. The legal body removed to the new site, and thenceforward were known by the name of the King's Inns. Possession of this property having been resumed by the government in 1742, and the present Four Courts erected thereon, a plot of ground at the top of Henrietta Street was purchased by the society, and the existing hall built in the year 1800. The library, numbering over 50,000 volumes, with a few MSS., is housed in buildings specially provided in the year 1831, and is open, not only to the members of the society, but also to strangers.

The collection comprises all kinds of literature. It is based principally upon a purchase made in 1787 of the large and valuable library of Mr Justice Robinson, and is maintained chiefly by an annual payment made from the Consolidated Fund to the society in lieu of the right to receive copyright works which was conferred by an Act of 1801, but abrogated in 1836.

In discipline and professional etiquette the members of the bar in Ireland differ little from their English brethren. The same style of costume is enforced, the same gradations of rank—attorney-general, solicitor-general, king's counsel and ordinary barristers—being found. There are also serjeants-at-law limited, however, to three in number, and designated 1st, 2nd and 3rd Serjeant. The King's Inns do not provide chambers for business purposes; there is consequently no aggregation of counsel in certain localities, as is the case in London in the Inns of Court and their immediate vicinity.

The corporation known as the *Faculty of Advocates* in Edinburgh corresponds with the Inns of Court in London and the King's Inns in Dublin (see Advocates, Faculty of).

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(J. C. W.)

INNUENDO (Latin for "by nodding," from *innuere*, to indicate by nodding), an insinuation, suggestion, in prima facie innocent words, of something defamatory or disparaging of a person. The word appears in legal documents in Medieval Latin, to explain, in parenthesis, that to which a preceding word refers; thus, "he, *innuendo*, the plaintiff, is a thief." The word is still found in pleadings in actions for libel and slander. The innuendo, in the plaintiff's statement of claim, is an averment that words written or spoken by the defendant, though prima facie not actionable, have, in fact, a defamatory meaning, which is specifically set out (see Libel and Slander).

INOUYE, KAORU, MARQUESS (1835-), Japanese statesman, was born in 1835, a *samurai* of the Chōshū fief. He was a bosom friend of his fellow-clansman Prince Ito, and the two youths visited England in 1863, serving as common sailors during the voyage. At that time all travel abroad was forbidden on pain of death, but the veto did not prove deterrent in the face of a rapidly growing conviction that, as a matter of self-protection, Japan must assimilate the essentials of Western civilization. Shortly after the departure of Inouye and Ito, the Chōshū fief, having fired upon foreign vessels passing the strait of Shimonoseki, was menaced by war with the Yedo government or with the insulted powers, and Inouye and Ito, on receipt of this news, hastened home hoping to avert the catastrophe. They repaired to the British legation in Yedo and begged that the allied squadron, then about to sail for Shimonoseki to call Chōshū to account, should be delayed that they might have an opportunity of advising the fief to make timely submission. Not only was this request complied with, but a British frigate was detailed to carry the two men to Shimonoseki, and, pending her departure, the British legation assisted them to lie *perdu*. Their mission proved futile, however, and Inouye was subsequently waylaid by a party of conservative *samurai*, who left him covered with wounds. This experience did not modify his liberal views, and, by the time of the Restoration in 1867, he had earned a high reputation as a leader of progress and an able statesman. Finance and foreign affairs were supposed to be the spheres specially suited to his genius, but his name is not associated with any signal practical success in either, though his counsels were always highly valued by his sovereign and his country alike. As minister of foreign affairs he conducted the long and abortive negotiations for treaty revision between 1883 and 1886, and in 1885 he was raised to the peerage with the title of count, being one of the first group of *Meiji* statesmen whose services were thus rewarded. Prior to his permanent retirement from office in 1898, he held the portfolios of foreign affairs, finance, home affairs, and agriculture and commerce, and throughout the war with Russia he attended all important state councils, by order of the emperor, being also specially designated adviser to the minister of finance. In 1907 he was raised to the rank of marquess. His name will go down in his country's history as one of the five *Meiji* statesmen, namely, Princes Ito and Yamagata, Marquesses Inouye and Matsukata and Count Okuma.

INOWRAZLAW, the Polish form of the German *Jung-Breslau*, by which the place was formerly known, a town in the Prussian province of Posen, situated on an eminence in the most fertile part of the province, 21 m. S.W. of Thorn. Pop. (1900) 26,141. Iron-founding, the manufacture of machinery and chemicals, and an active trade in cattle and country produce are carried on. In the vicinity are important salt works and a sulphur mine, and since 1876 a brine bath has been within the town. Inowrazlaw is mentioned as early as 1185, and in 1772 it passed to Prussia.

INQUEST (O. Fr. *enqueste*, modern *enquête*, from Lat. *inquisitum*, *inquirere*, to inquire), an inquiry, particularly a

formal legal inquiry into facts. The word is now chiefly confined to the inquiry held by a coroner and jury into the causes of certain deaths, in matters of treasure trove, and, in the city of London, in cases of fires (see Coroner). Formerly the term was applied to many formal and official inquiries for fixing prices, &c.

INQUISITION, THE (Lat. *inquisitio*, an inquiry),

the name given to the ecclesiastical jurisdiction dealing both in the middle ages and in modern times with the detection and punishment of heretics and all persons guilty of any offence against Catholic orthodoxy.

Punishment of heresy in the Roman Empire.

It is incorrect to say that the Inquisition made its appearance in the 13th century complete in all its principles and organs. It was the result of, or rather one step in, a process of evolution, the beginnings of which are to be traced back to the origins of Christianity. St Paul (1 Tim. i. 20) "delivered unto Satan" Hymenaeus and Alexander, "that they might learn not to blaspheme." The penalty of death by stoning inflicted by the book of Deuteronomy upon those who deserted the true faith (Deut. xiii. 6-9, xvii. 1-6) is thus reduced to a purely spiritual excommunication. During the first three centuries of the Church there is no trace of any persecution, and the earlier Fathers, especially Origen and Lactantius, reject the idea of it. Constantine, by the edict of Milan (313), inaugurated an era of official tolerance, but from the time of Valentinian I. and Theodosius I. onwards, laws against heretics began to appear, and increased with astonishing regularity and rapidity. We can count sixty-eight distributed over fifty-two years; heretics are subjected to exile or confiscation, disqualified from inheriting property, and even, in the case of a few groups of Manichaeans and Donatists, condemned to death; but it should be noticed that these penalties apply only to the outward manifestations of heresy, and not, as in the middle ages, to crimes of conscience. Within the Church, St Optatus alone (*De schismate Donatistarum*, *lib.* iii. cap. iii.) approved of this violent repression of the Donatist heresy; St Augustine only admitted a *temperata severitas*, such as scourging, fines or exile, and at the end of the 4th century the condemnation of the Spanish heretic Priscillian, who was put to death in 385 by order of the emperor Maximus, gave rise to a keen controversy. St Martin of Tours, St Ambrose and St Leo vigorously attacked the Spanish bishops who had obtained the condemnation of Priscillian. St John Chrysostom considered that a heretic should be deprived of the liberty of speech and that assemblies organized by heretics should be dissolved, but declared that "to put a heretic to death would be to introduce upon earth an inexpiable crime." From the 6th to the 9th century the heterodox, with the exception of the Manichaean sects in certain places, were hardly subjected to persecution. They were, moreover, rare and generally isolated, for groups of sectaries only began to appear to any extent at the time of the earliest appearances of Catharism. However, at the end of the 10th century, the disciples of Vilgard, a heretic of Ravenna, were destroyed in Italy and Sardinia, according to Glaber, *ferro et incendio*, probably by assimilation to the Manichaeans. Perhaps this was the precedent for the punishment of the thirteen Cathari who were burnt at Orleans in 1022 by order of King Robert, a sentence which has been commonly quoted as the first action of the "secular arm" (or lay power) against heresy in the West during the middle ages. However that may be, after 1022 there were numerous cases of the execution of heretics, either by burning or strangling, in France, Italy, the Empire and England. Up till about 1200 it is not quite easy to determine what part was taken by the Church and its bishops and doctors in this series of executions. At Orleans the people, supported by the Crown, were responsible for the death of the heretics; the historians give only the faintest indications of any direct intervention of the clergy, except perhaps for the examination of doctrine. At Goslar (1051-1052) the proceedings were the same. At Asti (1034) the bishop's name appears side by side with those of the other lords who attacked the Cathari, but it seems clear that it was not he who had the chief voice in their execution; at Milan, it was again the civil magistrates, and this time against the wish of the archbishop—who gave the heretics the choice between the adoration of the cross and death. At Soissons (1114) the mob, distrusting the weakness of the clergy, took advantage of their bishop's absence to burn heretics at the stake. It was also the mob who, infuriated at seeing him destroy and burn crosses, burnt the heresiarch Peter of Bruis (*c.* 1140). At Liége (1144) the bishop saved from the flames certain persons whom the faithful were attempting to burn. At Cologne (1163) the archbishop was less successful, and the mob put the heretics to death without even a trial. The condemnation of Arnold of Brescia was entirely political, though he was denounced as a heretic to the secular arm by Bernard of Clairvaux, and his execution was the act of the prefect of Rome (1155). At Vézelay, on the contrary (1167), the heretics were burnt after ecclesiastical judgment had been pronounced by the abbot and several bishops. From 1183 to 1206 Hugh, bishop of Auxerre, took upon himself the discretionary power of exiling, dispossessing or burning heretics, while about the same time William of the White Hands, archbishop of Reims, in concert with Philip, count of Flanders, stamped out heresy from his diocese by fire. There was a similar unanimity between the lay and ecclesiastical authorities in the famous condemnation of the disciples of Amalric of Bena, who were burnt at Paris in 1209 by order of Philip Augustus after an ecclesiastical inquiry and judgment. The theory in these matters was at first as uncertain as the practice; in the 11th century one bishop only, Theodwin of Liége (d. 1075), affirms the necessity for the punishment of heretics by the secular arm (1050). His predecessor, Wazo, bishop of Liége from 1041 to 1044, had expressly condemned any capital punishment and advised the bishop of Chalons to resort to peaceful conversion. In the 12th century Peter the Cantor[1] protested against the death penalty, admitting at the most imprisonment. It was imprisonment again, or exile, but not death, which the German abbot Gerhoh of Reichersperg (1093-1169) demanded in the case of Arnold of Brescia, and in dealing with the heretics of Cologne, St Bernard, who cannot be accused of leniency where heterodoxy was concerned, recommended pacific refutation, followed by excommunication or prison, but never the death penalty (see Bernard, St, of Clairvaux). In the councils, too, it is clear that the appeal to the secular arm was equally guarded: at Reims (1049) excommunication alone is decreed against heretics; and when, as at Toulouse (1119) and the Lateran council (1139), it is laid down that heretics, in addition to excommunication, should be dealt with *per potestates exteras*, or when, as at the council of Reims (1148), the secular princes are forbidden to support or harbour heretics, there is never any suggestion of capital punishment. But it must be noticed that from the opening years of the 12th century date the beginnings of a decided evolution in the canon law, continuing up to the time of Innocent III., which substituted for arbitrary decisions according to circumstances an organized and particularized legislation, in which judgment was given *secundum canonicas et legitimas sanctiones*. Anselm of Lucca and the *Panormia* attributed to Ivo of Chartres reproduced word for word under the rubric *De edicto imperatorum in dampnationem hoereticorum*, law 5 of the title *De hereticis* of Justinian's code, which pronounces the sentence of death against the Manichaeans; and we should remember that the Cathari, and in general all heretics in the West in the 11th and 12th centuries were considered by contemporary theologians as Manichaeans. Gratian in the *Decretum* proclaims the views of St Augustine (exile and fines). Certain of his commentators (*2ª pars Caus.* xxiii.), and notably Rufinus Johannes Teutonicus, and the anonymous glossator (in Uguccio's Great Summa of the *Decretum*) declare that impenitent heretics may, or even

Opinions of the Fathers.

In the early Middle Ages.

Conflicting views as to the punishment of heresy.

The Church Councils.

Influence of the Canon Law.

The Council

of Tours, 1163.

should, be punished by death. As early as 1163, the council of Tours suggested to the ecclesiastical authorities definite penalties to be inflicted on heretics, namely, imprisonment and loss of all their property. Pope Alexander III., who had attended the council of Tours of 1163, renewed at the Lateran council (1179) the decisions which had already been made with regard to the heterodox in the south of France, and at Verona in 1184 Pope Lucius III., in concert with the emperor Frederick Barbarossa, took still more severe measures: obstinate heretics were to be excommunicated, and then handed over to the secular arm, which would inflict a suitable penalty. The emperor, on his side, laid them under the imperial ban (exile, confiscation, demolition of their houses, *infamia*, loss of civil rights, disqualification from public offices, &c.). The usage, then, was already quite clear; but the death penalty had not as yet been demanded or inflicted. Possibly it was Count Raymond V. of Toulouse, in whose territories heretics abounded, who in 1194 enacted a law threatening them with the penalty of death; but the authenticity of this act has been questioned. It was more probably Peter II. of Aragon who was the first to decree, in 1197, the punishment of death by burning against the heretics who should not have left his kingdom within a given time. But it was Innocent III. who gave the most powerful impetus to the anti-heretical movement in the secular world by his frequent exhortations (beginning in 1198) to the secular princes (letters of March 25th, 1199, and September 22nd, 1207). As a jurist he henceforward assimilated the crime of high treason against God to that of high treason against temporal rulers, and admitted all the terrible consequences of this assimilation.

Definition of the procedure under Lucius III. and the Emperor Frederick I.

The death penalty.

Innocent III.

It is therefore incorrect to believe that the Inquisition arose out of, and at the time of, the crusade against the Albigenses. These executions *en masse* certainly created a definitive precedent for violent repression, but there was still no regular organization: the council of Toulouse, held in November 1229 by the Roman legate after the treaty of peace, attempted to organize one, and constituted itself the tribunal. But the procedure was still uncertain; in the north, from 1200 to 1222, at Paris (execution of the disciples of Amalric of Bena), at Strassburg, Cambrai, Troyes and Besançon executions took place, after trials in which the bishops were the judges, the exercise of the secular power being based on vague phrases in the decrees of Louis VIII. (that heretics be punished *animadversione debita*), or in those of Louis IX., ordering his *baillis* or barons to do to them *quod debebunt*. The emperor Frederick II. defined his jurisprudence more clearly: from 1220 to 1239, supported by Pope Honorius III., and above all by Gregory IX., he established against the heretics of the Empire in general a legislation in which the penalties of death, banishment and confiscation of property were formulated so clearly as to be henceforth incontestable. Gregory IX. felt his influence, and also that of the Dominican Guala, bishop of Brescia, who had subjected his episcopal town to the full rigour of the imperial laws. The pope no longer hesitated as to the principle or the degree of repression; but introduced new methods of inquiry and judgment: he created out of the material furnished him by the mendicant orders, and especially the Dominicans, who were more disciplined than the rest and better theologians, the monastic inquisition, which was more elastic, more constant in its activities and more numerous than the inquisition by legate, and better disciplined than the episcopal inquisition. In November 1232 the Dominican Alberic went round Lombardy with the title of *Inquisitor haereticae pravitatis*. In 1231 a similar commission was given to the Dominicans of Friesach and to the terrible Conrad of Marburg, whose zeal in Germany even exceeded the pope's wishes. In 1233 Gregory IX. addressed a letter to the bishops in the south of France, in which he announced his intention of employing the preaching friars in future for the discovery and repression of heresy.

Albigensian Crusade. No regular Inquisition.

The Emperor Frederick II.

Gregory IX. creates the monastic Inquisition.

The Dominicans.

The inquisition was now regularly instituted, but its jurisprudence was elaborated by successive additions or limitations, by the force of custom and the detailed prescriptions added by the papal constitutions. The pope's commissioners "in the matter of heresy" at first travelled from place to place. On arriving in a district they addressed its inhabitants, called upon them to confess, if they were heretics, or to denounce those whom they knew to be heretics: a "time of grace" was opened, during which those who freely confessed were dispensed from all penalties, or only given a secret and very light penance; while those whose heresy had been openly manifested were exempted from the penalties of death and perpetual imprisonment. But this time could not exceed one month. After that began the inquisition. As soon as their mission was at an end, and heresy was considered to be stamped out, the inquisitors left the country. Later, inquisitorial districts were formed. The seat of the Inquisition in each district was the monastery of the order (Dominican or Franciscan) to which the inquisitors for that part belonged. There was never any special court or prison: the *murus* (prison) was lent to the Inquisition by the ecclesiastical or secular authorities. The maintenance of the prisoners and the duty of providing the prison fell in principle upon the bishops (council of Toulouse, 1229), but they tried to evade it. The kings of France, and in particular Louis VIII., granted subsidies to the inquisitors. For each district the inquisitors were chosen by the provincials of their order, approved or rejected by the pope, and removable by him only. Their discretionary powers were absolute. They conducted their interrogations before two persons (laymen or ecclesiastics) and only pronounced their sentence after consultation with leading men in the district (*communicato bonorum virorum consilio*). This was the only protection for the accused. It was in vain that the civil lawyers tried to prove that the secular authorities had a right to see the documents bearing on the case; the Inquisition always succeeded in setting aside these claims. The share taken in the proceedings by the bishops, the accused or their representatives, though admitted in principle, was as a rule merely illusory. The Inquisition had in addition to these *boni viri* certain other lay assistant officials, its sworn notaries, messengers and familiars, all of whom were closely bound to it.

Beginnings of the Inquisition.

Inquisitorial districts.

The Inquisitors and their auxiliaries.

Bernard Guy (Bernardus Guidonis),[2] one of the earliest and most complete exponents of the theory of the Inquisition, admits distinctly that in its procedure *multa sunt specialia*. The procedure was secret and in the highest degree arbitrary, proceeding *sine strepitu et figura judicii*, its object being to ascertain not so much particular offences as tendencies: the murderers of the inquisitor Peter Martyr[3] were tried, not as assassins, but as guilty of heresy and adversaries of the Inquisition; and on the other hand, external acts of piety and verbal professions of faith were held of no value. Moreover the Inquisition was not bound by the ordinary rules of procedure in its inquiries: the accused was surprised by a sudden summons, and as a rule imprisoned on suspicion. All the accused were presumed to be guilty, the judge being at the same time the accuser. Absence was naturally considered as contumacy, and only increased the presumption of guilt by seeming to admit it. The accused had the right to demand a written account of the offences attributed to him (*capitula accusationis*), but the names of the witnesses were withheld from him (Innocent IV.; bulls Cum negocium and *Licet sicut accepimus*), he did not know who had denounced him, nor what weight was attached by the judges to the denunciations made against him. The utmost that was allowed him was the unsatisfactory privilege of the *recusationes divinatrices*, *i.e.* at his first examination he was asked for the names of any enemies of whom he knew, and the causes of their enmity. Heretics or persons deprived of civil rights (*infames*) were admitted as witnesses in cases of heresy. Women, children or slaves could be witnesses for the prosecution, but not for the defence, and cases are even to be found in which the witnesses were only ten years of age. Langhino Ugolini states that a witness who should retract his hostile evidence should be

Procedure of the Inquisition.

punished for false witness, but that his evidence should be retained, and have its full effect on the sentence. No witness might refuse to give evidence, under pain of being considered guilty of heresy. The prosecution went on in the utmost secrecy. The accused swore that he would tell the whole truth, and was bound to denounce all those who were partners of his heresy, or whom he knew or suspected to be heretics. If he confessed, and denounced his accomplices, relatives or friends, he was "reconciled" with the Church, and had to suffer only the humiliating penalties prescribed by the canon law. If further examination proved necessary, it was continued by various methods. Bernardus Guidonis enumerates many ways of obtaining confessions, sometimes by means of moral subterfuges, but sometimes also by a process of weakening the physical strength. And as a last expedient torture was resorted to. The Church was originally opposed to torture, and the canon law did not admit confessions extorted by that means; but by the bull *Ad extirpanda* (1252) Innocent IV. approved its use for the discovery of heresy, and Urban IV. confirmed this usage, which had its origin in secular legislation (cf. the Veronese Code of 1228, and Sicilian Constitution of Frederick II. in 1231). In 1312 excessive cruelty had to be suppressed by the council of Vienna. Canonically the torture could only be applied once, but it might be "continued." The next step was the torture of witnesses, a practice which was left to the discretion of the inquisitors. Moreover, all confessions or depositions extorted in the torture-chamber had subsequently to be "freely" confirmed. The confession was always considered as voluntary. The procedure was of course not litigious; any lawyer defending the accused would have been held guilty of heresy. The inquiry might last a long time, for it was interrupted or resumed according to the discretion of the judges, who disposed matters so as to obtain as many confessions or denunciations as possible. After the different phases of the examination, the accused were divided into two categories: (1) those who had confessed and abjured, (2) those who had not confessed and were consequently convicted of heresy. There was a third class, by no means the least numerous, namely, those who having previously confessed and abjured had relapsed into error. Next came the moment of the sentence: "there was never any case of an acquittal pure and simple" (H. C. Lea). The formula for full and complete acquittal given by Bernardus Guidonis in his *Practica*, should, he says, never or very rarely be employed. The sentences were solemnly pronounced on a Sunday, in a church or public place, in the presence of the inquisitors, their auxiliaries, the bishops, the secular magistrates and the people. This was the *sermo generalis* (see Auto da fé). The accused who had confessed were reconciled, and the penalties were then pronounced; these were, in order of severity, penances, fasting, prayers, pilgrimages (Palestine, St James of Compostella, Canterbury, &c.), public scourging, the compulsory wearing on the breast or back of crosses of yellow felt sewn on to the clothes or sometimes of tongues of red, letters, &c. These were the *poenae confusibiles* (humiliating). The inquisitors eventually acquired the right of inflicting fines at discretion. In 1244 and 1251 Innocent IV. reproved them for their exactions. All these minor penalties could be commuted for payments in money in the same way as absolution from the crusader's vow, and the council of Vienna tried to put an end to these extortions. Beyond these minor penalties came the severer ones of imprisonment for a period of time, perpetual imprisonment and imprisonment of various degrees of severity (*murus largus*, *murus strictus vel strictissimus*). The *murus strictus* consisted in the deepest dungeon, with single or double fetters, and "the bread and water of affliction"; but the severity of the prison régime varied very much. The *murus largus*, especially for a rich prisoner, amounted to a fairly mild imprisonment, but the mortality among those confined in the *murus strictus* became so high that Clement V. ordered an inquiry to be made into the prison régime in Languedoc, in spite of Bernard Guy's protest against the investigation as likely to diminish the prestige of the inquisitors. After the sentences had been pronounced, the obstinate heretics and renegades were for the last time called upon to submit and to confess and abjure. If they consented, they were received as penitents, and condemned on the spot to perpetual imprisonment; if they did not consent, they were handed over to the secular arm. When the heretic was handed over to the secular arm, the agents of the secular power were recommended to punish him *debita animadversione*, and the form of recommending him to mercy was gone through. But, as M. Vacandard says, "If the secular judges had thought fit to take this formula literally, they would soon have been brought back to a recognition of the true state of affairs by excommunication." In effect, handing over to the secular arm was equivalent to a sentence of death, and of death by fire. The Dominican Jacob Sprenger, provincial of his order in Germany (1494) and inquisitor, does not hesitate to speak of the victims *quas incinerari fecimus* ("whom we [the inquisitors] caused to be burnt to ashes"). But we must accept the conclusions of H. C. Lea and Vacandard that comparatively few people suffered at the stake in the medieval Inquisition. Between 1308 and 1323, Bernard Guy, who cannot be accused of inactivity, only handed over to the secular arm 42 persons, out of 930 who were convicted of heresy.

Use of torture.

Punishments.

"Handing over to the secular arm."

From the point of view of jurisprudence of the Inquisition, the confiscation of the condemned man's property by the ecclesiastical and secular powers is only the accompaniment to the more severe penalties of perpetual imprisonment or death; but from the point of view of its economic history the importance of the confiscation is supreme. The practice originated in the Roman law, and all secular princes had already, in their own interest, recognized it as lawful (Frederick Barbarossa, Decree of Verona; Louis VIII., ordinances of 1226, 1229; Louis IX., ordinance of 1234; Raymond VII. of Toulouse, &c.). In the kingdom of France there was a special official, the *procureur des encours* (confiscation in the matter of heresy), whose duty it was to collect the personal property of the heretics, and to incorporate their landed estates in the royal domain; in Languedoc crying abuses arose, especially under the reign of Alphonse of Poitiers. Soon the papacy managed to gain a share of the spoils, even outside the states of the Church, as is shown by the bulls *ad extirpanda* of Innocent IV. and Alexander IV., and henceforward the inquisitors had, in varying proportions, a direct interest in these spoliations. In Spain this division only applied to the property of the clergy and vassals of the Church, but in France, Italy and Germany, the property of all those convicted of heresy was shared between the lay and ecclesiastical authorities. Venice alone decided that all the receipts of the Holy Office should be handed over in full to the state. Clement V., in his attempted reform and regularization of inquisitorial procedure, endeavoured to reduce the confiscations to a fairly reasonable minimum, and in 1337-1338 a series of papal inquiries was held into this financial aspect of the matter. The Assize of Clarendon, the Constitutions of Frederick II. (1232) and of Count Raymond of Toulouse (1234) had also come to a joint decision with the councils on this question. King Charles V. of France prevailed upon the papacy to abolish this regulation (1378). Confiscation was, indeed, most profitable to the secular princes, and there is no doubt that the hope of considerable gain was what induced many princes to uphold the inquisitorial administration, especially in the days of the decay of faith. The resistance of the south of France to the Capetian monarchs was to a large extent broken owing to the decimation of the bourgeoisie by the Inquisition and their impoverishment by the extortions of the *encours*. The same was the case in certain of the Italian republics; while in districts such as the north of France, where heretics were both poor and few and far between, the Inquisition did not easily take root, nor did it prove very profitable. These confiscations, the importance of which in the political and economic history of the middle ages was first shown fully by H. C. Lea, were a constant source of uncertainty in transactions of all kinds; there was, for instance, always a risk in entering into a contract in a place where the existence of heretics was suspected, since any contract entered into with a heretic was void in itself. Nor was there any more security in the transmission of inheritances for posthumous trials were frequent; the *Liber sententiarum inquisitionis* of Bernardus Guidonis (1307-1323) records sentences pronounced after death against 89 persons during a period of 15 years. But not only was their property confiscated and their heirs disinherited; they were subject to still

Punishment by confiscation of goods.

Abuse of the system.

Economic and political importance of the system.

further penalties. Frederick II. extended to heresy the application of the Roman law disqualifying from holding office, and even included under its operation the children and grandchildren of the guilty man. Alexander IV. and Boniface VIII. lightened the severity of this law, and removed certain disqualifications, notably in the case of ecclesiastical offices and property.

Condemnation of books.

Among other accessory penalties, we must notice the condemnation of books. There were many precedents for this: Constantine had had the Arian writings burnt, Theodosius II. and Valentinian III. those of the Nestorians and Manichaeans, Justinian the Talmud. In 1210 were burnt the books of David of Dinant and the Periphyseon of Aristotle. In 1255 the *De periculis novissimorum temporum* of William of St Amour[4] was burnt by order of Pope Alexander IV., and from 1248 to 1319 was pronounced a series of condemnations of the Talmud. Nicholas Eymerich (*c.* 1320-1399), the Spanish inquisitor, demanded from Pope Gregory XI. the condemnation of Raymond Lully's books, and in 1376 obtained it, but before long the Lullists returned into favour with the pope and Eymerich was banished. This rebuff suffered by an inquisitor shows how uncertain the censure of books still was, even in a country where in less than two centuries' time it was to become one of the chief spheres of inquisitorial activity.

Sorcery and magic.

The definite object of the Inquisition was the prosecution of heresy; but its sphere of action was gradually extended by the theologians and casuists until sorcery and magic ranked with dogmatic heresy. The council of Valence (1248) dealt with sorcerers as well as sacrilegious persons, but did not treat them as heretics. Alexander IV. went further, declaring that divination and sorcery should only come within the competence of the inquisitor when they directly affected the unity or faith of the Church (9th December 1257; cf. bull *Quod super nonnullis*, 10th January 1260). Cases of simple sorcery were left to be dealt with by the ordinary judges. The distinction was very subtle, but it was not tampered with until 1451, at which date Nicholas V. gave the inquisitor Hugues Lenoir the cognizance of cases of divination, even when the crime did not savour of heresy. In dealing with such a subtle question, great variations had naturally arisen in practice, and the repression of sorcery was carried on jointly by the inquisitors, the bishops and the secular courts. John XXII., in consequence of a perfect epidemic of sorcery about 1320, handed over to the inquisitors for a time (1320-1333) all cases of crimes involving magic; but this measure was temporary and exceptional and only confirms the rule. There were various occasions during the middle ages when men's minds became infatuated, and it seemed as if the scourge of magic were likely entirely to destroy the Catholic faith; and during such times, morbidly infected with fear and the spirit of persecution, the ecclesiastical judges regained all their prestige. One of these crises culminated in the affair of the "Vauderie"[5] of Arras (1459), in which twelve unfortunates perished at the stake; and there were similar occurrences at the same period in Dauphiné and Gascony; of this nature again was the violent persecution in the Germanic countries begun by the bull *Summis desiderantes* of Innocent VIII. (5th December 1484), in the course of which the two authors of the *Malleus maleficorum*, the inquisitors Sprenger and Institoris (Heinrich Krämer), distinguished themselves as much by their knowledge of theoretical demonology as by their zeal as persecutors. In France the secular authority was not long in claiming and obtaining jurisdiction over sorcerers (parlement of Paris, 1374), and as early as 1378 the university of Paris gave judgment in a case of demonology. Those unfortunates who were charged with sorcery gained, however, nothing by this change of jurisdiction, for they were invariably put to death.

The Inquisition and the Jews.

The inquisitors could not take proceedings against Jews as such. They might profess their religion and observe its rites without being in a state of heresy; they were only heretic when they attacked the Christian faith or community, made proselytes, or returned to Judaism after being converted. Further, those who practised usury were "suspected of not holding very orthodox doctrine as to theft" (Vacandard), and on this account the Inquisition gained a hold on them. Pope Martin V. (6th November 1419) authorized inquisitors to take proceedings against usurers.

Treatment of heresy in the various countries.

But these are merely extensions of competence resulting from the works of the casuists; the Inquisition was primarily the instrument for the repression of all kinds of breaches of orthodoxy. Its work in this capacity we will now describe in outline for each of the great countries of medieval Christendom.

England.

England, whether before or after the establishment of the Inquisition, had but few trials for heresy and, particularist in this as in all her religious activity, judged them according to her own discipline, without asking Rome for laws or special judges. In 1166, a few heretics having been apprehended, Henry II. called a council at Oxford and summoned them to appear before it; they all confessed, and were condemned to be scourged, branded on the face with the mark of a key, and expelled from the country, and by the 21st article of the Assize of Clarendon the king forbade any one to harbour on their lands or in the house any "of that sect of renegades who had been excommunicated at Oxford." Any one offending against this law was to be "at the king's mercy" and his house was to be "carried outside the town and burnt." The sheriffs were obliged to swear observance of this law and to require a similar oath from all barons' stewards, knights and free tenants. This was the first civil law against heresy since the end of the Roman empire, and preceded the famous rescripts of Frederick II. against sectaries in the 13th century. It should, however, be noted that the political acts of Henry II. and Frederick II. drew down the most explicit condemnation of the church. Orthodoxy remained almost unimpaired in England up till the time of Wycliffe. Apparently neither the Catharist, Waldensian nor Pantheistic heresies gained any footing in Great Britain. The affair of the Templars in France, which was quite political, was repeated in England: Clement V. having ordered their arrest, Edward II., after much hesitation, gave orders to the sheriffs to execute it and then decided that the *ecclesiastical law* should be applied. The papal inquisitors sent to England met with a bad reception, and the pope was obliged to forbid them to use torture, which was contrary to the laws of the kingdom. It was found impossible to establish the Templars' guilt and only canonical penalties were inflicted on them. The rising of the Lollards having alarmed both the church and the state, the article *De haeretico comburendo* was established by statute in 1401, and gained a melancholy notoriety during the religious struggles of the 16th century; it seems to have been not so much a measure for the safeguarding of dogma as a violent assertion of the secular absolutism. It was not till 1676 that Charles II. caused it to be abrogated, and obtained a decision that in cases of atheism, blasphemy, heresy, schism and other religious offences, the ecclesiastical courts should be confined to the penalties of excommunication, removal from office, degradation and other ecclesiastical means of censure, to the exclusion of the death penalty.

Scotland.

Scotland was much later than England in giving up persecution and bloodshed; and so late as 1696 a student of medicine aged eighteen and named Aikenhead was accused of heresy and hanged at Edinburgh.

Ireland.

In Ireland Richard de Lederede or Ledred, a Franciscan and bishop of Ossory, in 1324 prosecuted on suspicion of heresy and for sorcery a certain Dame Alice Kettle or Kyteler and her accomplices, Petronilla of Meath and her daughter Bassilla, who were accused of holding "nightly conference with a spirit called Robert Artisson, to whom she sacrificed in the high way nine red cocks and nine peacocks' eyes." The lady had powerful connexions, and her brother-in-law, Arnold le Powre, seneschal of Kilkenny, even went so far as to imprison the bishop. But in spite of the refusal of the secular authorities to co-operate with him, the bishop was strong enough to force them in 1325 to burn some of the accused. Dame Kettle herself, however, who had been cited to appear at Dublin before the dean of St Patrick's, escaped with the assistance of some of the nobles to England. Meanwhile the bishop, who had attempted to involve Arnold le Powre in the same charge, became involved in a quarrel

with the administrators of the English government in Ireland; counter charges were brought against him, he was excommunicated by his metropolitan, Alexander de Bicknor, archbishop of Dublin; and in defiance of the king's commands, after publishing counter charges against the archbishop, he appealed to Rome and left the country. In 1335 Benedict XII. wrote to Edward III. deploring the absence of any inquisition in the king's dominions, and exhorting him to lend the aid of the secular arm in repressing heresy. Archbishop Alexander, who in 1347 was denounced as an abettor of heresy, died in 1349, and his successor was ordered to chastise those heretics who had taken refuge in the diocese from Richard de Lederede's violence, and whom his predecessor had protected. Finally, in 1354, Richard de Lederede himself was allowed to return to his diocese, where his zeal for persecution does not, however, seem to have found much further scope. He died in 1360.

France.

The scene of the activities of the monastic Inquisition in France lay chiefly in the south. The repression of the Albigensian heresy (see Albigenses) went on even when its importance had quite disappeared. The chronicle of the inquisitor Guilhem Pelhisso (d. 1268) shows us the most tragic episodes of the reign of terror which wasted Languedoc for a century. Guillaume Arnaud, Peter Cella, Bernard of Caux, Jean de St Pierre, Nicholas of Abbeville, Foulques de St Georges, were the chief of the inquisitors who played the part of absolute dictators, burning at the stake, attacking both the living and the dead, confiscating their property and land, and enclosing the inhabitants both of the towns and the country in a network of suspicion and denunciation. The secular authorities were of the utmost assistance to them in this task; owing to the confiscations, the crown had too direct an interest in the success of the inquisitorial trials not to connive at all their abuses. Under the regency of Alphonse of Poitiers Languedoc was regularly laid under contribution by the *procureur des encours*. There were frequent attempts at retaliation, directed for the most part against the inquisitors, and isolated attacks were made on Dominicans. In 1234-1235 there were regular risings of the people at Albi and Narbonne, which forced the inquisitors to retreat. In 1235 the inquisitors were driven out of Toulouse. These risings were followed by terrible measures of repression, which, in turn, led to violent outbreaks on the part of the relatives, friends or compatriots of the sufferers. During the night of the 28th or 29th of May 1242 the inquisitors and their agents were massacred at the castle of Avignonet. This massacre led to a persecution which went on without opposition and almost without a lull for nearly fifty years. At the beginning of the 14th century the terrified people found a defender in the heroic Franciscan Bernard Délicieux. For a moment King Philip the Fair and Pope Clement V. seemed to interest themselves in the misfortunes of Languedoc, and the king of France sent down reformers; but they had no effect, their activity being restrained by the king himself, who was alarmed at a separatist movement which was arising in Languedoc. The work of repression which followed this moment of hope was carried out, between 1308 and 1323, by the inquisitor Bernard Guy, and completed the destruction of the Catharist heresy, the appearances of which after the middle of the 14th century became less and less frequent. Other heretics, for a time at least, took their place, namely the Spirituals, who had developed out of a branch of the Franciscans, and were remotely disciples of Joachim, abbot of Floris (*q.v.*), and whom their rigid rule of absolute poverty led, by a reaction against the cupidity of the ordinary ecclesiastics, to repudiate any hierarchy and to uphold the doctrines of Peter John de Oliva against the word of the pope. On the 17th of February 1317 John XXII. condemned all these irregular followers of St Francis, "*fraticelli, fratres de paupere vita, bizochi* or *beghini*," and the Inquisition of Languedoc was at once set in motion against them. Four *spirituales* were burnt at Marseilles in 1318, and soon the persecution was extended to the Franciscan *beguins* or *tertiarii*, many people being burnt about 1320 at Narbonne, Lunel, Béziers, Carcassonne, &c. The persecution stopped for lack of an object, for the small groups of beguins were soon destroyed, and those of the *Spirituales* who were not sent to the stake or to prison were compelled by the papacy to enter other orders than the Franciscan. The Waldenses (*q.v.*) were more difficult to destroy: originally less dangerous to the church than the Cathari, they resisted longer, and their dispersal in scattered communities aided their long resistance.

In the north of France the workings of the Inquisition were very intermittent; for there were fewer heretics there than in the south, and as they were poorer, there was less zeal on the part of the secular arm to persecute them. At its outset, however, the Inquisition in the north of France was marked by a series of melancholy events: the inquisitor Robert le Bougre, formerly a Catharist, spent six years (1233-1239) in going through the Nivernais, Burgundy, Flanders and Champagne, burning at the stake in every place unfortunates whom he condemned without a judgment, supported as he was by the ecclesiastical authorities and by princes such as Theobald of Champagne. The pope was forced to put a check on his zeal, and, after an inquiry, condemned him to imprisonment for life. We know that there were inquisitors settled in Île de France, Orléanais, Touraine, Lorraine and Burgundy during the 12th century, but we know next to nothing of what they did. In the 14th century, the Flemish and German heresies of the Free Spirit made their appearance in France; in 1310 a heretic named Marguerite Porette was burnt at Paris, and in 1373 another named Jeanne Daubenton, both of whom seem to have professed a kind of rudimentary pantheism, the latter being the head of a sect called the Turlupins. The Turlupins reappeared in 1421 at Arras and Douai and were persecuted in a similar way. But in the 15th century, with the exception of a few condemnations aimed against the Hussites, the Inquisition acted but feebly against heresy, which, as in the famous case of the "Vauderie" of Arras, was often nothing but fairly ordinary sorcery.

From the middle of the 14th century onward, the parlement had taken upon itself the right of hearing appeals from persons sentenced by the Inquisition. And the University again, by its faculty of theology, escaped the jurisdiction of the Inquisition. It was these two great bodies which at the time of the Reformation took the place of the Inquisition in dealing with heresy.

Italy.

In Italy heresy not infrequently took on a social or political character; it was sometimes almost indistinguishable from the opposition of the Ghibellines or the communalist spirit of independence. Lombardy, besides a number of Cathari, contained a certain number of vaguely-defined sects against whom the efforts of the Apostolic Visitors sent by Innocent III. were not of much effect. From the very earliest days of the Inquisition, John of Vicenza, Roland of Cremona and Rassiero Sacchoni directed their persecutions against Lombardy, and especially against Milan. St Peter Martyr, who was conspicuous for his bigoted violence, was assassinated in 1252. On the 20th of March 1256 Alexander IV. ordered the provincial of the friar preachers of Lombardy to increase the number of inquisitors in that province from four to eight. At Florence both heresy and Ghibellinism were alike crushed by the terrible severities of Fra Ruggieri, and indulgences were promised to all who should aid in the extinction of heresy in Tuscany. Certain districts revolted against this violence, which threatened to devastate Italy as it had devastated Provence; in 1277 Fra Corrado Pagano was killed on an expedition against the heretics of the Vattelline, and two years after the people of Parma rose against the inquisitors. Besides, this reign of terror only raised to a furious pitch the passionate and independent piety of the Italian peoples. The body of a heretic, Armanno Ponzilupo, who was killed at Ferrara in 1269, was venerated by the people, and his mediation was even invoked, until the Inquisition had to suppress this cult. But it had a harder struggle against the successes of Gerard Legarelli, and especially Dolcino (see Apostolici), which only came to an end after a long and difficult trial of the adepts of the Messianist sect of Guglielma, some of whom belonged to the noble families of Lombardy. Up till the beginning of the 14th century, however, the power of the Inquisition steadily increased, and at this period Zanghino Ugolini appeared as the most skilful exponent of its theory and procedure. About the same time Charles of Anjou introduced the Inquisition into the Two Sicilies, but it could rarely

effect anything there; the religious cohesion of the country was weak, and refugees were sure of safe hiding, both Waldenses and Fraticelli being frequently harboured there. When Sicily passed into the hands of Peter III. of Aragon, moreover, it came into a position of open hostility to the Holy See and became a refuge for heretics.

Venice always preserved its autonomy as regards the repression of heresy; she was perfectly orthodox, but remained entirely independent of Rome; Innocent IV. sent inquisitors there, but the heretics continued actually to be subject to the secular tribunals. In 1288 a compromise was arrived at, and the papal Inquisition was admitted into the republic, but only on condition that it should remain under the control of the secular power; thus there was established a mixed régime which survived till the last days of the Venetian state. In Savoy the Inquisition constantly carried on severe measures against the Waldenses of the Alps. During the 14th and 15th centuries there was an uninterrupted succession of trials.

States of the Church.

As regards the papal states, "it was in the nature of things that, by a confusion of the two personages, the pope should consider all opposition to him *qua* Italian prince as resistance offered to the head of the church, *i.e.* to the church" (Ch. V. Langlois). The Colonna had a personal animosity against the Gaetani; therefore Boniface VIII., a Gaetano, declared the Colonna to be heretics. Rienzi was accused of heresy for having questioned the temporal sovereignty of the pope at Rome. The Venetians, who in 1309 opposed the annexation of Ferrara by Clement V. to the detriment of the house of Este, were proclaimed heretics and placed under the ban of Christendom. Savonarola was attacked because he interfered with the policy of Alexander VI. at Florence. It was this same desire for the hegemony of Italy which inspired the attitude of the popes throughout the middle ages, causing them to excommunicate, apparently without reason so far as doctrine was concerned, the Visconti of Milan, the Della Scala of Verona, the Maffredi of Faenza, &c., and prompting them to lay under an interdict or preach a crusade against certain rebellious great towns (Clement V. against Venice, John XXII. against Milan). Further, in each of the great cities of Lombardy and Tuscany, the papal party directed the local inquisition, and this power was rarely abused.

Germany.

In Germany heresies, especially of a mystical character, were numerous in the middle ages; some of them affected the mass of the people, and led to religious and social movements of no little importance. The repression of heresy went on by fits and starts, and the Inquisition was never exercised so regularly in the Germanic as in certain of the Latin countries. At the outset of the 13th century persecutions of the Waldenses and Ortlibarii (followers of Ortlieb of Strassburg, c. 1200) took place at Strassburg; measures were taken locally until, in 1231, Gregory IX. issued definite instructions to the German prelates with a view to a regular repression of heresy, and gave full powers to execute them to Conrad of Marburg. Certain nobles having offered him resistance, he preached a crusade against them, but died by the hand of an assassin. The council of Mainz (April 1234) dealt gently with Conrad's murderers, but severely with the false witnesses whom he had employed. Shortly before (February 1234), the diet of Frankfort had decided, in spite of the pope's injunctions, that the destruction of heresy should be entrusted to the ordinary magistrates. And besides, thanks to the struggle between the Empire and the papacy, the German prelates always limited the prerogatives of the papal Inquisition. Again, by the municipal laws of the north (*Sachsenspiegel*) the ecclesiastical jurisdiction in the matter of heresy was very much limited, while the *Schwabenspiegel* (municipal laws for southern Germany) does not seem to be aware of the existence of any inquisitional jurisdiction or procedure. When in the 14th century communities of Beghards developed with extraordinary rapidity, it was the episcopal authority, both at Cologne and Strassburg, which undertook to deal with these groups of sectaries, and at the very height of the conflict between the Empire and the papacy. Marsilius of Padua, the theoretical exponent of the imperial rights, attributes to the secular judge the right and obligation to punish heresy, the priest's rôle being merely advisory. In 1353 Innocent VI. tried to implant the papal Inquisition in Germany once for all; its success was but short, and Urban V.'s attempt in 1362 succeeded little better, in spite of the fact that Charles IV. (edicts of Lucca, June 1369) gave him the support of the secular power. Towards 1372, however, Gregory XI. succeeded in regularizing the exercise of the powers of the papal inquisitors on German soil; and the latter, notably Kerlinger, Hetstede, &c. set to work to destroy the communities of the Beghards, to burn their books, to close those *beguinages* which were under suspicion, and to check by more or less violent means mystical epidemics such as those of the "flagellants," "dancers," &c. But these measures provoked angry protests from the people, the secular magistrates and even the bishops, so that Gregory XI., perceiving that he was face to face with the popular party, invited the bishops to control the inquiries of his own envoys. At the end of the 15th century the two inquisitions were acting concurrently.

Bohemia.

In Bohemia and the provinces subject to it the Waldenses had found their chosen country, and by the middle of the 13th century their propaganda was very flourishing. In 1245 Innocent IV. ordered the bishops to prosecute them with the aid of the secular arm, and in 1257, at the request of King Přemysl Ottokar II., Alexander IV. introduced the Inquisition into Bohemia. But from this date till 1335 inquisitorial missions succeeded one another without effecting any sensible diminution in the material and moral strength of the heresy. The Waldenses had been joined by other sectaries, the Luciferani, and especially the Brethren of the Free Spirit. It was in vain that the bishops of Bohemia and Silesia carried on during the second half of the 14th century an active campaign against heresy; the spirit of criticism which had arisen with regard to the morals, and even to the dogmas of the church, was already preparing the way for Hussitism.

The Balkan States.

In the regions east of the Adriatic, Catharism, the first communities of which had very probably settled here, was supreme in the time of Innocent III. and Honorius III. The first Dominicans who established themselves in these parts had much to suffer from the aggression of those very heretics whom they had come to convert. Gregory XI., implacable in his persecution of Catharism, preached a crusade against them in 1234, and Bosnia was laid waste by fire and sword. But in spite of these violent measures Catharism only gained strength in the churches of Bulgaria, Rumania, Slavonia and Dalmatia. In 1298 Boniface VIII. tried to organize the Inquisition there, but the project remained fruitless. The attempt was revived in 1323 by John XXII. with doubtful success. The persecutions undertaken in the 14th and 15th centuries merely resulted in binding the Cathari to the invading Turks, with whom they found more tolerance than with the Slav princes converted to Roman orthodoxy.

Spain.

In Spain the papal Inquisition could gain no solid footing in the middle ages. Spain had been, in turn or simultaneously, Arian under the Visigoths, Catholic under the Hispano-Romans, Mussulman by conquest, and under a régime of religious peace Judaism had developed there. After the reconquest, and even at the height of the influence of the Cathari its heresies had been of quite minor importance. At the end of the 12th century Alphonso II. and Peter II. had on principle promulgated cruel edicts against heresy, but the persecution seemed to be dormant. By the bull *Declinante* of the 26th of May 1232 inquisitors were sent to Aragon by Gregory IX. on the request of Raymond of Penaforte, and by 1237-1238 the Inquisition was practically founded. But as early as 1233 King James I. had promulgated an edict against the heretics which quite openly put the Inquisition in a subaltern position, and secularized a great part of its activities. The people, moreover, showed great hostility towards it. The inquisitor Fray Pedro de Cadrayta was murdered by the mob, and in 1235 the Cortes, with the consent of King James, prohibited the use of inquisitorial procedure and of the torture, as constituting a violation of the Fueros, though they made no attempt to give effect to their prohibition. In Castile Alphonso the Wise had, by establishing in his *Fuero*

Real and his *Siete Partidas* an entirely independent secular legislation with regard to heretics (1255), removed his kingdom from all papal interference. At the opening of the 14th century Castile and Portugal had still no Inquisition. But at that time in Spain orthodoxy was generally threatened only by a few Fraticelli and Waldenses, who were not numerous enough to call for active repression. The Spanish inquisitor Nicholas Eymerich, the author of the famous *Directorium Inquisitorum*, had rarely to exercise his functions during the whole of his long career (end of 14th century). It was not against heresy that the church had to direct its vigilance. A mutual tolerance between the different religions had in fact sprung up, even after the conquest; the Christians in the north recognized the Mahommedan and Jewish religions, and Alphonso VI. of Castile took the title of *imperador de los dos cultos*. But for a long time past both the decisions of councils and papal briefs had proclaimed their surprise and indignation at this ominous indifference. As early as 1077 the third council of Rome, and in 1081 Gregory VII., protested against the admission of Jews to public offices in Spain. Clement IV., in a brief of 1266, exhorted James I. of Aragon to expel the Moors from his dominions. In 1278 Nicholas III. blamed Peter III. for having made a truce with them. One of the canons of the council of Vienne (1311-1312) denounces as intolerable the fact that Mahommedan prayers were still proclaimed from the top of the mosques, and under the influence of this council the Spanish councils of Zamora (1313) and Valladolid (1322) came to decisions which soon led to violent measures against the Mudegares (Mussulmans of the old Christian provinces). Already in 1210 massacres of Jews had taken place under the inspiration of Arnold of Narbonne, the papal legate; in 1276 fresh disturbances took place as a result of James I.'s refusal to obey the order of Clement IV., who had called upon him to expel the Jews from his dominions. In 1278 Nicholas IV. commanded the general of the Dominicans to send friars into all parts of the kingdom to work for the conversion of the Jews, and draw up lists of those who should refuse to be baptized. It was in vain that a few princes such as Peter III. or Ferdinand of Castile interfered; the Spanish clergy directed the persecution with ever increasing zeal. In the 14th century the massacres increased, and during the year 1391 whole towns were destroyed by fire and sword, while at Valencia eleven thousand forced baptisms took place. In the 15th century the persecution continued in the same way; it can only be said that the years 1449, 1462, 1470, 1473 were marked by the greatest bloodshed. Moreover, the Mudegares were also subjected to these baptisms and massacres *en masse*. From those, or the children of those who had escaped death by baptism, was formed the class of *Conversos* or *Marranos*, the latter name being confined to the converted Jews. This class was still further increased after the conquest of the kingdom of Granada and the completion of the conquest by Ferdinand and Isabella, and after the pacification of the kingdoms of Aragon and Valencia by Charles V. The Mahommedans and Jews in these parts were given the choice between conversion and exile. Being of an active nature, and desiring some immediate powers as a recompense for their moral sufferings, the Jewish or Mussulman *Conversos* soon became rich and powerful. In addition to the hatred of the church, which feared that it might quickly become Islamized or Judaized in this country which had so little love for theology, hatred and jealousy arose also among laymen and especially in the rich and noble classes. *Limpieza*, *i.e.* purity of blood, and the fact of being an "old Christian" were made the conditions of holding offices. It is true, this mistrust had assumed a theological form even before the Mahommedan conquest. As early as 633 the council of Toledo had declared heretics such converts, forced or voluntary, as returned to their old religion. When this principle was revived and, whether through secular jealousy, religious dislike or national pride, was applied to the *Conversos*, an essentially national Inquisition, directed against local heretics, was founded in Spain, and founded without the help of the papacy. It was created in 1480 by Ferdinand and Isabella. Sixtus IV. had wished the papal Inquisition to be established after the form and spirit of the middle ages; but Ferdinand, in his desire for centralization (his efforts in this direction had already led to the creation of the Holy Hermandad and the extension of the royal jurisdiction) wished to establish an inquisition which should be entirely Spanish, and entirely royal. Rome resisted, but at last gave way. Sixtus IV., Alexander VI., Innocent VIII., Julius II. and after them all the popes of the 16th century, saw in this secular attempt a great power in favour of orthodoxy, and approved it when established, and on seeing its constant activity. The Inquisition took advantage of this to claim an almost complete autonomy. The decisions of the Roman Congregation of the Index were only valid for Spain if the Holy Office of Madrid thought good to countersign them; consequently there were some books approved at Rome and proscribed in the peninsula, such as the *Historia pelagiana* of Cardinal Nores, and some which were forbidden at Rome and approved in the peninsula, such as the writings of Fathers Mateo Moya and Juan Bautista Poza. The Spanish Holy Office perceived long before Rome the dangers of mysticism, and already persecuted the mystics, the *Alumbrados* while Rome (impervious to Molinism) still favoured them. "During the last few centuries the church of Spain was at once the most orthodox and the most independent of the national churches" (Ch. V. Langlois). There was even a financial dispute between the Inquisition and the papacy, in which the Inquisition had the better of the argument; the Roman Penitentiary sold exemptions from penalties (involving loss of civil rights), such as prison, the galleys and wearing the *sanbenito*, and dispensations from the crime of *Marrania* (secret Judaism). The inquisitors tried to gain control of this sale, and at a much higher price, and were seconded in this by the kings of Spain, who saw that it was to their own interest. At first they tried a compromise; the unfortunate victims had to pay twice, to the pope and to the Inquisition. But the payment to the pope was held by the Inquisition to reduce too much its own share of the confiscated property, and the struggle continued throughout the first half of the 16th century, the Curia finally triumphing, thanks to the energy of Paul III. Since, however, the Inquisition continued to threaten the holders of papal dispensations, most of them found it prudent to demand a definite rehabilitation, in return for payments both to the king and the Inquisition. As a national institution the Inquisition had first of all the advantage of a very strong centralization and very rapid procedure, consisting as it did of an organization of local tribunals with a supreme council at Madrid, the *Suprema*. The grand inquisitor was *ex officio* president for life of the royal council of the Inquisition. It was the grand inquisitor, General Jimenez de Cisneros, who set in motion the inquisitorial tribunals of Seville, Cordova, Jaen, Toledo, Murcia, Valladolid and Calahorra. There was no such tribunal at Madrid till the time of Philip IV. The inquisitor-general of Aragon established inquisitors at Saragossa, Barcelona, Valencia, Majorca, Sardinia, Sicily and Pampeluna (moved later to Calahorra). From the very beginning the papacy strengthened this organization by depriving the Spanish metropolitans, by the bull of the 25th of September 1487, of the right of receiving appeals from the decisions given jointly by the bishops of the various dioceses, their suffragans and the apostolic inquisitors, and by investing the inquisitor-general with this right. And, more than this, Torquemada actually took proceedings against bishops, for example, the accusation of heresy against Don Pedro Aranda, bishop of Calahorra (1498); while the inquisitor Lucero prosecuted the first archbishop of Granada, Don Ferdinando de Talavera. Further, when once the Inquisition was closely allied to the crown, no Spaniard, whether clerk or layman, could escape its power. Even the Jesuits, though not till after 1660, were put under the authority of the Suprema. The highest nobles were kept constantly under observation; during the reigns of Charles III. and Charles IV. the duke of Almodovar, the count of Aranda, the great writer Campomanes, and the two ministers Melchior de Jovellanos and the count of Florida-Alanca, were attacked by the Suprema. But the descendants of Moors and Jews, though they were good Christians, or even nobles, were most held in suspicion. Even during the middle ages the descendants of the Paterenes were known, observed and denounced. In the eyes of the Inquisition the taint of heresy was even more indelible. A family into which a forced conversion or a mixed marriage had introduced Moorish or Jewish blood was almost entirely deprived of any chance of public office, and was bound, in order to disarm suspicion, to furnish agents or spies to the Holy Office. The Spaniards were very quick to accept the idea of the Inquisition to such an extent as to look upon heresy as a national scourge to be destroyed at all costs, and they consequently considered the Inquisition as a powerful and indispensable agent of public protection; it would be going too far to state that this conception is unknown to orthodox present-day

historians of the Inquisition, and especially certain Spanish historians (cf. the preface to Menendez y Pelayo's *Heterodoxos españoles*). As had happened among the Albigenses, commerce and industry were rapidly paralysed in Spain by this odious régime of suspicion, especially as the *Conversos*, who inherited the industrial and commercial capacity of the Moors and Jews, represented one of the most active elements of the population. Besides, this system of wholesale confiscations might reduce a family to beggary in a single day, so that all transactions were liable to extraordinary risks. It was in vain that the counsellors of Charles V., and on several occasions the Cortes, demanded that the inquisitors and their countless agents should be appointed on a fixed system by the state; the state, and above all the Inquisition, refused to make any such change. The Inquisition preferred to draw its revenues from heresy, and this is not surprising if we think of the economic aspect of the Albigensian Inquisition; the system of *encours* was simply made general in Spain, and managed to exist there for three centuries. In the case of the Inquisition in Languedoc, there still remained the possibility of an appeal to the king, the inquisitors, or more rarely the pope, against these extortions; but there was nothing of the kind in Spain. The Inquisition and the Crown could refuse each other nothing, and appeals to the pope met with their united resistance. As early as the reign of Ferdinand certain rich *Conversos* who had bought letters of indulgence from the Holy See were nevertheless prosecuted by Ferdinand and Torquemada, in spite of the protests of Sixtus IV. The papacy met with the most serious checks under the Bourbons. Philip V. forbade all his subjects to carry appeals to Rome, or to make public any papal briefs without the royal *exequatur*.

The political aspect of the work and character of the Inquisition has been very diversely estimated; it is a serious error to attribute to it, as has too often been done, extreme ideas of equality, or even to represent it as having favoured centralization and a royal absolutism to the same extent as the Inquisition of the 13th and 14th centuries in Languedoc. "It was a mere coincidence," says H. C. Lea, "that the Inquisition and absolutism developed side by side in Spain." The Suprema did not attack all nobles as nobles; it attacked certain of them as *Conversos*, and the Spanish feudal nobles were sure enough of their *limpieza* to have nothing to fear from it. But it is undeniable that it frequently tended to constitute a state within the state. At the time of their greatest power, the inquisitors paid no taxes, and gave no account of the confiscations which they effected; they claimed for themselves and their agents the right of bearing arms, and it is well known that their declared adversaries, or even those who blamed them in some respects, were without fail prosecuted for heresy. But that was not the limit to their pretensions. In 1574, under Philip II., there was an idea of instituting a military order, that of Santa Maria de la Espada Blanca, having as its head the grand inquisitor, and to him all the members of the order, *i.e.* all Spaniards distinguished by *limpieza* of blood, were to swear obedience in peace and in war. Moreover, they were to recognize his jurisdiction and give up to him the reversion of their property. Nine provinces had already consented, when Philip II. put a stop to this theocratic movement, which threatened his authority. It was, however, only the Bourbons, who had imbibed Gallican ideas, who by dint of perseverance managed to make the Inquisition subservient to the Crown, and Charles III., "the philosopher king," openly set limits to the privileges of the inquisitors. Napoleon, on his entry into Madrid (December 1808), at once suppressed the Inquisition, and the extraordinary general Cortes on the 12th of February 1813 declared it to be incompatible with the constitution, in spite of the protests of Rome. Ferdinand VII. restored it (July 21, 1814) on his return from exile, but it was impoverished and almost powerless. It was again abolished as a result of the Liberal revolution of 1820, was restored temporarily in 1823 after the French military intervention under the duc d'Angoulême, and finally disappeared on the 15th of July 1834, when Queen Christina allied herself with the Liberals. "It was not, however, till the 8th of May 1869 that the principle of religious liberty was proclaimed in the peninsula; and even since then it has been limited by the constitution of 1876, which forbids the public celebration of dissident religions" (S. Reinach). In 1816 the pope abolished torture in all the tribunals of the Inquisition. It is a too frequent practice to represent as peculiar to the Spanish Inquisition modes of procedure in use for a long time in the inquisitorial tribunals of the rest of Europe. There are no special manuals, or *practica*, for the inquisitorial procedure in Spain; but the few distinctive characteristics of this procedure may be mentioned. The Suprema allowed the accused an advocate chosen from among the members or familiars of the Holy Office; this privilege was obviously illusory, for the advocate was chosen and paid by the tribunal, and could only interview the accused in presence of an inquisitor and a secretary. The theological examination was a delicate and minute proceeding; the "qualificators of the Holy Office," special functionaries, whose equivalent can, however, easily be found in the medieval Inquisition, charged those books or speeches which had incurred "theological censures," with "slight, severe or violent" suspicion. There was no challenging of witnesses; on the contrary, witnesses who were objected to were allowed to give evidence on the most important points of the case. The torture, to the practice of which the Spanish Inquisition certainly added new refinements, was originally very much objected to by the Spaniards, and Alphonso X. prohibited it in Aragon; later, especially in the 15th, 16th and 17th centuries it was applied quite shamelessly on the least suspicion. But by the end of the 18th century, according to Llorente, it had not been employed for a long time; the *fiscal*, however, habitually demanded it, and the accused always went in dread of it. The punishment of death by burning was much more often employed by the Spanish than by the medieval Inquisition; about 2000 persons were burnt in Torquemada's day. Penitents were not always reconciled, as they were in the middle ages, but those condemned to be burnt were as a rule strangled previously.

Spanish and Portuguese Colonies.

With the extension of the Spanish colonial empire the Inquisition spread throughout it almost contemporaneously with the Catholic faith. Ferdinand IV. decreed the establishment of the Inquisition in America, and Jimenes in 1516 appointed Juan Quevedo, bishop of Cuba, inquisitor-general delegate with discretionary powers. Excesses having been committed by the agents of the Holy Office, Charles V. decreed (October 15, 1538) that only the European colonists should be subject to the jurisdiction of the Inquisition; but Philip II. increased the powers of the inquisitors' delegate and, in 1541, established on a permanent basis three new provinces of the Inquisition at Lima, Mexico and Cartagena. The first *auto-da-fé* took place at Mexico in 1574, the year in which Hernando Cortez died. The Inquisition of Portugal was no less careful to ensure the orthodoxy of the Portuguese colonies. An Inquisition of the East Indies was established at Goa, with jurisdiction over all the dominions of the king of Portugal beyond the Cape of Good Hope. Finally Philip II. even wished to establish an itinerant Inquisition, and at his request the pope created, by a brief of the 21st of July 1571, the "Inquisition of the galleys," or "of fleets and armies."

Other activities of the Spanish Inquisition.

After the expulsion of the Jews under Isabella the Catholic (1492), followed under Philip III. by that of the Moriscoes (1609), the Inquisition attacked especially Catholics descended from infidels, the *Marranes* and *Conversos*, who were, not without reason, suspected of often practising in secret the rites of their ancestral religions. As late as 1715 a secret association was discovered at Madrid, consisting of twenty families, having a rabbi and a synagogue. In 1727 a whole community of Moriscoes was denounced at Granada, and prosecuted with the utmost rigour. Again, a great number of people were denounced, sent to the galleys, or burnt, for having returned to their ancestral religion, on the flimsiest of evidence, such as making ablutions during the day time, abstaining from swine's flesh or wine, using henna, singing Moorish songs, or possessing Arabic manuscripts. During the 16th and 17th centuries the Inquisition in Spain was directed against Protestantism. The inquisitor-general, Fernando de Valdés, archbishop of Seville, asked the pope to condemn the Lutherans to be burnt even if they were not backsliders, or wished to be reconciled, while in 1560 three foreign Protestants, two Englishmen and a Frenchman were burnt in defiance of all international law. But the Reformation never had enough supporters in Spain to occupy the attention of the Inquisition for long. After the *Marranes* the

mystics of all kinds furnished the greatest number of victims to the terrible tribunal. Here again we should not lose sight of the tradition of the medieval Inquisition; the mysticism of the Beghards, the Brethren of the Free Spirit and the innumerable pantheist sects had been pitilessly persecuted by the inquisitors of Germany and France during the 14th and 15th centuries. The Illuminati (*alumbrados*), who were very much akin to the medieval sectaries, and the mystics of Castile and Aragon were ruthlessly examined, judged and executed. Not even the most famous persons could escape the suspicious zeal of the inquisitors Valdés and Melchior Cano. The writings of Luis de Granada were censured as containing *cosas de alumbrados*. St Ignatius de Loyola was twice imprisoned at the beginning of his career; St Theresa was accused of misconduct, and several times denounced; one of her works, *Conceptos del amor divino*, was prohibited by the Inquisition, and she was only saved by the personal influence of Philip II. Countless numbers of obscure visionaries, devotees both men and women, clerks and laymen, were accused of Illuminism and perished in the fires or the dungeons of the Inquisition. From its earliest appearance Molinosism was persecuted with almost equal rigour. Molinos himself was arrested and condemned to perpetual imprisonment (1685-1687), and during the 18th century, till 1781, several Molinosists were burnt. The Inquisition also attacked Jansenism, freemasonry (from 1738 onwards; cf. the bull *In eminenti*) and "philosophism," the learned naturalist José Clavigo y Faxarcho (1730-1806), the mathematician Benito Bails (1730-1797), the poet Tomas de Iriarte, the ministers Clavigo Ricla, Aranda and others being prosecuted as "philosophers." Subject also to the tribunal of the Holy Office were bigamists, blasphemers, usurers, sodomites, priests who had married or broken the secrecy of the confessional, laymen who assumed ecclesiastical costume, &c. "In all these matters, though the Inquisition may have been indiscreet in meddling with affairs which did not concern it, it must be confessed that it was not cruel, and that it was always preferable to fall into the hands of the Inquisition rather than those of the secular judges, or even the Roman inquisitors" (S. Reinach). Apart from certain exceptional cruelties such as those of the Inquisition of Calahorra, perhaps the greatest number of executions of sorcerers took place in the colonies, in the Philippines and Mexico. In Spain the persecution was only moderate; at certain times it disappeared almost completely, especially in the time of the clear-sighted inquisitor Salazar.

Two features of the Spanish Inquisition are especially noteworthy: the prosecutions for "speeches suspected of heresy" and the censure of books. The great scholar Pedro de Lerma, who after fifty years at Paris (where he was dean of the faculty of theology) had returned to Spain as abbot of Compluto, was called upon in 1537 to abjure eleven "Erasmian" propositions, and was forced to return to Paris to die. Juan de Vergara and his brother were summoned before the Inquisition for favouring Erasmus and his writings, and detained several years before they were acquitted. Fray Alonso de Virues, chaplain to Charles V., was imprisoned on an absurd charge of depreciating the monastic state, and was only released by the pope at the instance of the emperor. Mateo Pascual, professor of theology at Alcala, who had in a public lecture expressed a doubt as to purgatory, suffered imprisonment and the confiscation of his goods. A similar fate befell Montemayor, Las Brozas and Luis de la Cadena.

The censure of books was established in 1502 by Ferdinand and Isabella as a state institution. All books had to pass through the hands of the bishops; in 1521 the Inquisition took upon itself the examination of books suspected of Lutheran heresy. In 1554 Charles V. divided the responsibility for the censorship between the Royal Council, whose duty it was to grant or refuse the *imprimatur* to manuscripts and the Inquisition, which retained the right of prohibiting books which it judged to be pernicious; but after 1527 it also gave the licence to print. In 1547 the Suprema produced an Index of prohibited books, drawn up in 1546 by the university of Louvain; it was completed especially as regards Spanish books, in 1551, and several later editions were published. Moreover, the *revisores de libros* might present themselves in the name of the Holy Office in any private library or bookshop and confiscate prohibited books. In 1558 the penalty of death and confiscation of property was decreed against any bookseller or individual who should keep in his possession condemned books. The censure of books was eventually abolished in 1812.

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(P. A.)

1 Pierre de Beauvoisis (?), choir-master (*grand-chantre*) of the university of Paris (1184), bishop of Tournai (1191), of Paris (1196); died as a Cistercian in 1197. He was beatified.

2 He was born *c.* 1261, was a Dominican at Limoges in 1279, successively prior of Albi (1294), Carcassonne (1297), Castres (1301) and Limoges (1305), inquisitor at Toulouse (1307), bishop of Tuy (1323) and of Lodève (1325). He died in 1331.

3 Peter, a Dominican, born at Verona, was murdered near Milan in 1252 and canonized in 1253.

4 Guillaume de St Amour (d. 1272), named after his birthplace in the Jura, was canon of Beauvais and rector of the university of Paris. He was conspicuous as the mouthpiece of the secular clergy in their attacks on the mendicant orders, the Dominicans in particular.

5 The name of *vauderie*, *i.e.* the Vaudois or Waldensian heresy, had come to be used of witchcraft.

INSANITY (from Lat. *in*, not, and *sanus*, sound), a generic term applied to certain morbid mental conditions produced by defect or disease of the brain. The synonyms in more or less frequent use are *lunacy* (from a supposed influence of the moon), *mental disease*, *alienation*, *derangement*, *aberration*, *madness*, *unsoundness of mind*. The term *Psychiatry* (ψυχή, mind, and ἰατρεία, treatment) is applied to the study and treatment of the condition.

I. MEDICAL AND GENERAL

There are many diseases of the general system productive of disturbance of the mental faculties, which, either on account of their transient nature, from their being associated with the course of a particular disease, or from their

Definition. slight intensity, are not included under the head of insanity proper. From a strictly scientific point of view it cannot be doubted that the fever patient in his delirium, or the drunkard in his excitement or stupor, is insane; the brain of either being under the influence of a morbific agent or of a poison, the mental faculties are deranged; yet such derangements are regarded as functional disturbances, *i.e.* disturbances produced by agencies which experience tells will, in the majority of cases, pass off within a given period without permanent results on the tissues of the organ. The comprehensive scientific view of the position is that all diseases of the nervous system, whether primary or secondary, congenital or acquired, should, in the words of Griesinger, be regarded as one inseparable whole, of which the so-called mental diseases comprise only a moderate proportion. However important it may be for the physician to keep this principle before him, it may be freely admitted that it cannot be carried out fully in practice, and that social considerations compel the medical profession and the public at large to draw an arbitrary line between such functional diseases of the nervous system as *hysteria*, *hypochondriasis* and *delirium* on the one hand, and such conditions as *mania*, *melancholia*, *stupor* and *dementia* on the other.

All attempts at a short definition of the term "insanity" have proved unsatisfactory; perhaps the nearest approach to accuracy is attained by the rough statement that it is *a symptom of disease of the brain inducing disordered mental symptoms*—the term disease being used in its widest acceptance. But even this definition is at once too comprehensive, as under it might be included certain of the functional disturbances alluded to, and too exclusive, as it does not comprehend certain rare transitory forms. Still, taken over all, this may be accepted as the least defective short definition; and moreover it possesses the great practical advantage of keeping before the student the primary fact that insanity is the result of disease of the brain (see Brain, and Neuropathology), and that it is not a mere immaterial disorder of the intellect. In the earliest epochs of medicine the corporeal character of insanity was generally admitted, and it was not until the superstitious ignorance of the middle ages had obliterated the scientific, though by no means always accurate, deductions of the early writers, that any theory of its purely psychical character arose. At the present day it is unnecessary to combat such a theory, as it is universally accepted that the brain is the organ through which mental phenomena are manifested, and therefore that it is impossible to conceive of the existence of an insane mind in a healthy brain. On this basis insanity may be defined as consisting in *morbid conditions of the brain, the results of defective formation or altered nutrition of its substance induced by local or general morbid processes, and characterized especially by non-development, obliteration, impairment or perversion of one or more of its psychical functions*. Thus insanity is not a simple condition; it comprises a large number of diseased states of the brain, gathered under one popular term, on account of mental defect or aberration being the predominant symptom.

The insanities are sharply divided into two great classes—the *Congenital* and the *Acquired*. Under the head of Congenital Insanity must be considered all cases in which, from whatever cause, brain development has been arrested, with consequent impotentiality of development of the mental faculties; under that of Acquired Insanity all those in which the brain has been born healthy but has suffered from morbid processes affecting it primarily, or from diseased states of the general system implicating it secondarily. In studying the causation of these two great classes, it will be found that certain remote influences exist which are believed to be commonly predisposing; these will be considered as such, leaving the proximate or exciting causes until each class with its subdivisions comes under review.

Classification.

In most treatises on the subject will be found discussed the bearing which civilization, nationality, occupation, education, &c., have, or are supposed to have, on the production of insanity. Such discussions are as a rule eminently unsatisfactory, founded as they are on common observation, broad generalizations, and very imperfect statistics. As they are for the most part negative in result, at the best almost entirely irrelevant to the present purpose, it is proposed merely to summarize shortly the general outcome of what has been arrived at by those authorities who have sought to assess the value to be attached to the influence exercised by such factors, without entering in any detail on the theories involved. The causes of insanity may be divided into (*a*) general, and (*b*) proximate.

Causation.

(*a*) General Causes.—1. *Civilization.*—Although insanity is by no means unknown amongst savage races, there can be no reasonable doubt that it is much more frequently developed in civilized communities; also that, as the former come under the influence of civilization, the percentage of lunacy is increased. This is in consonance with the observation of disease of whatever nature, and is dependent in the case of insanity on the wear and tear of nerve tissue involved in the struggle for existence, the physically depressing effects of pauperism, and on the abuse of alcoholic stimulants; each of which morbid factors falls to be considered separately as a proximate cause. In considering the influence of civilization upon the production of insanity, regard must be had to the more evolved ethical attitude towards disease in general which exists in civilized communities as well as to the more perfect recognition and registration of insanity.

2. *Nationality.*—In the face of the imperfect social statistics afforded by most European and American nations, and in their total absence or inaccessibility amongst the rest of mankind, it is impossible to adduce any trustworthy statement under this head.

3. *Occupation.*—There is nothing to prove that insanity is in any way connected with the prosecution of any trade or profession *per se*. Even if statistics existed (which they do not) showing the proportion of lunatics belonging to different occupations to the 1000 of the population, it is obvious that no accurate deduction *quoad* the influence of occupation could be drawn.

4. *Education.*—There is no evidence to show that education has any influence over either the production or the prevention of insanity. The general result of discussions on the above subjects has been the production of a series of arithmetical statements, which have either a misleading bearing or no bearing at all on the question. In the study of insanity statistics are of slight value from the scientific point of view, and are only valuable in its financial aspects.

5. *Inheritance.*—The hereditary transmission of a liability to mental disease must be reckoned as the most important among all predisposing causes of insanity. It is probably well within the mark to say that at least 50% of the insane have a direct or collateral hereditary tendency towards insanity. The true significance of this factor cannot as yet be explained or described shortly and clearly, but it cannot be too definitely stated that it is not the insanity which is inherited, but only the predisposition to the manifestation of mental symptoms in the presence of a sufficient exciting cause. The most widely and generally accepted view of the exciting cause of insanity is that the predisposed brain readily breaks down under mental stress or bodily privations. There is, however, another view which has been recently advanced to the effect that the majority of mental diseases are secondary to bodily disorders, hereditary predisposition being the equally predisposing causal factor. There is probably truth in both these views, and such an admission accentuates the complexity of the factorship of heredity. If insanity can be induced by physical disorders, which must essentially be of the nature of toxic action or of mechanical agency which can alter or influence the functional powers of the brain, then it is probable that hereditary predisposition to insanity means, not only the transmission of an unstable nervous system, but also a constitution which is either peculiarly liable to the production of such toxic or poisonous substances, or incapable of effectively dealing with the toxins or poisonous substances normally formed during metabolic processes. Such a view broadens our conception of the factorship of hereditary transmission and offers explanation as to the manner in which insanity may appear in families previously free from the taint. Very frequently we find in the history of insane patients that although there may be no insanity in the family there are undoubted

indications of nervous alongside of physical instability, the parental nervous defects taking the form of extreme nervousness, vagabondage, epilepsy, want of mental balance, inequality in mental development or endowment, extreme mental brilliancy in one direction associated with marked deficiency in others, the physical defects showing themselves in the form of insanity; liability to tubercular and rheumatic infections. The failure of constitutional power which allows of the invasion of the tubercle bacillus and the micrococcus rheumaticus in certain members of a family is apparently closely allied to that which favours the development of mental symptoms in others.

6. *Consanguinity.*—It has been strongly asserted that consanguineous marriage is a prolific source of nervous instability. There is considerable diversity of opinion on this subject; the general outcome of the investigations of many careful inquirers appears to be that the offspring of healthy cousins of a healthy stock is not more liable to nervous disease than that of unrelated parents, but that evil consequences follow where there is a strong tendency in the family to degeneration, not only in the direction of the original diathesis, but also towards instability of the nervous system. The objection to the marriage of blood relations does not arise from the bare fact of their relationship, but has its ground in the fear of their having a vicious variation of constitution, which, in their children, is prone to become intensified. There is sufficient evidence adducible to prove that close breeding is productive of degeneration; and when the multiform functions of the nervous system are taken into account, it may almost be assumed, not only that it suffers concomitantly with other organs, but that it may also be the first to suffer independently.

7. *Parental Weakness.*—Of the other causes affecting the parents which appear to have an influence in engendering a predisposition to insanity in the offspring, the abuse of alcoholic stimulants and opiates, over-exertion of the mental faculties, advanced age and weak health may be cited. Great stress has been laid on the influence exercised by the first of these conditions, and many extreme statements have been made regarding it. Such statements must be accepted with reserve, for, although there is reason for attaching considerable weight to the history of ancestral intemperance as a probable causating influence, it has been generally assumed as the proved cause by those who have treated of the subject, without reference to other agencies which may have acted in common with it, or quite independently of it. However unsatisfactory from a scientific point of view it may appear, the general statement must stand that whatever tends to lower the nervous energy of a parent may modify the development of the progeny. Constitutional tendency to nervous instability once established in a family may make itself felt in various directions—epilepsy, hysteria, hypochondriasis, neuralgia, certain forms of paralysis, insanity, eccentricity. It is asserted that exceptional genius in an individual member is a phenomenal indication. Confined to the question of insanity, the morbid inheritance may manifest itself in two directions—in defective brain organization manifest from birth, or from the age at which its faculties are potential, *i.e.* congenital insanity; or in the neurotic diathesis, which may be present in a brain to all appearance congenitally perfect, and may present itself merely by a tendency to break down under circumstances which would not affect a person of originally healthy constitution.

8. *Periodic Influence.*—The evolutional periods of puberty, adolescence, utero-gestation, the climacteric period and old age exercise an effect upon the nervous system. It may be freely admitted that the nexus between physiological processes and mental disturbances is, as regards certain of the periods, obscure, and that the causal relation is dependent more on induction than on demonstration; but it may be pleaded that it is not more obscure in respect of insanity than of many other diseases. The pathological difficulty obtains mostly in the relation of the earlier evolutional periods, puberty and adolescence, to insanity; in the others a physiologico-pathological nexus may be traced; but in regard to the former there is nothing to take hold of except the purely physiological process of development of the sexual function, the expansion of the intellectual powers, and rapid increase of the bulk of the body. Although in thoroughly stable subjects due provision is made for these evolutional processes, it is not difficult to conceive that in the nervously unstable a considerable risk is run by the brain in consequence of the strain laid on it. Between the adolescent and climacteric periods the constitution of the nervous, as of the other systems, becomes established, and disturbance is not likely to occur, except from some accidental circumstances apart from evolution. In the most healthily constituted individuals the “change of life” expresses itself by some loss of vigour. The nourishing (trophesial) function becomes less active, and either various degrees of wasting occur or there is a tendency towards restitution in bulk of tissues by a less highly organized material. The most important instance of the latter tendency is fatty degeneration of muscle, to which the arterial system is very liable. In the mass of mankind those changes assume no pathological importance: the man or woman of middle life passes into advanced age without serious constitutional disturbance; on the other hand, there may be a break down of the system due to involutional changes in special organs, as, for instance, fatty degeneration of the heart. In all probability the insanity of the climacteric period may be referred to two pathological conditions: it may depend on structural changes in the brain due to fatty degeneration of its arteries and cells, or it may be a secondary result of general systemic disturbance, as indicated by cessation of menstruation in the female and possibly by some analogous modification of the sexual function in men. The senile period brings with it further reduction of formative activity; all the tissues waste, and are liable to fatty and calcareous degeneration. Here again, the arteries of the brain are very generally implicated; atheroma in some degree is almost always present, but is by no means necessarily followed by insanity.

The various and profound modifications of the system which attend the periods of utero-gestation, pregnancy and child-bearing do not leave the nervous centres unaffected. Most women are liable to slight changes of disposition and temper, morbid longings, strange likes and dislikes during pregnancy, more especially during the earlier months; but these are universally accepted as accompaniments of the condition not involving any doubts as to sanity. But there are various factors at work in the system during pregnancy which have grave influence on the nervous system, more especially in those hereditarily predisposed, and in those gravid for the first time. There is modification of direction of the blood towards a new focus, and its quality is changed, as is shown by an increase of fibrin and water and a decrease of albumen. To such physical influences are superadded the discomfort and uneasiness of the situation, mental anxiety and anticipation of danger, and in the unmarried the horror of disgrace. In the puerperal (recently delivered) woman there are to be taken into pathological account, in addition to the dangers of sepsis, the various depressing influences of child-bed, its various accidents reducing vitality, the sudden return to ordinary physiological conditions, the rapid call for a new focus of nutrition, the translation as it were of the blood supply from the uterus to the mammae—all physical influences liable to affect the brain. These influences may act independently of moral shock; but, where this is coincident, there is a condition of the nervous system unprepared to resist its action.

(*b*) Proximate Causes.—The proximate causes of insanity may be divided into (1) toxic agents, (2) mechanical injury to the brain, including apoplexies and tumours, and (3) arterial degeneration.

1. *Toxic Agents.*—The definite nature of the symptoms in the majority of the forms of acute insanity leave little reason to doubt that they result from an invasion of the system by toxins of various kinds. The symptoms referred to may be briefly indicated as follows: (i.) Pyrexia, or fever generally of an irregular type; (ii.) Hyperleucocytosis, or an increase of the white blood corpuscles, which is the chief method by which the animal organism protects itself against the noxious influence of micro-organisms and their toxins. In such cases as typhoid fever, which is caused by a bacillus, or Malta fever which is caused by a coccus, it is found that if the blood serum of the patient is mixed *in vitro* with a broth culture of the infecting organism in a dilution of 1 in 50, that the bacilli or the cocci, as the case may be, when examined microscopically, are seen to run into groups or clusters. The organisms are said to be agglutinated, and the substance in the serum which produces this reaction is termed an agglutinine. In many of the forms of insanity which present the symptom of hyperleucocytosis there can also be demonstrated the fact that the blood serum of the patients contains agglutinines to certain members of a group of streptococci (so called on account of their tendency to grow in the form of

a chain, στρεπτός); (iii.) the rapid organic affection of the special nerve elements depending upon the virulence of the toxin, and the resistance of the individual to its influence; (iv.) the marked physical deterioration as indicated by emaciation and other changes in nutrition; (v.) the close analogy between the character of many of the mental symptoms, *e.g.* delirium, hallucinations or depression, and the symptoms produced artificially by the administration of certain poisonous drugs.

The toxic substances which are generally believed to be associated with the causation of mental disorders may be divided into three great classes: (*a*) those which arise from the morbific products of metabolism within the body itself "auto-intoxicants"; (*b*) those due to the invasion of the blood or tissues by micro-organisms; (*c*) organic or inorganic poisons introduced into the system voluntarily or accidentally.

(*a*) Auto-intoxication may be due to defective metabolism or to physiological instability, or to both combined. The results of defective metabolism are most clearly manifested in the mental symptoms which not infrequently accompany such diseases as gout, diabetes or obesity, all of which depend primarily upon a deficient chemical elaboration of the products of metabolism. The association of gout and rheumatism with nervous and mental diseases is historical, and the gravest forms of spinal and cerebral degeneration have been found in association with diabetes. Until the pathology of these affections is better understood we are not in a position to determine the nature of the toxins which appear to be the cause of these diseases and of their accompanying nervous symptoms. Physiological instability is usually manifested by neurotic persons under the strain of any unusual change in their environment. If, for instance, any material change in the food supply consisting either in a decrease of its quality or quantity, or in a failure to assimilate it properly, the nerve-cells become exhausted and irritable, sleep is diminished and a condition known as the delirium of collapse or exhaustion may supervene. An extreme instance of this condition is presented by the delirium occurring in shipwrecked persons, who having to take to the boats are suddenly deprived of food, water or both. Poisoning of the nervous system may also result from the defective action of special glands such as the thyroid, the liver or the kidneys. These conditions are specially exemplified in the mental disturbances which accompany exophthalmic goitre, uraemic poisoning, and the conditions of depression which are observed in jaundice and other forms of hepatic insufficiency.

The results of modern research point to a growing belief in the frequency of infection of the nervous system from the hosts of micro-organisms which infest the alimentary tract. No definite or substantiated discoveries have as yet been formulated which would justify us in treating this source of infection as more than a highly probable causative influence.

(*b*) When we turn, however, to the potentiality of infection by micro-organisms introduced from without into the system we are upon surer if not upon entirely definite ground. A special form of insanity called by Weber, who first described it, the delirium of collapse, was observed by him to follow certain infectious diseases such as typhus fever and pneumonia. In later years it has been frequently observed to follow attacks of influenza. Recently our views have broadened and we find that the delirium of collapse is an acute, confusional insanity which may arise without any previous febrile symptoms, and is in fact one of the common forms of acute insanity. The nature of the physical symptoms, the mental confusion and hallucinations which accompany it, as well as the fact that it frequently follows some other infective disease, leave no doubt as to its toxic origin. A similar and analogous condition is presented by incidence of general paralysis after a previous syphilitic infection. The symptoms of general paralysis coupled with the extensive and rapid degeneration of not only the nervous but of the whole of the body tissues point to a microbic disease of intense virulence which, though probably not syphilitic, is yet induced, and enhanced in its action by the previous devitalizing action of the syphilitic toxin. There is abundant evidence to show that emotions which powerfully affect the mind, if long continued, conduce towards a condition of metabolic change, which in its turn deleteriously affects the nervous system, and which may terminate in inducing a true toxic insanity.

One of the best examples of insanity arising from micro-organisms is that form which occurs after childbirth, and which is known as puerperal mania. Other insanities may, it is true, arise at this period, but those which occur within the first fourteen days after parturition are generally of infective origin. The confusional nature of the mental symptoms, the delirium and the physical symptoms are sufficient indications of the analogy of this form of mental aberration with such other toxic forms of insanity as we find arising from septic wounds and which sometimes accompany the early toxic stages of virulent infectious diseases such as typhus, diphtheria or malignant scarlet fever.

The infective origin of puerperal mania is undoubted, though, as yet, no special pathogenic organism has been isolated. Dr Douglas (*Ed. Med. Journ.*, 1897, i. 413) found the staphylococcus pyogenes aureus present in the blood in one case; Jackman (quoted *loc. cit.*) found the micrococcus pneumonial crouposae in one case; while Haultain (*Ed. Med. Journ.*, 1897, ii. 131) found only the bacillus coli communis in the blood and secretions of several cases. From our experience of similar mental and physical symptoms produced as a result of septic wounds or which succeed surgical operations there seems to be no doubt that several forms of micrococci or streptococci of a virulent character are capable by means of the toxins they exude of causing acute delirium or mania of a confusional clinical type when introduced into the body.

(*c*) Accidental and voluntary poisonings of the system which result in insanity are illustrated by the forms of insanity which follow phosphorus or lead poisoning and by Pellagra. The voluntary intoxication of the system by such drugs as morphia and alcohol will be treated of below.

2 and 3. Mechanical injuries to the brain arise from direct violence to the skull, from apoplectic hemorrhage or embolism, or from rapidly growing tumours, or from arterial degeneration.

The forms of insanity may be divided into (I.) Congenital Mental Defect and (II.) Acquired Insanity.

Forms of Insanity.

I. *Congenital Mental Defect.*—The morbid mental conditions which fall to be considered under this head are *Idiocy* (with its modification, Imbecility) and *Cretinism* (*q.v.*).

Idiocy.

Idiocy (from Gr. ἰδιώτης, in its secondary meaning of a deprived person). In treating of idiocy it must be carefully borne in mind that we are dealing with mental phenomena dissociated for the most part from active bodily disease, and that, in whatever degree it may exist, we have to deal with a brain condition fixed by the pathological circumstances under which its possessor came into the world or by such as had been present before full cerebral activity could be developed, and the symptoms of which are not dependent on the intervention of any subsequent morbid process. From the earliest ages the term *Amentia* has been applied to this condition, in contradistinction to *Dementia*, the mental weakness following on acquired insanity.

The causes of congenital idiocy may be divided into four classes: (1) hereditary predisposition, (2) constitutional conditions of one or both parents affecting the constitution of the infant, (3) injuries of the infant prior to or at birth, and (4) injuries or diseases affecting the infant head during infancy. All these classes of causes may act in two directions: they may produce either non-development or abnormal development of the cranial bones as evidenced by microcephalism, or by deformity of the head; or they may induce a more subtle morbid condition of the constituent elements of the brain. As a rule, the pathological process is more easily traceable in the case of the last three classes than in the first. For instance, in the case of constitutional conditions of the parents we may have a history of syphilis, a disease which often leaves its traces on the bones of the skull; and in the third case congenital malformation of the brain may be produced by mechanical causes acting on the child in utero, such as an attempt to procure abortion, or deformities of the maternal pelvis rendering labour difficult and instrumental interference necessary. In such cases the

bones of the skull may be injured; it is only fair, however, to say that more brains are saved than injured by instrumental interference. With regard to the fourth class, it is evident that the term congenital is not strictly applicable; but, as the period of life implicated is that prior to the potentiality of the manifestation of the intellectual powers, and as the result is identical with that of the other classes of causes, it is warrantable to connect it with them, on pathological principles more than as a mere matter of convenience.

Dr Ireland, in his work *On Idiocy and Imbecility* (1877), classifies idiots from the standpoint of pathology as follows: (1) Genetous idiocy: in this form, which he holds to be complete before birth, he believes the presumption of heredity to be stronger than in other forms; the vitality of the general system is stated to be lower than normal; the palate is arched and narrow, the teeth misshapen, irregular and prone to decay and the patient dwarfish in appearance; the head is generally unsymmetrical and the commissures occasionally atrophied; (2) Microcephalic idiocy, a term which explains itself; (3) Eclampsic idiocy, due to the effects of infantile convulsions; (4) Epileptic idiocy; (5) Hydrocephalic idiocy, a term which explains itself; (6) Paralytic idiocy, a rare form, due to the brain injury causing the paralysis; (7) Traumatic idiocy, a form produced by the third class of causes above mentioned; (8) Inflammatory idiocy; (9) Idiocy by deprivation of one or more of the special senses.

The general conformation of the idiot is generally imperfect; he is sometimes deformed, but more frequently the frame is merely awkwardly put together, and he is usually of short stature. Only about one-fourth of all idiots have heads smaller than the average. Many cases are on record in which the cranial measurements exceed the average. It is the irregularity of development of the bones of the skull, especially at the base, which marks the condition. Cases, however, often present themselves in which the skull is perfect in form and size. In such the mischief has begun in the brain matter. The palate is often highly arched; hare-lip is not uncommon; in fact congenital defect or malformation of other organs than the brain is more commonly met with among idiots than in the general community. Of the special senses, hearing is most frequently affected. Sight is good, although co-ordination may be defective. Many are mute. On account of the mental dullness it is difficult to determine whether the senses of touch, taste and smell suffer impairment; but the impression is that their acuteness is below the average. It is needless to attempt a description of the mental phenomena of idiots, which range between utter want of intelligence and mere weakness of intellect.

The term *Imbecility* has been conventionally employed to indicate the less profound degrees of idiocy, but in point of fact no distinct line of demarcation can be drawn between the conditions. As the scale of imbeciles ascends it is found that the condition is evidenced not so much by obtuseness as by irregularity of intellectual development. This serves to mark the difference between the extreme stupidity of the lowest of the healthy and the highest forms of the morbidly deprived type. The two conditions do not merge gradually one into the other. Absolute stupidity and sottishness mark many cases of idiocy, but only in the lowest type, where no dubiety of opinion can exist as to its nature, and in a manner which can never be mistaken for the dulness of the man who is less talented than the average of mankind. Where in theory the morbid (in the sense of deprivation) and the healthy types might be supposed to approach each other, in practice we find that, in fact, no debatable ground exists. The uniformity of dulness of the former stands in marked opposition to the irregularity of mental conformation in the latter. Comparatively speaking, there are few idiots or imbeciles who are uniformly deprived of mental power; some may be utterly sottish, living a mere vegetable existence, but every one must have heard of the quaint and crafty sayings of manifest idiots, indicating the presence of no mean power of applied observation. In institutions for the treatment of idiots and imbeciles, children are found not only able to read and write, but even capable of applying the simpler rules of arithmetic. A man may possess a very considerable meed of receptive faculty and yet be idiotic in respect of the power of application; he may be physically disabled from relation, and so be manifestly a deprived person, unfit to take a position in the world on the same platform as his fellows.

Dr Ireland subdivides idiots, for the purpose of education, into five grades, the first comprising those who can neither speak nor understand speech, the second those who can understand a few easy words, the third those who can speak and can be taught to work, the fourth those who can be taught to read and write, and the fifth those who can read books for themselves. The treatment of idiocy and imbecility consists almost entirely of attention to hygiene and the building up of the enfeebled constitution, along with endeavours to develop what small amount of faculty exists by patiently applied educational influences. The success which has attended this line of treatment in many public and private institutions has been very considerable. It may be safely stated that most idiotic or imbecile children have a better chance of amelioration in asylums devoted to them than by any amount of care at home.

In the class of idiots just spoken of, imperfect development of the intellectual faculties is the prominent feature, so prominent that it masks the arrest of potentiality of development of the moral sense, the absence of which, even if noticed, is regarded as relatively unimportant; but, in conducting the practical study of congenital idiots, a class presents itself in which the moral sense is wanting or deficient, whilst the intellectual powers are apparently up to the average. It is the custom of writers on the subject to speak of “intellectual” and “moral” idiots. The terms are convenient for clinical purposes, but the two conditions cannot be dissociated, and the terms therefore severally only imply a specially marked deprivation of intellect or of moral sense in a given case. The everyday observer has no difficulty in recognizing as a fact that deficiency in receptive capacity is evidence of imperfect cerebral development; but it is not so patent to him that the perception of right or wrong can be compromised through the same cause, or to comprehend that loss of moral sense may result from disease. The same difficulty does not present itself to the pathologist; for, in the case of a child born under circumstances adverse to brain development, and in whom no process of education can develop an appreciation of what is right or wrong, although the intellectual faculties appear to be but slightly blunted, or not blunted at all, he cannot avoid connecting the physical peculiarity with the pathological evidence. The world is apt enough to refer any fault in intellectual development, manifested by imperfect receptivity, to a definite physical cause, and is willing to base opinion on comparatively slight data; but it is not so ready to accept the theory of a pathological implication of the intellectual attributes concerned in the perception of the difference between right and wrong. Were, however, two cases pitted one against another—the first one of so-called intellectual, the second one of so-called moral idiocy—it would be found that, except as regards the psychical manifestations, the cases might be identical. In both there might be a family history of tendency to degeneration, a peculiar cranial conformation, a history of previous symptoms during infancy, and of a series of indications of mental incapacities during adolescence, differing only in this, that in the first the prominent indication of mental weakness was inability to add two and two together, in the second the prominent feature was incapacity to distinguish right from wrong. What complicates the question of moral idiocy is that many of its subjects can, when an abstract proposition is placed before them, answer according to the dictates of morality, which they may have learnt by rote. If asked whether it is right or wrong to lie or steal they will say it is wrong; still, when they themselves are detected in either offence, there is an evident non-recognition of its concrete nature. The question of moral idiocy will always be a moot one between the casuist and the pathologist; but, when the whole natural history of such cases is studied, there are points of differentiation between their morbid depravation and mere moral depravity. Family history, individual peculiarities, the general bizarre nature of the phenomena, remove such cases from the category of crime.

Statistics.—According to the census returns of 1901 the total number of persons described as idiots and imbeciles in

England and Wales was 48,882, the equality of the sexes being remarkable, namely, 24,480 males and 24,402 females. Compared with the entire population the ratio is 1 idiot or imbecile to 665 persons, or 15 per 10,000 persons living. Whether the returns are defective, owing to the sensitiveness of persons who would desire to conceal the occurrence of idiocy in their families, we have no means of knowing; but such a feeling is no doubt likely to exist among those who look upon mental infirmity as humiliating, rather than, as one of the many physical evils which afflict humanity. Dr. Ireland estimates that there is 1 idiot or imbecile to every 500 persons in countries that have a census. The following table shows the number of idiots according to official returns of the various countries:—

	Males.	Females.	Total.	Proportion to 100,000 of Pop.
England and Wales	24,480	24,402	48,882	150
Scotland	3,246	3,377	6,623	148
Ireland	2,946	2,270	5,216	117
France (including cretins) (1872)	20,456	14,677	35,133	97
Germany (1871)	—	—	33,739	82
Sweden (1870)	—	—	1,632	38
Norway (1891)	1,357	1,074	2,431	121
Denmark (1888-89)	2,106	1,751	3,857	200

For the United States there are no later census figures than 1890 when the feeble-minded or idiotic were recorded as 95,571 (52,940 males and 42,631 females). In 1904 (*Special Report of Bureau of Census*, 1906) the “feeble-minded” were estimated at 150,000.

The relative frequency of congenital and acquired insanity in various countries is shown in the following table, taken from Koch’s statistics of insanity in Württemberg, which gives the number of idiots to 100 lunatics:—

Prussia	158	France	66
Bavaria	154	Denmark	58
Saxony	162	Sweden	22
Austria	53	Norway	65
Hungary	140	England and Wales	74
Canton of Bern	117	Scotland	68
America	79	Ireland	69

It is difficult to understand the wide divergence of these figures, except it be that in certain states, such as Prussia and Bavaria, dements have been taken along with aments and in others cretins. This cannot, however, apply to the case of France, which is stated to have only 66 idiots to every 100 lunatics. In many districts of France cretinism is common; it is practically unknown in England, where the proportion of idiots is stated as higher than in France; and it is rare in Prussia, which stands at 158 idiots to 100 lunatics. Manifestly imperfect as this table is, it shows how important an element idiocy is in social statistics; few are aware that the number of idiots and that of lunatics approach so nearly.

II. *Acquired Insanity.*—So far as the mental symptoms of acquired insanity are concerned, Pinel’s ancient classification, into *Mania*, *Melancholia* and *Dementia*, is still applicable to every case, and although numberless classifications have been advanced they are for the most part merely terminological variations. Classifications of the insanities based on pathology and etiology have been held out as a solution of the difficulty, but, so far, pathological observations have failed to fulfil this ideal, and no thoroughly satisfactory pathological classification has emerged from them.

Acquired Insanity.

Classifications are after all matters of convenience; the following system admittedly is so:—

Melancholia.

Mania.

Delusional Insanity.

Katatonia.

Hebephrenia.

Traumatic Insanity.

Insanity following upon arterial degeneration.

Insanities associated or caused by: General Paralysis; Epilepsy.

Insanities associated with or caused by Alcoholic and Drug intoxication: Delirium Tremens, Chronic Alcoholic Insanity, Dipsomania, Morphinism.

Senile Insanity.

The general symptoms of acquired insanity group themselves naturally under two heads, the physical and the mental.

The physical symptoms of mental disease generally, if not invariably, precede the onset of the mental symptoms, and the patient may complain of indefinite symptoms of malaise for weeks and months before it is suspected that the disorder is about to terminate in mental symptoms. The most general physical disorder common to the onset of all the insanities is the failure of nutrition, *i.e.* the patient rapidly and apparently without any apparent cause loses weight. Associated with this nutritional failure it is usual to have disturbances of the alimentary tract, such as loss of appetite, dyspepsia and obstinate constipation. During the prodromal stage of such conditions as mania and melancholia the digestive functions of the stomach and intestine are almost or completely in abeyance. To this implication of other systems consequent on impairment of the trophesial (nourishment-regulating) function of the brain can be traced a large number of the errors which exist as to the causation of idiopathic melancholia and mania. Very frequently this secondary condition is set down as the primary cause; the insanity is referred to derangements of the stomach or bowels, when in fact these are, concomitantly with the mental disturbance, results of the cerebral mischief. Doubtless these functional derangements exercise considerable influence on the progress of the case by assisting to deprave the general economy, and by producing depressing sensations in the region of the stomach. To them may probably be attributed, together with the apprehension of impending insanity, that phase of the disease spoken of by the older writers as the *stadium melancholicum*, which so frequently presents itself in incipient cases.

General symptoms.

The skin and its appendages—the hair and the nails—suffer in the general disorder of nutrition which accompanies all

insanities. The skin may be abnormally dry and scurfy or moist and offensive. In acute insanities rashes are not uncommon, and in chronic conditions, especially conditions of depression, crops of papules occur on the face, chest and shoulders. The hair is generally dry, loses its lustre and becomes brittle. The nails become deformed and may exhibit either excessive and irregular or diminished growth.

Where there are grave nutritional disorders it is to be expected that the chief excretions of the body should show departures from the state of health. In this article it is impossible to treat this subject fully, but it may suffice to say that in many states of depression there is a great deficiency in the excretion of the solids of the urine, particularly the nitrogenous waste products of the body; while in conditions of excitement there is an excessive output of the nitrogenous waste products. It has lately been pointed out that in many forms of insanity indoxyl is present in the urine, a substance only present when putrefactive processes are taking place in the intestinal tract.

The nervous system, both on the sensory and motor side, suffers very generally in all conditions of insanity. On the sensory side the special senses are most liable to disorder of their function, whereby false sense impressions arise which the patient from impairment of judgment is unable to correct, and hence arise the psychical symptoms known as hallucinations and delusions. Common sensibility is generally impaired.

On the motor side, impairment of the muscular power is present in many cases of depression and in all cases of dementia. The incontinence of urine so frequently seen in dementia and in acute insanity complicated with the mental symptom of confusion depends partly on impairment of muscular power and partly on disorder of the sensory apparatus of the brain and spinal cord.

The outstanding mental symptom in nearly all insanities, acute and recent or chronic, is the failure of the capacity of judgment and loss of self-control. In early acute insanities, however, the two chief symptoms which are most evident and easily noted are depression on the one hand and excitement or elevation on the other. Some distinction ought to be made between these two terms, excitement and elevation, which at present are used synonymously. Excitement is a mental state which may be and generally is associated with confusion and mental impairment, while elevation is an exaltation of the mental faculties, a condition in which there is no mental confusion, but rather an unrestrained and rapid succession of fleeting mental processes.

The symptoms which most strongly appeal to the lay mind as conclusive evidence of mental disorder are hallucinations and delusions. Hallucinations are false sense impressions which occur without normal stimuli. The presence of hallucinations certainly indicates some functional disorder of the higher brain centres, but is not an evidence of insanity so long as the sufferer recognizes that the hallucinations are false sense impressions. So soon, however, as conduct is influenced by hallucinations, then the boundary line between sanity on the one hand and insanity on the other has been crossed. The most common hallucinations are those of sight and hearing.

Delusions are not infrequently the result of hallucinations. If the hallucinations of a melancholic patient consist in hearing voices which make accusatory statements, delusions of sin and unworthiness frequently follow. Hallucinations of the senses of taste and smell are almost invariably associated with the delusion that the patient's food is being poisoned or that it consists of objectionable matter. On the other hand, many delusions are apparently the outcome of the patient's mental state. They may be pleasant or disagreeable according as the condition is one of elevation or depression. The intensity and quality of the delusions are largely influenced by the intelligence and education of the patient. An educated man, for instance, who suffers from sensory disturbances is much more ingenious in his explanations as to how these sensory disturbances result from electricity, marconigrams, X-rays, &c., which he believes are used by his enemies to annoy him, than an ignorant man suffering from the same abnormal sensations. Loss of self-control is characteristic of all forms of insanity. Normal self-control is so much a matter of race, age, the state of health, moral and physical upbringing, that it is impossible to lay down any law whereby this mental quality can be gauged, or to determine when deficiency has passed from a normal to an abnormal state. In many cases of insanity there is no difficulty in appreciating the pathological nature of the deficiency, but there are others in which the conduct is otherwise so rational that one is apt to attribute the deficiency to physiological rather than to pathological causes. Perversion of the moral sense is common to all the insanities, but is often the only symptom to be noticed in cases of imbecility and idiocy, and it as a rule may be the earliest symptom noticed in the early stages of the excitement of manic-depressive insanity and general paralysis.

The tendency to commit suicide, which is so common among the insane and those predisposed to insanity, is especially prevalent in patients who suffer from depression, sleeplessness and delusions of persecution. Suicidal acts may be divided into accidental, impulsive and premeditated. The accidental suicides occur in patients who are partially or totally unconscious of their surroundings, and are generally the result of terrifying hallucinations, to escape from which the patient jumps through a window or runs blindly into water or some other danger. Impulsive suicides may be prompted by suddenly presented opportunities or means of self-destruction, such as the sight of water, fire, a knife, cord or poison. Premeditated suicides most frequently occur in states of long continued depression. Such patients frequently devote their attention to only one method of destruction and fail to avail themselves of others equally practicable. As a rule the more educated the patient, the more ingenious and varied are the methods adopted to attain the desired result.

The faculty of attention is variously affected in the subjects of insanity. In some the attention is entirely subjective, being occupied by sensations of misery, depression or sensory disturbances. In others the attention is objective, and attracted by every accidental sound or movement. In most of the early acute insanities the capacity of attention is wholly abolished, while in hebephrenia the stage of exhaustion which follows acute excitement, and the condition known as secondary dementia, loss of the power of attention is one of the most prominent symptoms. The memory for both recent and remote events is impaired or abolished in all acute insanities which are characterized by confusion and loss or impairment of consciousness. In the excited stage of manic-depressive insanity it is not uncommon to find that the memory is abnormally active. Loss of memory for recent but not remote events is characteristic of chronic alcoholism and senility and even the early stage of general paralysis.

Of all the functions of the brain that of sleep is the most liable to disorder in the insane. Sleeplessness is the earliest symptom in the onset of insanity; it is universally present in all the acute forms, and the return of natural sleep is generally the first symptom of recovery. The causes of sleeplessness are very numerous, but in the majority of acute cases the sleeplessness is due to a state of toxaemia. The toxins act either directly on the brain cells producing a state of irritability incompatible with sleep, or indirectly, producing physical symptoms which of themselves alone are capable of preventing the condition of sleep. These symptoms are high arterial tension and a rapid pulse-rate. The arterial tension of health ranges between 110 and 120 millimetres of mercury, and when sleep occurs the arterial tension falls and is rarely above 100 millimetres. In observations conducted by Bruce (*Scottish Medical and Surgical Journal*, August 1900) on cases of insanity suffering from sleeplessness the arterial tension was found to be as high as 140 and 150 millimetres. When such sleep was obtained the tension always sank at once to 110 millimetres or even lower. In a few cases suffering from sleeplessness the arterial tension was found to be below 100 millimetres, accompanied by a rapid pulse-rate. When sleep set in, in these cases, no alteration was noted in the arterial tension, but the pulse was markedly diminished.

Melancholia.—Melancholia is a general term applied to all forms of insanity in which the prevailing mental symptom is

Melancholia. that of depression and dates back to the time of Hippocrates. Melancholic patients, however, differ very widely from one another in their mental symptoms, and as a consequence a perfectly unwarrantable series of subdivisions have been invented according to the prominence of one or other mental symptoms. Such terms as delusional melancholia, resistive melancholia, stuporose melancholia, suicidal melancholia, religious melancholia, &c. have so arisen; they are, however, more descriptive of individual cases than indicative of types of disease.

So far as our present knowledge goes, at least three different and distinct disease conditions can be described under the general term melancholia. These are, acute melancholia, excited melancholia and the state of depression occurring in *Folie circulaire* or alternating insanity, a condition in which the patient is liable to suffer from alternating attacks of excitement and depression.

Acute Melancholia is a disease of adult life and the decline of life. Women appear to be more liable to be attacked than men. Hereditary predisposition, mental worry, exhausting occupations, such as the sick-nursing of relatives, are the chief predisposing causes, while the direct exciting cause of the condition is due to the accumulation in the tissues of waste products, which so load the blood as to act in a toxic manner on the cells and fibres of the brain.

The onset of the disease is gradual and indefinite. The patient suffers from malaise, indigestion, constipation and irregular, rapid and forcible action of the heart. The urine become scanty and high coloured. The nervous symptoms are irritability, sleeplessness and a feeling of mental confusion. The actual onset of the acute mental symptoms may be sudden, and is not infrequently heralded by distressing hallucinations of hearing, together with a rise in the body temperature. In the fully developed disease the patient is flushed and the skin hot and dry; the temperature is usually raised 1° above the normal in the evening. The pulse is hard, rapid and often irregular. There is no desire for food, but dryness of the mouth and tongue promote a condition of thirst. The bowels are constipated. The urine is scanty and frequently contains large quantities of indoxyl. The blood shows no demonstrable departure from the normal. The patient is depressed, the face has a strained, anxious expression, while more or less mental confusion is always present. Typical cases suffer from distressing aural hallucinations, and the function of sleep is in abeyance.

Acute melancholia may terminate in recovery either gradually or by crises, or the condition may pass into chronicity, while in a small proportion of cases death occurs early in the attack from exhaustion and toxaemia. The acute stage of onset generally lasts for from two to three weeks, and within that period the patient may make a rapid and sudden recovery. The skin becomes moist and perspiration is often profuse. Large quantities of urine are excreted, which are laden with waste products. The pulse becomes soft and compressible, sleep returns, and the depression, mental confusion and hallucinations pass away. In the majority of untreated cases, however, recovery is much more gradual. At the end of two or three weeks from the onset cf the attack the patient gradually passes into a condition of comparative tranquillity. The skin becomes moister, the pulse less rapid, and probably the earliest symptom of improvement is return of sleep. Hallucinations accompanied by delusions persist often for weeks and months, but as the patient improves physically the mental symptoms become less and less prominent.

If the patient does not recover, the physical symptoms are those of mal-nutrition, together with chronic gastric and intestinal disorder. The skin is dull and earthy in appearance, the hair dry, the nails brittle and the heart’s action weak and feeble. Mentally there is profound depression with delusions, and persistent or recurring attacks of hallucinations of hearing. When death occurs, it is usually preceded by a condition known as the “typhoid state.” The patient rapidly passes into a state of extreme exhaustion, the tongue is dry and cracked, sordes form upon the teeth and lips, diarrhoea and congestion of the lungs rapidly supervene and terminate life.

Treatment.—The patient in the early stage of the disease must be confined to bed and nursed by night as well as day. The food to begin with should be milk, diluted with hot water or aerated water, given frequently and in small quantities. The large intestine should be thoroughly cleared out by large enemata and kept empty by large normal saline enemata administered every second day. Sleep may be secured by lowering the blood pressure with half-grain doses of erythrol-tetra-nitrate. If a hypnotic is necessary, as it will be if the patient has had no natural sleep for two nights in succession, then a full dose of paraldehyde or veronal may be given at bed-time. Under this treatment the majority of cases, if treated early, improve rapidly. As the appetite returns great care must be taken that the patient does not suddenly resume a full ordinary dietary. A sudden return to a full dietary invariably means a relapse, which is often less amenable to treatment than the original attack. Toast should first be added to the milk, and this may be followed by milk puddings and farinaceous foods in small quantities. Any rise of temperature or increase of pulse-rate or tendency to sleeplessness should be regarded as a threatened relapse and treated accordingly.

Excited Melancholia.—Excited melancholia is almost invariably a disease of old age or the decline of life, and it attacks men and women with equal frequency. Chronic gastric disorders, deficient food and sleep, unhealthy occupations and environments, together with worry and mental stress, are all more or less predisposing causes of the disease. The direct exciting cause or causes have not as yet been demonstrated, but there is no doubt that the disease is associated with, or caused by, a condition of bacterial toxaemia, analogous to the bacterial toxaemias of acute and chronic rheumatism.

The onset of the disease is always gradual and is associated with mal-nutrition, loss of body weight, nervousness, depression, loss of the capacity for work, sleeplessness and attacks of restlessness, these attacks of restlessness become more and more marked as self-control diminishes, and as the depression increases the disease passes the borderland of sanity.

In the fully developed disease the appearance of the patient is typical. The expression is drawn, depressed, anxious or apprehensive. The skin is yellow and parchment like. The hair is often dry and stands out stiffly from the head. The hands are in constant movement, twisting and untwisting, picking the skin, pulling at the hair or tearing at the clothes. The patient moans continuously, or emits cries of grief and wanders aimlessly. Mentally the patient, although depressed, miserable and self-absorbed, is not confused. There is complete consciousness except during the height of a paroxysm of restlessness and depression, and the patient can talk and answer questions clearly and intelligently, but takes no interest in the environment. Some of the patients suffer from delusions, generally a sense of impending danger, but very few suffer from hallucinations.

Physically there is loss of appetite, constipation and rapid heart action, a great increase in the number of the white blood corpuscles, particularly of the multinucleated cells which are frequently increased in bacterial infections. In the blood serum also there can be demonstrated the presence of agglutinines to certain members of the streptococci group.

The course of the disease is prolonged and chronic. The acute symptoms tend to remit at regular intervals, the patient becoming more quiet and less demonstratively depressed; but as a rule these remissions are extremely temporary. Excited melancholia is a disease characterized by repeated relapses, and recoveries are rare in cases above the age of forty.

Treatment.—There is no curative treatment for excited melancholia. The patient must be carefully nursed; kept in bed

during the exacerbations of the disease and treated with graduated doses of nepenthe or tincture of opium, to secure some amelioration of the acute symptoms. Careful dieting, tonics and baths are of benefit during the remissions of the disease, and in a few cases seem to promote recovery.

Folie circulaire, or alternating insanity, was first described by Falret and Baillarger, and more recently Kraepelin has considerably widened the conception of this class of disease, which he describes under the term "manic-depressive insanity." Of the two terms (*folie circulaire* and manic-depressive insanity) the latter is the more correct. *Folie circulaire* implies that the disease invariably passes through a complete cycle, which description is only applicable to very few of the cases. Manic-depressive insanity implies that the patient may either suffer from excitement or depression which do not necessarily succeed one another in any fixed order. As a matter of fact, the majority of patients who suffer from the disease either have marked excited attacks with little or no subsequent depression, or marked attacks of depression with a subsequent period of such slight exaltation as hardly to be distinguished from a state of health.

Depression of the manic-depressive variety, therefore, may either precede or follow upon an attack of maniacal excitement, or it may be the chief and only obvious symptom of the disease and may recur again and again. The disease attacks men and women with equal frequency, and as a rule manifests itself either late in adolescence or during the decline of life. Hereditary predisposition has been proved to exist in over 50% of cases, beyond which no definite predisposing cause is at present known. A considerable number of cases follow upon attacks of infective disease such as typhoid fever, scarlet fever or rheumatic fever. The actual exciting cause is probably an intestinal toxaemia of bacterial origin; at all events, mal-nutrition, gastric and intestinal symptoms not infrequently precede an attack, and the condition of the blood—the increase in number in the multinucleated white blood corpuscles and the presence of agglutinines to certain members of the streptococci group of bacteria—are symptoms which have been definitely demonstrated by Bruce in every case so far examined.

If the depression is the sequel to an attack of excitement, the onset may be very sudden or it may be gradual. If, on the other hand, the depression is not the sequel of excitement, the onset is very gradual and the patient complains of lassitude, incapacity for mental or physical work, loss of appetite, constipation and sleeplessness often for months before the case is recognized as one of insanity. In the fully developed disease the temperature is very rarely febrile, on the contrary it is rather subnormal in character. The stomach is disordered and the bowels confined. The urine is scanty, turbid and very liable to rapid decomposition. The heart's action is slow and feeble and the extremities become cold, blue and livid. In extreme cases gangrene of the lower extremities may occur, but in all there is a tendency to oedema of the extremities. The skin is greasy, often offensive, and the palms of the hands and the soles of the feet are sodden.

Mentally there is simple depression, without, in the majority of cases, any implication of consciousness. Many patients pass through attack after attack without suffering from hallucinations or delusions, but in rare cases hallucinations of hearing and sight are present. Delusions of unworthiness and unpardonable sin are not uncommon, and if once expressed are liable to recur again during the course of each successive attack. The disease is prolonged and chronic in its course, and the condition of the patient varies but little from day to day. When the depression follows excitement, the patient as a rule becomes fat and flabby. On the other hand, if the illness commences with depression, the chief physical symptoms are mal-nutrition and loss of body weight, and the return to health is always preceded by a return of nutrition and a gain in body weight.

The attacks may last from six months to two or three years. The intervals between attacks may last for only a few weeks or months or may extend over several years. During the interval the patient is not only capable of good mental work but may show capacity of a high order. In other words this form of mental disorder does not tend to produce dementia; the explanation probably being that between the attacks there is no toxaemia.

Treatment.—There is no known curative treatment for the depression of manic-depressive insanity, but the depression, the sleeplessness and the gastric disorder are to some extent mitigated by common sense attention to the general health of the body. If the patient is thin and wasted, then treatment is best conducted in bed. The diet should be bland, consisting largely of milk, eggs and farinaceous food, given in small quantities and frequently. Defecation should be maintained by enemata, and the skin kept clean by daily warm baths. What is of much more importance is the fact that in some instances subsequent attacks can be prevented by impressing upon the patient the necessity for attending to the state of the bowels, and of discontinuing work when the slightest symptoms of an attack present themselves. If these symptoms are at all prominent, rest in bed is a wise precaution, butcher-meat should be discontinued from the dietary and a tonic of arsenic or quinine and acid prescribed.

Mania.—The term mania, meaning pathological elevation or excitement, has, like the term melancholia, been applied to all varieties of morbid mental conditions in which the prevailing mental symptom is excitement or elevation. As in melancholia so in mania various subdivisions have been invented, such as delusional mania, religious mania, homicidal mania, according to the special mental characteristics of each case, but such varieties are of accidental origin and cannot be held to be subdivisions.

Mania.

Under the term mania two distinct diseased conditions can be described, viz. acute mania, and the elevated stage of *folie circulaire* or manic-depressive insanity.

Acute Mania.—Acute mania is a disease which attacks both sexes at all ages, but its onset is most prevalent during adolescence and early adult life. Hereditary predisposition, physical and mental exhaustion, epileptic seizures and childbirth are all predisposing causes. The direct exciting cause or causes are unknown, but the physical symptoms suggest that the condition is one of acute toxaemia or poisoning, and the changes in the blood are such as are consequent on bacterial toxaemia.

The onset is gradual in the large majority of cases. Histories of sudden outbursts of mania can rarely be relied on, as the illness is almost invariably preceded by loss of body weight, sleeplessness, bad dreams, headaches and symptoms of general malaise, sometimes associated with depression. The actual onset of the mental symptoms themselves, however, are frequently sudden. A typical case of the fully developed disease is not easily mistaken. The patient is usually anaemic and thin, the expression of the face is unnatural, the eyes widely opened and bright; and there is great motor restlessness, the muscular movements being purposeless and inco-ordinate. This inco-ordination of movement affects not only the muscles of the limbs and trunk but also those of expression, so that the usual aspect of the face becomes entirely altered. The temperature is generally slightly febrile. The tongue and lips are cracked and dry through excessive shouting or speaking. There is often no desire for food or drink. The heart's action is rapid and forcible. The skin is soft and moist. The urine is scanty, turbid and loaded with urates. The white blood corpuscles per cubic millimetre of blood are markedly increased, and the blood serum contains agglutinines to certain strains of streptococci which are not present in healthy persons. Sensibility to pain is lost or much impaired. Such patients will swing and jerk a broken limb apparently unaware that it is broken. Sleep is absent or obtained in short snatches, and even when asleep the patient is often restless and talkative as if the disease processes were still active.

Mentally the patient is excited, often wildly so, quite confused and unable to recognize time or place. Answers to questions may sometimes be elicited by repeated efforts to engage the attention of the patient. The speech is incoherent, and for all practical purposes the patient is mentally inaccessible. This state of acute excitement lasts usually for two or three weeks and gradually passes into a condition of chronic restlessness and noise, in which the movements are more coordinate and purposeful. The confusion of the acute stage passes off and the attention can be more readily attracted but cannot be concentrated on any subject for any length of time. The patient will now recognize friends, but the affections are in abeyance and the memory is defective. The appetite becomes insatiable, but the patient does not necessarily gain in weight. This stage of subacute excitement may last for months, but as a rule favourable cases recover within six months from the onset of the disease. A recovering patient gradually gains weight, sleeps soundly at night and has periods of partial quiescence during the day, particularly in the morning after a good night's sleep. These lucid intervals become more and more prolonged and finally pass into a state of sanity. Some cases on the other hand, after the acute symptoms decline, remain confused, and this state of confusion may last for months; by some alienists it is described as secondary stupor.

The symptoms detailed above are those typical of an attack such as is most frequently met with in adult cases. Acute mania, however, is a disease which presents itself in various forms. Adolescent cases, for instance, very commonly suffer from recurrent attacks, and the recurrent form of the disease is also to be met with in adults. The recurrent form at the onset does not differ in symptoms from that already described, but the course of the attack is shorter and more acute, so that the patient after one or two weeks of acute excitement rapidly improves, the mental symptoms pass off and the patient is apparently perfectly recovered. An examination of the blood, however, reveals the fact that the patient is still suffering from some disorder of the system, inasmuch as the white blood corpuscles remain increased above the average of health. Subsequent attacks of excitement come on without any obvious provocation. The pulse becomes fast and the face flushed. The patient frequently complains of fullness in the head, ringing in the ears and a loss of appetite. Sleeplessness is an invariable symptom. Self-control is generally lost suddenly, and the patient rapidly passes into a state of delirious excitement, to recover again, apparently, in the course of a few weeks. Recurrent mania might therefore be regarded as a prolonged toxaemia, complicated at intervals by outbursts of delirious excitement. Acute mania in the majority of cases ends in recovery. In the continuous attack the recovery is gradual. In the recurrent cases the intervals between attacks become longer and the attacks less severe until they finally cease. In such recovered cases very frequently a persistent increase in the number of the white blood corpuscles is found, persisting for a period of two or three years of apparently sound mental health. A few cases die, exhausted by the acuteness of the excitement and inability to obtain rest by the natural process of sleep. When death does occur in this way the patient almost invariably passes into the typhoid state.

The residue of such cases become chronic, and chronicity almost invariably means subsequent dementia. The chronic stage of acute mania may be represented by a state of continuous subacute excitement in which the patient becomes dirty and destructive in habits and liable from time to time to exacerbations of the mental symptoms. Continuous observation of the blood made in such cases over a period extending for weeks reveals the fact that the leucocytosis, if represented in chart form, shows a regular sequence of events. Just prior to the onset of an exacerbation the leucocytosis is low. As the excitement increases in severity the leucocytosis curve rises, and just before improvement sets in there may be a decided rise in the curve and then a subsequent fall; but this fall rarely reaches the normal line. In other cases, which pass into chronicity, a state of persistent delusion, rather than excitement, is the prevailing mental characteristic, and these cases may at recurrent intervals become noisy and dangerous.

Treatment.—Acute mania can only be treated on general lines. During the acute stage of onset the patient should be placed in bed. If there is difficulty in inducing the patient to take a sufficient quantity of food, this difficulty can be got over by giving food in liquid form, milk, milk-tea, eggs beaten up in milk, meat juice and thin gruel, and it is always better to feed such a patient with small quantities given frequently. Cases of mania following childbirth are those which most urgently demand careful and frequent feeding, artificially administered if necessary. If there is any tendency to exhaustion, alcoholic stimulants are indicated, and in some cases strychnine, quinine and cardiac tonics are highly beneficial. The bowels should be unloaded by large enemata or the use of saline purgatives. The continuous use of purgatives should as a rule be avoided, as they drain the system of fluids. On the other hand, the administration of one large normal saline enema by supplying the tissues with fluids, and probably thereby diluting the toxins circulating in the system, gives considerable relief. A continuous warm bath frequently produces sleep and reduces excitement. The sleeplessness of acute mania is best treated by warm baths wherever possible, and if a drug must be administered, then paraldehyde is the safest and most certain, unless the patient is also an alcoholic, when chloral and bromide is probably a better sedative.

The Elevated Stage of Folie Circulaire or Manic Depressive Insanity.—As previously mentioned in the description of the depressed stage of this mental disorder, the disease is equally prone to attack men and women, generally during late adolescence or in early adult life, and in a few cases first appears during the decline of life. Hereditary predisposition undoubtedly plays a large part as a predisposing cause, and after that is said it is difficult to assign any other definite predisposing causes and certainly no exciting causes. As in the stage of depression, so in the stage of excitement the first attack may closely follow upon typhoid fever, erysipelas or rheumatic fever. On the other hand many cases occur without any such antecedent disease. Another fact which has been commented upon is that these patients at the onset of an attack of excitement often appear to be in excellent physical health.

The earliest symptoms of onset are moral rather than physical. The patient changes in character, generally for the worse. The sober man becomes intemperate. The steady man of business enters into foolish, reckless speculation. There is a tendency for the patient to seek the society of inferiors and to ignore the recognized conventionalities of life and decency. The dress becomes extravagant and vulgar and the speech loud, boastful and obscene. These symptoms may exist for a considerable period before some accidental circumstance or some more than usually extravagant departure from the laws and customs of civilization draws public attention to the condition of the patient. The symptoms of the fully developed disease differ in degree in different cases. The face is often flushed and the expression unnatural. There is constant restlessness, steady loss of body weight, and sleeplessness. In very acute attacks there are frequently symptoms of gastric disorder, while in other cases the appetite is enormous, gross and perverted. The leucocytosis is above that usually met with in health, and the increase in the early stages is due to the relative and absolute increase in the multinucleated or polymorphonuclear leucocytes. The hyperleucocytosis is not, however, so high as it is in acute mania, and upon recovery taking place the leucocytosis always falls to normal. In the serum of over 80% of cases there are present agglutinines to certain strains of streptococci, which agglutinines are not present in the serum of healthy persons. The changes in the urine are those which one would expect to find in persons losing weight; the amount of nitrogenous output is in excess of the nitrogen ingested in the food.

Mentally there is always exaltation rather than excitement, and when excitement is present it is never of a delirious nature, that is to say, the patient is cognizant of the surroundings, and the special senses are abnormally acute, particularly those of sight and hearing. Hallucinations and delusion are sometimes present, but many cases pass through several attacks without exhibiting either of these classes of symptoms. The patient is always garrulous and delighted to make any chance acquaintance the confidant of his most private affairs. The mood is sometimes expansive

and benevolent, interruption in the flow of talk may suddenly change the subject of the conversation or the patient may with equal suddenness fly into a violent rage, use foul and obscene language, ending with loud laughter and protestations of eternal friendship. In other words the mental processes are easily stimulated and as easily diverted into other channels. The train of thought is, as it were, constantly being changed by accidental associations. Although consciousness is not impaired, the power of work is abolished as the attention cannot be directed continuously to any subject, and yet the patient may be capable of writing letters in which facts and fiction are most ingeniously blended. A typical case will pass through the emotions of joy, sorrow and rage in the course of a few minutes. The memory is not impaired and is often hyper-acute. The speech may be rambling but is rarely incoherent.

The course of the attack is in some cases short, lasting for from one to three weeks, while in others the condition lasts for years. The patient remains in a state of constant restlessness, both of body and mind, untidy or absurd in dress, noisy, amorous, vindictive, boisterously happy or virulently abusive. As time passes a change sets in. The patient sleeps better, begins to lay on flesh, the sudden mental fluctuations become less marked and finally disappear. Many of these patients remember every detail of their lives during the state of elevation, and many are acutely ashamed of their actions during this period of their illness. As a sequel to the attack of elevation there is usually an attack of depression, but this is not a necessary sequel.

The majority of patients recover even after years of illness, but the attacks are always liable to recur. Even recurrent attacks, however, leave behind them little if any mental impairment.

Treatment.—General attention to the health of the body, and an abundance of nourishing food, and, where necessary, the use of sedatives such as bromide and sulphonal, sum up the treatment of the elevated stage of manic-depressive insanity. In Germany it is the custom to treat such cases in continuous warm baths, extending sometimes for weeks. The use of warm baths of several hours' duration has not proved satisfactory.

Delusional Insanity.—Considerable confusion exists at the present day regarding the term delusional insanity. It is not correct to define the condition as a disease in which fixed delusions dominate the conduct and are the chief mental symptom present. Such a definition would include many chronic cases of melancholia and mania. All patients who suffer from attacks of acute insanity and who do not recover tend to become delusional, and any attempt to include and describe such cases in a group by themselves and term them delusional insanity is inadmissible. The fact that delusional insanity has been described under such various terms as progressive systematized insanity, mania of persecution and grandeur, monomanias of persecution, unseen agency, grandeur and paranoia, indicates that the disease is obscure in its origin, probably passing through various stages, and in some instances having been confused with the terminal stages of mania and melancholia. If this is admitted, then probably the best description of the disease is that given by V. Magnan under the term of "systematized delusional insanity," and it may be accepted that many cases conform very closely to Magnan's description.

Delusional Insanity.

The disease occurs with equal frequency in men and women, and in the majority of cases commences during adolescence or early adult life. The universally accepted predisposing cause is hereditary predisposition. As to the exciting causes nothing is known beyond the fact that certain forms of disease, closely resembling delusional insanity, are apparently associated or caused by chronic alcoholism or occur as a sequel to syphilitic infection. In the vast majority of cases the onset is lost in obscurity, the patient only drawing attention to the diseased condition by insane conduct after the delusional state is definitely established. The friends of such persons frequently affirm that the patient has always been abnormal. However this may be, there is no doubt that in a few cases the onset is acute and closely resembles the onset of acute melancholia. The patient is depressed, confused, suffers from hallucinations of hearing and there are disturbances of the bodily health. There is generally mal-nutrition with dyspepsia and vague neuralgic pains, often referred to the heart and intestines. Even at this stage the patient may labour under delusions. These acute attacks are of short duration and the patient apparently recovers, but not uncommonly both hallucinations and delusions persist, although they may be concealed.

The second or delusional stage sets in very gradually. This is the stage in which the patient most frequently comes under medical examination. The appearance is always peculiar and unhealthy. The manner is unnatural and may suggest a state of suspicion. The nutrition of the body is below par, and the patient frequently complains of indefinite symptoms of malaise referred to the heart and abdomen. The heart's action is often weak and irregular, but beyond these symptoms there are no special characteristic symptoms.

Mentally there may be depression when the patient is sullen and uncommunicative. It will be found, however, that he always suffers from hallucinations. At first hallucinations of hearing are the most prominent, but later all the special senses may be implicated. These hallucinations constantly annoy the patient and are always more troublesome at night. Voices make accusations through the walls, floors, roofs or door. Faces appear at the window and make grimaces. Poisonous gases are pumped into the room. Electricity, Röntgen rays and marconigrams play through the walls. The food is poisoned or consists of filth. In many cases symptoms of visceral discomfort are supposed to be the result of nightly surgical operations or sexual assaults. All these persecutions are ascribed to unknown persons or to some known person, sect or class. Under the influence of these sensory disturbances the patient may present symptoms of angry excitement, impulsive violence or of carefully-thought-out schemes of revenge; but the self-control may be such that although the symptoms are concealed the behaviour is peculiar and unreasonable. It is not uncommon to find that such patients can converse rationally and take an intelligent interest in their environments, but the implication of the capacity of judgment is at once apparent whenever the subject of the persecutions is touched upon.

All cases of delusional insanity at this stage are dangerous and their actions are not to be depended upon. Assaults are common, houses are set on fire, threatening letters are written and accusations are made which may lead to much worry and trouble before the true nature of the disease is realized.

This, the second or persecutory stage of delusional insanity, may persist through life. The patient becomes gradually accustomed to the sensory disturbances, or possibly a certain amount of mental enfeeblement sets in which reduces the mental vigour. In other cases, the disease goes on to what Magnan calls the third stage or stage of grandiose delusions. The onset of this stage is in some cases gradual. The patient, while inveighing against the persecutions, hints at a possible cause. One man is an inventor and his enemies desire to deprive him of the results of his inventions. Another is the rightful heir to a peerage, of which he is to be deprived. Women frequently believe themselves to be abducted princesses or heirs to the throne. Others of both sexes, even more ambitious, assume divine attributes and proclaim themselves Virgin Marys, Gabriels, Holy Ghosts and Messiahs. Cases are recorded in which the delusions of grandeur were of sudden onset, the patient going to bed persecuted and miserable and rising the following morning elated and grandiose. In this stage the hallucinations persist but appear to change in character and become pleasant. The king hears that arrangements are being made for his coronation and waits quietly for the event. The angel Gabriel sees visions in the heavens. The heirs and heiresses read of their prospective movements in the court columns of the daily papers and are much soothed thereby. In short, no delusion is too grotesque and absurd for such patients to believe and express.

Cases of delusional insanity never become demented in the true sense of the word, but their mental state might be described as a dream in which an imaginary existence obliterates the experiences of their past lives.

Treatment.—No treatment influences the course of the disease. During the stage of persecution such patients are a danger to themselves, as they not infrequently commit suicide, and to their supposed persecutors, whom they frequently assault or otherwise annoy.

KATATONIA.—This disease, so called on account of the symptom of muscular spasm or rigidity which is present during certain of its stages, was first described and named by K. L. Kahlbaum in 1874. Many British alienists refuse to accept katatonia as a distinct disease, but as it has been accepted and further elaborated by such an authority as E. Kraepelin reference to it cannot be avoided.

Katatonia.

Katatonia attacks women more frequently than men, and is essentially a disease of adolescence, but typical cases occasionally occur in adults. Hereditary predisposition is present in over 50% of the cases and is the chief predisposing cause. Childbirth, worry, physical strain and mental shocks are all advanced as secondary predisposing causes. The disease is one of gradual onset, with loss of physical and mental energy. Probably the earliest mental symptom is the onset of aural hallucinations. For convenience of description the disease may be divided into (1) the stage of onset; (2) the stage of stupor; (3) the stage of excitement.

The symptoms of the stage of onset are disorders of the alimentary tract, such as loss of appetite, vomiting after food and obstinate constipation. The pulse is rapid, irregular and intermittent. The skin varies between extreme dryness and drenching perspirations. In women the menstrual function is suppressed. At uncertain intervals the skeletal muscles are thrown into a condition of rigidity, but this symptom does not occur invariably. The instincts of cleanliness are in abeyance, owing to the mental state of the patient, and as a result these cases are inclined to be wet and dirty in their habits.

Mentally there is great confusion, vivid hallucinations, which apparently come on at intervals and are of a terrifying nature, for the patient often becomes frightened, endeavours to hide in corners or escape by a window or door. A very common history of such a case prior to admission is that the patient has attempted suicide by jumping out of a window, the attempt being in reality an unconscious effort on the part of the patient to escape from some imaginary danger. During these attacks the skin pours with perspiration. The patient is oblivious to his surroundings and is mentally inaccessible. In the intervals between these attacks the patient may be conscious and capable of answering simple questions. This acute stage, in which sleep is abolished, lasts from a few days to four or six weeks and then, generally quite suddenly, the patient passes into the state of stupor. In some cases a sharp febrile attack accompanies the onset of the stupor, while in others this symptom is absent; but in every case examined by Bruce during the acute stage there was an increase in the number of the white blood corpuscles, which, just prior to the onset of stupor, were sometimes enormously increased; the increase being entirely due to multiplication of the multinucleated or polymorphonuclear leucocytes.

In the second or stuporose stage of the disease the symptoms are characteristic. The patient lies in a state of apparent placidity, generally with the eyes shut. Consciousness is never entirely abolished, and many of the patients give unmistakable evidence that they understand what is being said in their presence. Any effort at passive movement of a limb immediately sets up muscular resistance, and throughout this stage the sternomastoid and the abdominal muscles are more or less in a state of over-tension, which is increased to a condition of rigidity if the patient is interfered with in any way. This symptom of restiveness or negativism is one of the characteristics of the disease. The patient resists while being fed, washed, dressed and undressed, and even the normal stimuli which in a healthy man indicate that the bladder or rectum require to be emptied are resisted, so that the bladder may become distended and the lower bowel has to be emptied by enemata. The temperature is low, often subnormal, the pulse is small and weak, and the extremities cold and livid. This symptom is probably due in some part to spasm of the terminal arterioles. Mentally the symptoms are negative. Though conscious, the patient cannot be got to speak and apparently is oblivious to what is passing around. Upon recovery, however, these cases can often recount incidents which occurred to them during their illness, and may also state that they laboured under some delusion. Coincidently with the onset of the stupor sleep returns, and many cases sleep for the greater part of the twenty-four hours. The duration of the stuporose state is very variable. In some cases it lasts for weeks, in others for months or years, and may be the terminal stage of the disease, the patient gradually sinking into dementia or making a recovery. The third stage or stage of excitement comes on in many cases during the stage of stupor: the stages overlap; while in others a distinct interval of convalescence may intervene between the termination of the stupor and the onset of the excitement. The excitement is characterized by sudden impulsive actions, rhythmical repetition of words and sounds (verbigeration), and by rhythmical movements of the body or limbs, such as swaying the whole frame, nodding the head, swinging the arms, or walking in circles. The patient may be absolutely mute in this stage as in the stage of stupor. Others again are very noisy, singing, shouting or abusive. The speech is staccato in character and incoherent. Physically the patient, who often gains weight in the stage of stupor, again becomes thin and haggard in appearance owing to the incessant restlessness and sleeplessness which characterize the stage of excitement. The patient may, during the stage of onset, die through exhaustion, or accidentally and unconsciously commit suicide usually by leaping from a window. During the stuporose stage symptoms of tubercular disease of the lungs may commence. All the adolescent insane are peculiarly liable to contract and die from tubercular disease. Accidental suicide is also liable to occur during this stage. The stage of excitement, if at all prolonged, invariably ends in dementia. According to Kraepelin 13% of the cases recover, 27 make partial recoveries, and 60% become more or less demented.

Treatment.—No treatment arrests or diverts the course of katatonia, and the acute symptoms of the disease as they arise must be treated on hospital principles.

HEBEPHRENIA.—This is a disease of adolescence (Gr. ἥβη) which was first described by Hecker and Kahlbaum and more recently by Kraepelin and other foreign workers. Hebephrenia is not yet recognized by British alienists. The descriptions of the disease are indefinite and confusing, but there are some grounds for the belief that such an entity does exist, although it is probably more correct to say that as yet the symptoms are very imperfectly understood. Hebephrenia is always a disease of adolescence and never occurs during adult life. It attacks women more frequently than men, and according to Kahlbaum hereditary predisposition to insanity is present in over 50% of the cases attacked. The onset of the disease is invariably associated with two symptoms. On the physical side an arrested or delayed development and on the mental a gradual failure of the power of attention and concentrated thought. The onset of the condition is always gradual and the symptoms which first attract attention are mental. The patient becomes restless, is unable to settle to work, becomes solitary and peculiar in habits and sometimes dissolute and mischievous. As the disease advances the patient becomes more and more enfeebled, laughs and mutters to himself and wanders aimlessly and without object. There is no natural curiosity, no interest in life and no desire for occupation. Later, delusions may appear and also hallucinations of hearing, and under their influence the patient may be impulsive and violent. Physically the subjects are always badly developed. The temperature is at times slightly elevated and at intervals the white blood corpuscles are markedly increased. The menstrual function in women

Hebephrenia.

is suppressed and both male and female cases are addicted to masturbation. According to Kraepelin 5% of the cases recover, 15% are so far relieved as to be able to live at home, but are mentally enfeebled, the remaining 80% become hopelessly demented. The patients who recover frequently show at the onset of their disease acute symptoms, such as mild excitement, slightly febrile temperature and quick pulse-rate. When recovery does take place there is marked improvement in development. The subjects of hebephrenia are peculiarly liable to tubercular infection and many die of phthisis.

There is no special treatment for hebephrenia beyond attention to the general health.

Insanity following upon Injuries to the Brain, or Apoplexies or Tumours or Arterial Degeneration. (*a*) *Traumatic Insanity.*—

Traumatic Insanity.

Insanity following blows on the head is divided into (1) the forms in which the insanity immediately follows the accident; (2) the form in which there is an intermediate prodromal stage characterized by strange conduct and alteration in disposition; and (3) in which the mental symptoms occur months or years after the accident, which can have at most but a remote predisposing causal relation to the insanity. The cases which immediately succeed injuries to the head are in all respects similar to confusional insanity after operations or after fevers. There is generally a noisy incoherent delirium, accompanied by hallucinations of sight or of hearing, and fleeting unsystematized delusions. The physical symptoms present all the features of severe nervous shock.

In those cases in which there is an intervening prodromal condition, with altered character and disposition, there is usually a more or less severe accidental implication of the cortex cerebri, either by depression of bone or local hemorrhage, or meningitic sub-inflammatory local lesions. Most of the cases during the prodromal stage are sullen, morose or suspicious, and indifferent to their friends and surroundings. At the end of the prodromal stage there most usually occurs an attack of acute mania of a furious impulsive kind. The cases which for many years after injury are said to have remained sane will generally be found upon examination and inquiry to exhibit symptoms of hereditary degeneration or of acquired degeneracy, which may or may not be a consequence of the accident.

The most common site of vascular lesion is one of the branches of the middle cerebral artery within the sylvian fissure, or of one of the smaller branches of the same artery which go directly to supply the chief basal ganglia. When an artery like the middle cerebral or one of its branches becomes either through rupture or blocking of its lumen, incapable of performing its function of supplying nutrition to important cerebral areas, there ensues devitality of the nervous tissues, frequently followed by softening and chronic inflammation. It is these secondary changes which give rise to and maintain those peculiar mental aberrations known as post-apoplectic insanity.

Various characteristic physical symptoms, depending upon the seat of the cerebral lesion, are met with in the course of this form of insanity. These consist of paraplegias, hemiplegias and muscular contractures. Speech defects are very common, being due either to the enfeebled mental condition, to paralysis of the nerve supplying the muscles of the face and tongue, or to aphasia caused by implication of those parts of the cortex which are intimately associated with the faculty of speech. Mental symptoms vary considerably in different cases and in accordance with the seat and extent of the lesion. There is almost always present, however, a certain degree of mental enfeeblement, accompanied by loss of memory and of judgment, often by mental confusion. Another very general mental symptom is the presence of emotionalism which leads the patient to be affected either to tears or to laughter upon trifling and inadequate occasions.

Cerebral tumours do not necessarily produce insanity. Indeed it has been computed that not one half of the cases become insane. When insanity appears it is met with in all degrees varying from slight mental dulness up to complete dementia, and from mere moral perversion up to the most intense form of maniacal excitement. On the physical side the various symptoms of cerebral tumour such as coma, ataxia, paralysis, headache, vomiting, optic neuritis and epileptiform convulsions are met with. All forms of so-called moral changes and of changes of disposition are met with as mental symptoms and all the ordinary forms of insanity may occur in varying intensity; but by far the most common mental change occurring in connexion with cerebral tumour is a progressive enfeeblement of the intelligence, unattended with any more harmful symptoms than mental deterioration which ends in complete dementia.

(*b*) *Arterial Degeneration.*—Arterial degeneration is a common cause of mental impairment, especially of that form of mental affection known as “Early” dementia. It also predisposes to embolism and thrombosis, which often results in the paralytic and aphasic groups of nerve disturbance, and which are always accompanied by more or less marked interference with normal cerebral action.

Insanity due to Arterial Degeneration.

The commonest seat for atheroma of the cerebral vessels is the arteries at the base of the brain and their main branches, especially the middle cerebral. As a general rule the other arteries of the cerebrum are not implicated to the same extent, although in a not inconsiderable number of cases of the disease all the arteries of the brain may participate in the change. When this is so, we obtain those definite symptoms of slowly advancing dementia commencing in late middle life and ending in complete dementia before the usual period for the appearance of senile dementia. The same appearances are met with in certain patients who have attained the age in which senile changes in the arteries are not unexpected. As a rule atheroma in the cerebral vessels is but a part of a general atheroma of all the arteries of the body. Atheroma is common after middle life and increases in frequency with age. The chief causes are syphilis, alcoholism, the gouty and rheumatic diatheses and above all Bright’s disease of the kidneys. Perhaps certain forms of Bright’s disease, owing to the tendency to raise the blood pressure, are of all causes the most common.

It is not easy to say to what extent, alone, the arteriosclerosis is effectual in inducing the gradual failure of the mental powers, and to what extent it is assisted in its operation by the action on the brain-cells of the general toxic substances which give rise to the arterial atheroma. In any case there can be no question that the gradual mechanical diminution of the blood-supply to the cortex caused by the occlusion of the lumen of the arteries is a factor of great importance in the production of mental incapacity.

General Paralysis of the Insane (syn. General Paralysis, *dementia paralytica*, progressive dementia) is a disease characterized by symptoms of progressive degeneration of the central nervous system, more particularly of the motor centres. The disease is almost invariably fatal. Apparent recoveries do very occasionally occur, though this is denied by the majority of alienists. The disease is in every case associated with gradually advancing mental enfeeblement, and very frequently is complicated by attacks of mental disease.

General Paralysis.

General paralysis, which is a very common disease, was first recognized in France; it was identified by J. E. D. Esquirol, and further described and elaborated by A. L. J. Bayle, Delaye and J. L. Calmeil, the latter giving it the name of *paralysie générale des aliénés*.

As first described by the earlier writers the disease was regarded as being invariably associated with delusions of grandeur. At the present day this description does not apply to the majority of cases admitted into asylums. The change may be explained as being either due to an alteration in the type of the disease, or more probably the disease is better

understood and more frequently diagnosed than formerly, the diagnosis being now entirely dependent on the physical and not on the mental symptoms. This latter may also be the explanation why general paralysis is much more common at the present day in British asylums than it was. The total death-rate from this disease in English and Scottish asylums rose from 1321 in 1894 to 1795 in 1904.

General paralysis attacks men much more frequently than women, and occurs between the ages of 35 and 50 years. It is essentially a disease of town life. In asylums which draw their patients from country districts in Scotland and Ireland, the disease is rare, whereas in those which draw their population from large cities the disease is extremely common.

Considerable diversity of opinion exists at present regarding the causation of general paralysis. Hereditary predisposition admittedly plays a very small part in its causation. There is, however, an almost universal agreement that the disease is essentially the result of toxaemia or poisoning, and that acquired or inherited syphilitic infection is an important predisposing factor. A history of syphilitic infection occurs in from 70 to 90% of the patients affected. At first it was held that general paralysis was a late syphilitic manifestation, but as it was found that no benefit followed the use of anti-syphilitic remedies the theory was advanced that general paralysis was a secondary auto-intoxication following upon syphilitic infection. The latest view is that the disease is a bacterial invasion, to which syphilis, alcoholism, excessive mental and physical strain, and a too exclusively nitrogenous diet, only act as predisposing causes. This latter theory has been recently advanced and elaborated by Ford Robertson and McRae of Edinburgh.

Whatever the cause of general paralysis may be, the disease is essentially progressive in character, marked by frequent remissions and so typical in its physical symptoms and pathology that we regard the bacterial theory with favour, although we are far from satisfied that the actual causative factor has as yet been discovered.

For descriptive purposes the disease is most conveniently divided into three stages,—called respectively the first, second and third,—but it must be understood that no clear line of demarcation divides these stages from one another.

The onset of general paralysis is slow and gradual, and the earliest symptoms may be either physical or mental. The disease may commence either in the brain itself or the spinal cord may be primarily the seat of lesion, the brain becoming affected secondarily. When the disease originates in the spinal cord the symptoms are similar to those of locomotor ataxia, and it is now believed that general paralysis and locomotor ataxia are one and the same disease; in the one case the cord, in the other the brain, being the primary seat of lesion. The early physical symptoms are generally motor. The patient loses energy, readily becomes tired, and the capacity for finely co-ordinated motor acts, such as are required in playing games of skill, is impaired. Transient attacks of partial paralysis of a hand, arm, leg or one side of the body, or of the speech centre are not uncommon. In a few cases the special senses are affected early and the patient may complain of attacks of dimness of vision or impairment of hearing. Or the symptoms may be purely mental and affect the highest and most recently acquired attributes of man, the moral sense and the faculty of self-control. The patient then becomes irritable, bursts into violent passions over trifles, changes in character and habits, frequently takes alcohol to excess and behaves in an extravagant, foolish manner. Theft is often committed in this stage and the thefts are characterized by an open, purposeless manner of commission. The memory is impaired and the patient is easily influenced by others, that is to say he becomes facile. In other cases a wild attack of sudden excitement, following upon a period of restlessness and sleeplessness may be the first symptom which attracts attention. Whatever the mode of onset the physical symptoms which characterize the disease come on sooner or later. The speech is slurred and the facial muscles lose their tone, giving the face a flattened expression. The muscular power is impaired, the gait is straddling and the patient sways on turning. All the muscles of the body, but particularly those of the tongue, upper lip and hands, which are most highly innervated, present the symptom of fine fibrillary tremors. The pupils become irregular in outline, often unequal in size and either one or both fail to react normally to the stimuli of light, or of accommodation for near or distant vision.

As the disease advances there is greater excitability and a tendency to emotionalism. In classical cases the general exaltation of ideas becomes so great as to lead the patient to the commission of insanely extravagant acts, such as purchases of large numbers of useless articles, or of lands and houses far beyond his means, numerous indiscriminate proposals of marriage, the suggestion of utterly absurd commercial schemes, or attempts at feats beyond his physical powers. The mental symptoms, in short, are very similar to those of the elevated stage of manic-depressive insanity.

Delusions of the wildest character may also be present. The patient may believe himself to be in possession of millions of money, to be unsurpassed in strength and agility, to be a great and overruling genius, and the recipient of the highest honours. This grandiose condition is by no means present in every case and is not in itself diagnostic of the disease. But mental facility, placid contentment, complete loss of judgment and affection for family and friends, with impaired memory, are symptoms universally present. As the disease advances the motor symptoms become more prominent. The patient has great difficulty in writing, misses letters out of words, words out of sentences, and writes in a large laboured hand. The expression becomes fatuous. The speech is difficult and the facial muscles are thrown into marked tremors whenever any attempt at speech is made. The voice changes in timbre and becomes high-pitched and monotonous. The gait is weak and uncertain and the reflexes are exaggerated. In the first stage the patient, through restlessness and sleeplessness, becomes thin and haggard. As the second stage approaches sleep returns, the patient lays on flesh and becomes puffy and unhealthy in appearance. The mental symptoms are marked by greater facility and enfeeblement, while the paralysis of all the muscles steadily advances. The patient is now peculiarly liable to what are called congestive seizures or epileptiform attacks. The temperature rises, the face becomes flushed and the skin moist. Twitchings are noticed in a hand or arm. These twitchings gradually spread until they may involve the whole body. The patient is now unconscious, bathed in perspiration, which is offensive. The bowels and bladder empty themselves reflexly or become distended, and bedsores are very liable to form over the heels, elbows and back. Congestive seizures frequently last for days and may prove fatal or, on the other hand, the patient may have recurrent attacks and finally die of exhaustion or some accidental disease, such as pneumonia. In the second stage of the disease the patient eats greedily, and as the food is frequently swallowed unmasticated, choking is not an uncommon accident. The special senses of taste and smell are also much disordered. We have seen a case of general paralysis, in the second stage drink a glass of quinine and water under the impression that he was drinking whisky.

The third stage of the disease is characterized by sleeplessness and rapid loss of body weight. Mentally the patient becomes quite demented. On the physical side the paralysis advances rapidly, so that the patient becomes bedridden and speechless. Death may occur as the result of exhaustion, or a congestive seizure, or of some intercurrent illness.

The duration of the disease is between eighteen months and three years, although it has been known to persist for seven.

No curative measures have so far proved of any avail in the treatment of general paralysis.

Insanity Associated with Epilepsy.—The term “epileptic insanity,” which has for many years been in common use, is now regarded as a misnomer. There is in short no such disease as epileptic insanity. A brain, however, which is so unstable as to exhibit the sudden discharges of nervous energy which are known as

Epileptic

Insanity. epileptic seizures, is prone to be attacked by insanity also, but there is no form of mental disease exclusively associated with epilepsy. Many epileptics suffer from the disease for a lifetime and never exhibit symptoms of insanity. The majority of patients, however, who suffer from epilepsy are liable to exhibit certain mental symptoms which are regarded as characteristic of the disease. Some suffer from recurrent attacks of depression, ill-humour and irritability, which may readily pass into violence under provocation. Others are emotionally fervid in religious observances, though sadly deficient in the practice of the religious life. A third class are liable to attacks of semi-consciousness which may either follow upon or take the place of a seizure, and during these attacks actions are performed automatically and without consciousness on the part of the patient.

When epileptics do become insane the insanity is generally one of the forms of mania. Either the patient suffers from sudden furious attacks of excitement in which consciousness is entirely abolished, or the mania is of the type of the elevated stage of folie circulaire (manic-depressive insanity) and alternates with periods of deep depression. In the elevated period the patient shows exaggerated self-esteem, with passionate outbursts of anger, and periods of religious emotionalism. While in the stage of depression the patient is often actively suicidal.

Epileptic patients who suffer from recurrent attacks of delirious mania are liable to certain nervous symptoms which indicate that not only are the motor centres in the brain damaged, but that the motor tracts in the spinal cord are also affected. The gait becomes awkward and laboured, the feet being lifted high off the ground and the legs thrown forward with a jerk. The tendon reflexes are at the same time exaggerated. These symptoms indicate descending degeneration of the motor tracts of the cord.

If the mental attacks partake of the character of elevation or depression the mental functions suffer more than the motor. These patients, in course of time, become delusional, enfeebled and childish, and in some cases the enfeeblement ends in complete dementia of a very degraded type.

Where insanity is superadded to epilepsy the prognosis is unfavourable.

Insanity Associated with or caused by Alcoholic and Drug Intoxication.—The true rôle of alcoholic indulgence in the production of insanity is at present very imperfectly understood. In many cases the alcoholism is merely a symptom of the mental disease—a result, not a cause. In others, alcohol seems to act purely as a predisposing factor, breaking down the resistance of the patient and disordering the metabolism to such an extent that bodily disorders are engendered which produce well-marked and easily recognized mental symptoms. In others, again, alcohol itself may possibly act as a direct toxin, disordering the functions of the brain. In the latter class may be included the nervous phenomena of drunkenness, which commence with excitement and confusion of ideas, and terminate in stupor with partial paralysis of all the muscles. Certain brains which, either through innate weakness or as the result of direct injury, have become peculiarly liable to toxic influences, under the influence of even moderate quantities of alcohol pass into a state closely resembling delirious mania, a state commonly spoken of as *mania a potu*.

Toxic Insanity.

Delirium Tremens.—Delirium tremens is the form of mental disorder most commonly associated with alcoholic indulgence in the lay mind. Considerable doubt exists, however, as to whether the disease is directly or secondarily the result of alcoholic poisoning. Much evidence exists in favour of the latter supposition. Delirium tremens may occur in persons who have never presented the symptom of drunkenness, or it may occur weeks after the patient has ceased to drink alcohol, and in such cases the actual exciting cause of the disease may be some accidental complication, such as a severe accident, a surgical operation, or an attack of pneumonia or erysipelas.

The early symptoms are always physical. The stomach is disordered. The desire for food is absent, and there may be abdominal pain and vomiting. The hands are tremulous, and the patient is unable to sleep. At this stage the disease may be checked by the administration of an aperient and some sedative such as bromide and chloral. The mental symptoms vary greatly in their severity. In a mild case one may talk to the patient for some time before discovering any mental abnormality, and then it will be found that confusion exists regarding his position and the identity of those around him, while the memory is also impaired for recent events. Hallucinations of sight and hearing may be present. The hallucinations of sight may be readily induced by pressure upon the eyeballs. If the symptoms are more acute they usually come on suddenly, generally during the evening or night. The patient becomes excited, suffers from vivid hallucinations of sight and hearing which produce great fear, and these hallucinations may be so engrossing as to render him quite oblivious to the environment. The hallucinations of sight are characterized by the false sense impressions taking the forms of animals or insects which surround or menace the patient. Visions may also appear in the form of flames, goblins or fairies. The hallucinations of hearing rarely consist of voices, but are more of the nature of whistlings, and ringings in the ears, shouts, groans or screams which seem to fill the air, or emanate from the walls or floors of the room. All the special senses may be affected, but sight and hearing are always implicated. Delirium tremens is a short-lived disease, generally running its course in from four to five days. Recovery is always preceded by the return of the power of sleep.

> The patient must be carefully nursed and constantly watched, as homicidal and suicidal impulses are liable to occur under the terrifying influence of the hallucinations. The food should be concentrated and fluid, given frequently and in small quantities.

Chronic Alcoholic Insanity.—Almost any mental disorder may be associated with chronic alcoholism, but the most characteristic mental symptoms are delusions of suspicion and persecution which resemble very closely those of the persecution stage of systematized delusional insanity. The appearance of the patient is bloated and heavy; the tongue is furred and tremulous, and symptoms of gastric and intestinal disorder are usually present. The gait is awkward and dragging, owing to the partial paralysis of the extensor muscles of the lower limbs. All the skeletal muscles are tremulous, particularly those of the tongue, lips and hands. The common sensibility of the skin is disordered so that the patient complains of sensory disturbances, such as tinglings and prickings of the skin, which may be interpreted as electric shocks. In some cases the mental symptoms may be concealed, but delusions and hallucinations, particularly hallucinations of sight and hearing, are very commonly present. The delusions are often directly the outcome of the physical state; the disordered stomach suggesting poisoning, and the disturbances of the special senses being interpreted as various forms of persecution. The patient hears voices shouting foul abuse at him; all his thoughts are read and repeated aloud; electric shocks are sent through him at night; gases are pumped into his room. Sexual delusions are very common and frequently affect marital relations by arousing suspicions regarding the fidelity of wife or husband; or the delusions may be more gross and take the form of belief in actual attempts at sexual mutilations. The memory is always impaired.

Patients who in addition to chronic alcoholism are also insane are always dangerous and liable to sudden and apparently causeless outbursts of violence.

Dipsomania.—Dipsomania is a condition characterized by recurrent or periodic attacks of an irresistible craving for stimulants. The general bodily condition has a great deal to do with the onset of the attack, that is to say, the patient is more liable to an attack when the bodily condition is low than when the health is good. The attacks may be frequent or

recur at very long intervals. They generally last for a few weeks, and may be complicated by symptoms of excitement, delusions or hallucinations.

Treatment consists in attention to the general health between attacks, with the use of such tonics as arsenic and strychnine. During the attack the patient should be confined to bed and treated with sedatives.

Morphinism.—The morphia habit is most commonly contracted by persons of a neurotic constitution. The mental symptoms associated with the disease may arise either as the result of an overdose, when the patient suffers from hallucinations, confusion and mild delirium, frequently associated with vomiting. On the other hand, mental symptoms very similar to those of delirium tremens may occur as the result of suddenly cutting off the supply of morphia in a patient addicted to the habit. Finally, chronic morphia intoxication produces mental symptoms very similar to those of chronic alcoholism. This latter condition, characterized by delusions of persecution, mental enfeeblement and loss of memory, is hopelessly incurable. The patient is always thin and anaemic on account of digestive disturbances. There is weakness or slight paralysis of the lower limbs, and the skeletal muscles are tremulous.

Treatment.—The quantity of the drug used must be gradually reduced until it is finally discontinued, and during treatment the patient must be confined to bed.

Senile Insanity.—States of mental enfeeblement are always the result of failure of development or of structural changes in the cortical grey matter of the brain. If the enfeeblement is due to failure of development or brain damage occurring in early life, it is spoken of as *idiocy* or imbecility. Every form of insanity which occurs after a certain period of life is apt to be regarded by some observers as senile, but although the failing mental power may colour the character of the symptoms it cannot be regarded as correct to designate, for instance, a recurrent form of mania as senile merely because it necessarily manifests itself in a subject who has lived into the senile period. On the other hand, many persons first suffer from mental derangement at an advanced period of life without at the same time manifesting any marked failure of mental power, while others only manifest their insanity as a result of the decay of their mental faculties.

Senile Insanity.

From this statement it will be seen that senile insanity is a complex of different conditions, some of them accompanied by dementia, others without dementia.

Senile Dementia is distinguished occasionally into “senile” properly so called, and “presenile” dementia, which supervenes at middle age or even earlier.

The occurrence of dementia is sometimes preceded by an acute hallucinatory phase, accompanied by mania or melancholia; but as a general rule, in the presenile cases, by neurasthenia, indifference, and mental apathy which extends to a disregard for the ordinary conventions and the means of subsistence.

It has pithily been remarked that the age of a man is the age of his blood-vessels. The two conditions of senile and presenile dementia cannot therefore be separated scientifically. From a clinical point of view, however, the two are distinguishable in so far as their symptoms are concerned, for the presenile cases are more complete and the process of dementia achieves its consummation earlier and quicker, while in the senile the gradual disease of the arteries and the slow decay of the mental faculties offer a different background for the manifestation of mental symptoms. Moreover, the senile patients more frequently present symptoms of recurrent attacks of acute insanity, a more pronounced emotionalism, and a greater tendency to restlessness at night. The presenile cases, on the other hand, except at the commencement of their malady, are usually free from acute and troublesome symptoms and present chiefly an apathetic indifference and irresponsiveness on the mental side, and on the physical side a neurasthenic and enfeebled bodily state. In both conditions memory is greatly impaired.

Added to senile dementia there is often found a condition of mania or melancholia or even of systematized delusional insanity. The chief symptoms of the maniacal attacks are the great motor restlessness and excitement, which are worst during the night time. Sleep is almost always seriously disturbed, and the patients rapidly become exhausted unless carefully nursed and tended. The actions of senile maniacs are often puerile and foolish, and they may exhibit impulses of a homicidal, suicidal or sexual character. The melancholic cases are also extremely restless, and their emotion is loudly expressed in an uncontrollable manner. They often have delusions of persecution. Their cries and groans have an automatic character, as if the patient, though compelled to utter them, did not experience the mental pain which he expressed. They also, many of them, eat their food ravenously, although a few obstinately refuse it. The senile delusional cases may manifest any of the classical forms of paranoia described above, but their delusions are of a rudimentary and unfinished type. The most common of all senile delusions is that they are being robbed. They therefore often hide their small valuables in corners and out-of-the-way places, and as their memories are very defective they are afterwards unable to find them. Others, who live alone, barricade their doors and try to prevent any one entering for fear of thieves. Delusions of ambition in senile subjects are usually of a very improbable and childish character. Hallucinations are generally present in the senile delusional cases.

The *treatment* of senile insanity is from the medical point of view not hopeful; it resolves itself largely into instructions for careful nursing, suitable feeding, and the protection of the patient from all the physical dangers to which he may be exposed.

Statistics.—The statistics of lunacy are merely of interest from a sociological point of view; for under that term are comprised all forms of insanity. It is needless to produce tables illustrative of the relative numbers of lunatics in the various countries of Europe, the systems of registration being so unequal in their working as to afford no trustworthy basis of comparison.

Even in Great Britain, where the systems are more perfect than in any other country, the tables published in the Blue Books of the three countries can only be regarded as approximately correct, the difficulty of registering all cases of lunacy being insuperable. On the 1st of January 1907, according to the returns made to the offices of the Commissioners in Lunacy, the numbers of lunatics stood thus on the registers:—

	Males.	Females.	Totals.
England and Wales	57,176	66,812	123,988
Scotland	8,594	8,999	17,593
Ireland	12,254	11,300	23,554
Gross total	78,024	87,111	165,135

These figures show the ratio of lunatics to 100,000 of the population to be 354 in England and Wales, 312 in Scotland, and 538 in Ireland.

Numbers of Lunatics on the 1st of January of the years 1857-1907 inclusive, according to Returns made to the Offices of

Years.	England and Wales.	Scotland.	Ireland.
1858	..	5,823	..
1859	36,762	6,072	..
1860	38,058	6,273	..
1861	39,647	6,327	..
1862	41,129	6,398	8,055
1863	43,118	6,386	7,862
1864	44,795	6,422	8,272
1865	45,950	6,533	8,845
1866	47,648	6,730	8,964
1867	49,086	6,888	8,962
1868	51,000	7,055	9,086
1869	53,177	7,310	9,454
1870	54,713	7,571	10,082
1871	56,755	7,729	10,257
1872	58,640	7,849	10,767
1873	60,296	7,982	10,958
1874	60,027	8,069	11,326
1875	63,793	8,225	11,583
1876	64,916	8,509	11,777
1877	66,636	8,862	12,123
1878	68,538	9,097	12,380
1879	69,885	9,386	12,585
1880	71,191	9,624	12,819
1881	73,113	10,012	13,062
1882	74,842	10,355	13,444
1883	76,765	10,510	13,882
1884	78,528	10,739	14,088
1885	79,704	10,918	14,279
1886	80,156	11,187	14,590
1887	80,891	11,309	14,702
1888	82,643	11,609	15,263
1889	84,340	11,954	15,685
1890	86,067	12,302	16,159
1891	86,795	12,595	16,251
1892	87,848	12,799	16,688
1893	89,822	13,058	17,124
1894	92,067	13,300	17,276
1895	94,081	13,852	17,665
1896	96,446	14,093	18,357
1897	99,365	14,500	18,966
1898	101,972	14,906	19,590
1899	105,086	15,399	20,304
1900	106,611	15,663	20,863
1901	107,944	15,899	21,169
1902	110,713	16,288	21,630
1903	113,964	16,658	22,138
1904	117,199	16,894	22,794
1905	119,829	17,241	22,996
1906	121,979	17,450	23,365
1907	123,988	17,593	23,554

There is thus an increased ratio in England and Wales of lunatics to the population (which in 1859 was 19,686,701, and in 1907 was estimated at 34,945,600) of 186.8 per 100,000 as against 354.8, and in Scotland of 157 as against 312 per 100,000. The Irish figures on the same basis have increased from 130.9 in 1862 to 538.1 in 1907. The publication of these figures has given rise to the question whether lunacy has actually become more prevalent during the last twenty years, whether there is real increase of the disease. There is a pretty general consent of all authorities that if there has been an increase it is very slight, and that the apparent increase is due, first to the improved systems of registration, and secondly (a far more powerful reason) to the increasing tendency among all classes, and especially among the poorer class, to recognize the less pronounced forms of mental disorder as being of the nature of insanity. Thirdly, the grant of four shillings per week which in 1876 was made by parliament from imperial sources for the maintenance of pauper lunatics has induced parochial authorities to regard as lunatics a large number of weak-minded paupers, and to force them into asylums in order to obtain the benefit of the grant and to relieve the rates. These views receive support from the fact that the increase of private patients, *i.e.* patients who are provided for out of their own funds or those of the family, has advanced in a vastly smaller ratio. In their case the increase, small as it is, can be accounted for by the growing disinclination on the part of the community to tolerate irregularities of conduct due to mental disease. And again, careful inquiry has failed to show a proportional increase of admissions into asylums of such well-marked forms as general paralysis, puerperal mania, &c. The main cause of the registered increase of lunatics is thus to be sought for in the improved registration, and parochial and family convenience. If there is an actual increase, and there is reason for believing that there is a slight actual increase, it is due to the tendency of the population to gravitate towards towns and cities, where the conditions of health are inferior to those of rural life, and where there is therefore a greater disposition to disease of all kinds.

The futility of seeking for accurate figures bearing on the relative number of lunatics in other countries is illustrated by the tables set forth in a report by the United States Census Bureau. They show that the number of registered lunatics in 1903 was 150,151; in 1890, 74,028; and in 1880, 40,942. An attempt was made in 1890 to estimate the number of insane persons outside of hospitals, which was stated to be 32,457. In 1903 no such attempt was made, as it was admitted that so many sources of fallacy existed as to render it useless. Thus the mere statement that of every 100,000 of the population (calculated at 80,000,000) 186.2 were registered as insane is of no value.

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II. Legal Aspects

The effect of insanity upon responsibility and civil capacity has been recognized at an early period in every system of law.

Roman Law.—In the Roman jurisprudence its consequences were very fully developed, and the provisions and terminology of that system have largely affected the subsequent legal treatment of the subject. Its leading principles were simple and well marked. The insane person having no intelligent will, and being thus incapable of consent or voluntary action, could acquire no right and incur no responsibility by his own acts (see Sohm's *Inst. Roman Law*, 3rd ed. pp. 216, 217, 219); his person and property were placed after inquiry by the magistrate under the control of a curator, who was empowered and bound to manage the property of the lunatic on his behalf (Sohm, p. 513; Hunter, *Roman Law*, pp. 732-735). The different terms by which the insane were known, such as *demens*, *furiosus*, *fatuus*, although no doubt signifying different types of insanity, did not in Roman law infer any difference of legal treatment. They were popular names, which all denoted the complete deprivation of reason.

Medieval Law.—During the middle ages the insane were little protected. Their legal acts were annulled, and their property placed under control, but little or no attempt was made to supervise their personal treatment. In England the wardship of idiots and lunatics, which was annexed before the reign of Edward II. to the king's prerogative, had regard chiefly to the control of their lands and estates, and was only gradually elaborated into the systematic control of their persons and property now exercised under the jurisdiction in lunacy. Those whose means were insignificant were left to the care of their relations or to charity. In criminal law the plea of insanity was unavailing except in extreme cases. About the beginning of the 19th century a very considerable change commenced. The public attention was strongly attracted to the miserable condition of the insane incarcerated in asylums without any efficient check or inspection; and at the same time the medical knowledge of insanity entered on a new phase. The possibility and advantages of a better treatment of insanity were illustrated by eminent physicians, Philippe Pinel in France, H. Tuke in England, Bond, B. Rush and I. Ray in the United States; its physical origin became generally accepted; its mental phenomena were more carefully observed, and its relation was established to other mental conditions.

Modern Law.—From this period we date the commencement of legislation such as that known in England as the Lunacy Acts, which aimed at the regulation and control of all constraint applied to the insane. Hitherto, the criteria of insanity had been very rude, and the evidence was generally of a loose and popular character; but, whenever it was fully recognized that insanity was a disease with which physicians who had studied the subject were peculiarly conversant, expert evidence obtained increased importance, and from this time became prominent in every case. The newer medical views of insanity were thus brought into contact with the old narrow conception of the law courts, and a controversy arose in the field of criminal law which in England, at least, still continues.

Relations between Insanity and Law.—The fact of insanity may operate in law—(1) by excluding responsibility for crime; (2) by invalidating legal acts; (3) by affording ground for depriving the insane person by a legal process of the control of his person and property; or (4) by affording ground for putting him under restraint.

Legal Terminology.—Before proceeding, however, to deal with these matters in succession, it may be desirable to say something with regard to the chief legal terms respecting persons suffering under mental disabilities. The subject is now of less importance than formerly, because the modern tendency of the law is to determine the capacity or responsibility of a person alleged to be insane by considering it with reference to the particular matter or class of matters which brings his mental condition *sub judice*. But the literature of the law of lunacy cannot be clearly understood unless the distinctions between the different terms employed to describe the insane are kept in view. The term *non compos mentis* is as old as the statute *De praerogativa regis* (1325), and is used sometimes, as in that statute, to indicate a species contrasted with idiot, sometimes (*e.g.* in Co. Litt. 246 (*b*)) as a genus, and afterwards, chiefly in statutes relating to the insane, in connexion with the terms "idiot" and "lunatic" as a word *ejusdem generis*. The word "idiot" (Gr. ἴδιος, a private person, one who does not hold any public office, and ἰδιώτης, an ignorant and illiterate person) appears in the statute *De praerogativa regis as fatuus naturalis*, and it is placed in contradistinction to *non compos mentis*. The "idiot" is defined by Sir E. Coke (4 Rep. 124 (*b*)) as one who from his nativity, by a perpetual infirmity, is non compos mentis, and Sir M. Hale (*Pleas of the Crown*, i. 29) describes idiocy as "fatuity a *nativitate vel dementia naturalis*." In early times various artificial criteria of idiocy were suggested. Fitzherbert's test was the capacity of the alleged idiot to count twenty pence, or tell his age, or who were his father and mother (*De natura brevium*, 233). Swinburne proposed as a criterion of capacity, inter alia, to measure a yard of cloth or name the days in the week (*Testaments*, 42). Hale propounded the sounder view that "idiocy or not is a question of fact triable by jury and sometimes by inspection" (*Pleas of the Crown*, i. 29). The legal incidents of idiocy were at one time distinct in an important particular from those of lunacy. Under the statute *De praerogativa regis* the king was to have the rents and profits of an idiot's lands to his own use during the life of the idiot, subject merely to an obligation to provide him with necessaries. In the case of the lunatic the king was a trustee, holding his lands and tenements for his benefit and that of his family. It was on account of this difference in the legal consequences of the two states that on inquisitions distinct writs, one *de idiota inquirendo*, the other *de lunatico inquirendo*, were framed for each of them. But juries avoided finding a verdict of idiocy wherever they could, and the writ *de idiota inquirendo* fell into desuetude. A further blow was struck at the distinction when it came to be recognized even by the legislature (see the Idiots Act 1886) that idiots are capable of being educated and trained, and it was practically abolished when the Lunacy Regulation Act 1862, in a provision reproduced in substance in the Lunacy Act 1890, limited the evidence admissible in proof of unsoundness of mind on an inquisition (without special leave of the Master trying the case) to a period of two years before the date of the inquiry, and raised a uniform issue, viz. the state of mind of the alleged lunatic at the time when the inquisition is held.

The term "lunatic," derived from the Latin *luna* in consequence of the notion that the moon had an influence on mental disorders,[1] does not appear in the statute-book till the time of Henry VIII. (1541). Coke defines a lunatic as a "person who has sometimes his understanding and sometimes not, *qui gaudet lucidis intervallis*, and therefore he is called *non compos mentis* so long as he has not understanding" (Co. Litt. 247 (*a*), 4 Rep. 124 (*b*)). Hale defines "lunacy" as "interpolated" (*i.e.* intermittent) *dementia accidentalis vel adventitia*, whether total or (a description, it will be observed, of "partial insanity") *quoad hoc vel illud* (*Pleas of the Crown*, i. 29). In modern times, the word "lunacy" has lost its former precise signification. It is employed sometimes in the strict sense, sometimes in contradistinction to "idiocy" or "imbecility"; once at least—viz. in the Lunacy Act 1890—as including "idiot"; and frequently in conjunction

with the vague terms “unsound mind” (non-sane memory) and “insane.” Section 116 of the Lunacy Act 1890 has by implication extended the meaning of the term lunacy so as to include for certain purposes the incapacity of a person to manage his affairs through mental infirmity arising from disease or age. “Imbecility” is a state of mental weakness “between the limits of absolute idiocy on the one hand and of perfect capacity on the other” (see 1 Haggard, *Eccles. Rep.* p. 401).

1. *The Criminal Responsibility of the Insane.*—The law as to the criminal responsibility of the insane has pursued in England a curious course of development. The views of Coke and Hale give the best exposition of it in the 17th century. Both were agreed that in criminal causes the act and wrong of a madman shall not be imputed to him; both distinguished, although in different language, between *dementia naturalis* (or a *nativitate*) and *dementia accidentalis* or *adventitia*; and the main points in which the writings of Hale mark an advance on those of Coke are in the elaboration by the former of the doctrine of “partial insanity,” and his adoption of the level of understanding of a child of fourteen years of age as the test of responsibility in criminal cases (*Pleas of the Crown*, i. 29, 30; and see Co. 4 *Rep.* 124 (*b*)). In the 18th century a test, still more unsatisfactory than this “child of fourteen” theory, with its identification of “healthy immaturity” with “diseased maturity” (Steph. *Hist. Crim. Law*, ii. 150), was prescribed. On the trial of Edward Arnold in 1723 for firing at and wounding Lord Onslow, Mr Justice Tracy told the jury that “a prisoner, in order to be acquitted on the ground of insanity, must be a man that is totally deprived of his understanding and memory, and doth not know what he is doing, no more than an infant, than a brute or wild beast.” In the beginning of the 19th century a fresh statement of the test of criminal responsibility in mental disease was attempted. On the trial of Hadfield for shooting at George III. in Drury Lane Theatre on 15th May 1800, Lord Chief Justice Kenyon charged the jury in the following terms: “If a man is in a deranged state of mind at the time, he is not criminally answerable for his acts; but the material part of the case is whether at the very time when the act was committed the man’s mind was sane.” The practical effect of this ruling, had it been followed, would have been to make the question of the amenability of persons alleged to be insane to the criminal law very much one of fact, to be answered by juries according to the particular circumstances of each case, and without being aided or embarrassed by any rigid external standard. But in 1812, on the trial of Bellingham for the murder of Mr Perceval, the First Lord of the Treasury, Sir James Mansfield propounded yet another criterion of criminal responsibility in mental disease, viz. whether a prisoner has, at the time of committing an offence, a sufficient degree of capacity to distinguish between good and evil. The objection to this doctrine consisted in the fact, to which the writings of Continental and American jurists soon afterwards began to give prominence, that there are very many lunatics whose general ideas on the subject of right and wrong are quite unexceptionable, but who are yet unable, in consequence of delusions, to perceive the wrongness of particular acts. Sir James Mansfield’s statement of the law was discredited in the case (4 *State Tri.* (n.s.) 847; 10 Cl. and Fin. 200) of Daniel Macnaughton, who was tried in March 1843, before Chief Justice Tindal, Mr Justice Williams and Mr Justice Coleridge, for the murder of Mr Drummond, the private secretary of Sir Robert Peel. Mr (afterwards Lord Chief Justice) Cockburn, who defended the prisoner, used Hale’s doctrine of partial insanity as the foundation of the defence, and secured an acquittal, Chief Justice Tindal telling the jury that the question was whether Macnaughton was capable of distinguishing right from wrong *with respect to the act with which he stood charged*. This judicial approval of the doctrine of partial insanity formed the subject of an animated debate in the House of Lords, and in the end certain questions were put by that House to the judges, and answered by Chief Justice Tindal on behalf of all his colleagues except Mr Justice Maule, who gave independent replies. The answers to those questions are commonly called “The Rules in Macnaughton’s case,” and they still nominally contain the law of England as to the criminal responsibility of the insane. The points affirmed by the Rules that must be noted here are the propositions that knowledge of the nature and quality of the particular criminal act, at the time of its commission, is the test of criminal responsibility, and that delusion is a valid exculpatory plea, when, and only when, the fancies of the insane person, if they had been facts, would have been so. The Rules in Macnaughton’s case are open to serious criticism. They ignore, at least on a literal interpretation, those forms of mental disease which may, for the present purpose, be roughly grouped under the heading “moral insanity,” and in which the moral faculties are more obviously deranged than the mental—the affections and the will, rather than the reason, being apparently disordered. The test propounded with reference to delusions has also been strenuously attacked by medical writers, and especially by Dr Maudsley in his work on *Responsibility in Mental Disease*, on the ground that it first assumes a man to have a delusion in regard to a particular subject, and then expects and requires him to reason sanely upon it. It may be pointed out, however, that in thus localizing the range of the immunity which insane delusion confers, the criminal law is merely following the course which, *mutatis mutandis*, the civil law has, with general acceptance, adopted in questions as to the contractual and testamentary capacity of the insane.

Macnaughton’s Case.

The Rules in Macnaughton’s case have, as regards moral insanity, undergone considerable modification. Soon after they were laid down, Sir (then Mr) James Fitz-James Stephen, in an article in the *Juridical Papers*, i. 67, on the policy of maintaining the existing law as to the criminal responsibility of the insane, foreshadowed the view which he subsequently propounded in his *History of the Criminal Law*, ii. 163, that no man who was deprived by mental disease of the power of passing a fairly rational judgment on the moral character of an act could be said to “know” its nature and quality within the meaning of the Rules; and it has in recent years been found possible in practice so to manipulate the test of the criminal responsibility which they prescribed as to afford protection to the accused in the by no means infrequent cases of insanity which in its literal interpretation it would leave without excuse.

In Scotland the Rules in Macnaughton’s case are recognized, but, as in England, there is a tendency among judges to adopt a generous construction of them. Mental unsoundness insufficient to bar trial, or to exempt from punishment, may still, it is said, be present in a degree which is regarded as reducing the offence from a higher to a lower category, —a doctrine first practically applied in Scotland, it is believed, in 1867 by Lord Deas; and the fact that a prisoner is of weak or ill-regulated mind is often urged with success as a plea in mitigation of punishment. The Indian Penal Code (Act XLV. of 1860, § 84) expressly adopts the English test of criminal responsibility, but the qualifications noted in the case of Scotland have received some measure of judicial acceptance (see Mayne, *Crim. Law Ind.*, 3rd ed., pp. 403-419; Nelson, *Ind. Pen. Code*, 3rd ed., pp. 135 et seq.). The Rules in Macnaughton’s case have also been adopted in substance in those colonies which have codified the criminal law. The following typical references may be given: 55 and 56 Vict. (Can.) c. 29, § 11; 57 Vict. (N.Z.), No. 56 of 1893, § 23; No. 101 of 1888 (St Lucia), § 50; No. 5 of 1876 (Gold Coast), § 49 (*b*); No. 2 of 1883, art. 77 (Ceylon); No. 4 of 1871, art. 84 (Straits Settlements). On the other hand, a departure towards a recognition of “moral insanity” is made by the Queensland Criminal Code (No. 9 of 1899), § 27 of which provides that “a person is not criminally responsible for an act” if at the time of doing it “he is in such a state of mental disease ... as to deprive him ... of capacity to control his actions”: and the law has been defined in the same sense in the Cape of Good Hope in the case of *Queen* v. *Hay* (1899, 16 S.C.R. 290). The Rules were rapidly reproduced in the United States, but the modern trend of American judicial opinion is adverse to them (see Clevenger, *Med. Jur. of Ins.* p. 125; *Parsons* v. *State* (1887) 81 Ala. 577). On the Continent of Europe moral insanity and irresistible impulse are freely recognized as exculpatory pleas (see the French *Code Penal*, § 64; Belgian *Code Penal*, § 71; German *Penal Code*, § 51; Italian *Penal Code*, §§ 46, 47).

Not only is insanity at the time of the commission of an offence a valid exculpatory plea, but supervening insanity

stays the action of the criminal law at every stage from arrest up to punishment. High treason was formerly an exception, but the statute making it so (33 Hen. VIII. c. 20) was repealed in the time of Philip and Mary. The Home Secretary has power, under the Criminal Lunatics Act 1884 to order by warrant the removal of a prisoner, certified to be insane, to a lunatic asylum, before[2] trial or after trial, whether under sentence of death or not. Prisoners dealt with under these provisions are styled "Secretary of State's lunatics." On the other hand, a prisoner who on arraignment appears, or is found by the jury to be unfit to plead, or who is found "guilty but insane" at the time of committing the offence—a verdict substituted by the Trial of Lunatics Act 1883 for the old verdict of "acquitted on the ground of insanity," in the hope that the formal conviction recorded in the new finding might have a deterrent effect on the mentally unstable—is committed to a criminal lunatic asylum by the order of the judge trying the case, to be detained there "during the king's pleasure." Lunatics of this class are called "king's pleasure lunatics." There was no doubt at common law as to the power of the courts to order the detention of criminal lunatics in safe custody, but, prior to 1800, the practice was varying and uncertain. On the acquittal of Hadfield, however, in that year for the attempted murder of George III., a question arose as to the provision which was to be made for his detention, and the Criminal Lunatics Act 1800, part of which is still in force, was passed to affirm the law on the subject.

The Criminal Lunatics Act contains provisions similar to those of the Lunacy Act 1890, as to the discharge (conditional or absolute) and transfer of criminal lunatics and the detention of persons becoming pauper lunatics. The expenses of the maintenance of criminal lunatics are defrayed out of moneys provided by Parliament (Crim. Luns. Act 1884, and Hansard, 3rd series, vol. ccxc. p. 75; 139 Com. Jo. pp. 336, 340, 344). The Lunatics' Removal (India) Act 1851 provides for the removal to a criminal lunatic asylum in Great Britain of persons found guilty of crimes and offences in India, and acquitted on the ground of insanity. Similar provisions with regard to colonial criminal lunatics are contained in the Colonial Prisoners' Removal Act 1884; and the policy of this statute has been followed by No 5. of 1894 (New South Wales), and Ordin. No. 2 of 1895 (Falkland Islands). Indian law (see Act V. of 1898, §§ 464-475) and the laws of the colonies (the Cape Act No. 1 of 1897 is a typical example) as to the trial of lunatics are similar to the English. In Scotland all the criminal lunatics, except those who may have been removed to the ordinary asylums or have been discharged, are confined in the Criminal Asylum established at Perth in connexion with H.M.'s General Prison, and regulated by special acts (23 & 24 Vict. c. 105, and 40 & 41 Vict. c. 53). Provision similar to the English has been made for prisoners found insane as a bar to trial, or acquitted on the ground of insanity or becoming insane in confinement. In New York, Michigan and other American states there are criminal lunatic asylums. Elsewhere insane criminals are apparently detained in state prisons, &c. The statutory rules as to the maintenance of criminal lunatic asylums, the treatment of the criminal insane, and the plea of insanity in criminal courts in America, closely resemble English practice. The only special point in Continental law calling for notice is the system by which official experts report for the guidance of the tribunals on questions of alleged criminal irresponsibility (see, *e.g.*, the German *Code of Penal Procedure*, § 293, and cp. § 81).

2. *Insanity and Civil Capacity.*—The law as to the civil capacity of the insane was for some time influenced in Great Britain by the view propounded by Lord Brougham in 1848 in the case of *Waring* v. *Waring*, and by Sir J. P. Wilde in a later case, raising the question of the validity of a marriage, that, as the mind is one and indivisible, the least disorder of its faculties was fatal to civil capacity. In the leading case of *Banks* v. *Goodfellow* in 1870, the court of queen's bench, in an elaborate judgment delivered by Chief Justice Cockburn, disapproved of this doctrine, and in effect laid down the principle that the question of capacity must be considered with strict reference to the act which has to be or has been done. Thus a certain degree of unsoundness of mind is not now, in the absence of undue influence, a bar to the formation of a valid marriage, if the party whose capacity is in question knew at the time of the marriage the nature of the engagement entered into (but see 51 Geo. III. c. 37 as to the marriage of lunatics so found by inquisition). Again, a man whose mind is affected may make a valid will, if he possesses at the time of executing it a memory sufficiently active to recall the nature and extent of his property, the persons who have claims upon his bounty, and a judgment and will sufficiently free from the influence of morbid ideas or external control to determine the relative strength of those claims. So far has this rule been carried, that in 1893 probate was granted of the will of a lady who was a Chancery lunatic at the date of its execution, and died without the inquisition having been superseded. (*Roe* v. *Nix*, 1893, P. 55.) It is also now settled that the simple contract of a lunatic is voidable and not void, and is binding upon him, unless he can show that at the time of making it he was, to the knowledge of the other party, so insane as not to know what he was about. (*Imperial Loan Co.* v. *Stone*, 1892, 1 Q.B. 599.) The test established by *Banks* v. *Goodfellow* is applied also in a number of minor points in which civil capacity comes into question, *e.g.* competency of the insane as witnesses. The law implies, on the part of a lunatic, whether so found or not, an obligation to pay a reasonable price for "necessaries" supplied to him; and the term "necessaries" means goods suitable to his condition in life and to his actual requirements at the time of sale and delivery (Sale of Goods Act 1893).

The question of the liability of an insane person for tort appears still to be undecided (see Pollock on *Torts*, 7th ed. p. 53; Clerk and Lindsell on *Torts*, 2nd ed. pp. 39, 40; *Law Quart. Rev.* vol. xiii. p. 325). Supervening insanity is no bar to proceedings by or against a lunatic husband or wife for divorce or separation for previous matrimonial offences. It does not avoid a marriage nor constitute *per se* a ground either for divorce or for judicial separation. But cruelty does not cease to be a cause of suit if it proceeds from disorderly affections or want of moral control falling short of positive insanity; and possibly even cruelty springing from intermittent or recurrent insanity might be held a ground for judicial separation, since in such case the party offended against cannot obtain protection by securing the permanent confinement of the offending spouse. Whether insanity at the time when an alleged matrimonial offence was committed is a bar to a suit for divorce or separation is an open question; and in any event, in order that it may be so, the insanity must be of such a character as to have prevented the insane party from knowing the nature and consequences of the act at the time of its commission. The laws of Scotland, Ireland, India (see, *e.g.*, Act IX. of 1872, § 12), the colonies and the United States are substantially identical with English law on the subject of the civil capacity of the insane. The German Civil Code (§ 1569) recognizes the lunacy of a spouse as a ground for divorce, but only where the malady continues during at least three years of the union, and has reached such a pitch that intellectual intercourse between the spouses is impossible, and that every prospect of a restoration of such association is excluded. If one of the spouses obtains a divorce on the ground of the lunacy of the other the former has to allow alimony, just as a husband declared to be the sole guilty party in a divorce suit would have to do (§§ 1585, 1578).

3. *The Jurisdiction in Lunacy.*—In order to effect a change in the status of persons alleged to be of unsound mind, and to bring their persons and property under control, the aid of the jurisdiction in lunacy must be invoked. Under the unrepealed statute *De Praerogativa Regis* (1325) the care and custody of lunatics belong to the Crown. But the Crown has, at least since the 16th century, exercised this branch of the prerogative by delegates, and principally through the Lord Chancellor—not as head of the Court of Chancery, but as the representative and delegate of the sovereign. Under the Lunacy Acts 1890 and 1891, the jurisdiction in lunacy is exercised first by the Lord Chancellor and such of the Lords Justices and other judges as may be invested with it by the sign-manual; and, secondly, by the two Masters in Lunacy, appointed by the Lord Chancellor, from members of the bar of at least ten years' standing, whose duties include the holding of inquisitions and summary inquiries, and the making of most of the consequential orders dealing with the persons and estates of lunatics. County court judges may also exercise a limited jurisdiction in lunacy in the

case of lunatics as to whom a reception order has been made, if their entire property is under £200 in value, and no relative or friend is willing to undertake the management of it; in partnership cases where the assets do not exceed £500; and upon application by the guardians of any union for payment of expenses incurred by them in relation to any lunatic.

Persons of unsound mind are brought under the jurisdiction in lunacy either by an inquisition *de lunatico inquirendo*, or, in certain cases which will be adverted to below, by proceedings instituted under § 116 of the Lunacy Act 1890, which is now the great practice section in the Lunacy Office. Prior to 1853 a special commission was issued to the Masters in each alleged case of lunacy. But by the Lunacy Regulation Act of that year a general commission was directed to the Masters, empowering them to proceed in each case in which the Lord Chancellor by order required an inquisition to be held. This procedure is still in force. A special commission would now be issued only where both Masters were personally interested in the subject of the inquiry, or for some other similar reason. An inquisition is ordered by the judge in lunacy (a term which does not, for this purpose, at present include the Masters, although this is one of the points in regard to which a change in the law has been suggested, on the petition generally of a near relative of the alleged lunatic). The inquiry is held before one of the Masters, and a jury may be summoned if the alleged lunatic, being within the jurisdiction, demands it, unless the judge is satisfied that he is not competent to form and express such a wish; and even in that case the Master has power to direct trial by jury if he thinks fit on consideration of the evidence. Where the alleged lunatic is not within the jurisdiction the trial must be by jury; and the judge in lunacy may direct this mode of trial to be adopted in any case whatever.

A few points of general interest in connexion with inquisitions must be noted. In practice thirty-four jurors are summoned by the sheriff, and not more than twenty-four are empanelled. Twelve at least must concur in the verdict. Counsel for the petitioner ought to act in the judicial spirit expected from counsel for the prosecution in criminal cases. The issue to be determined on an inquisition is “whether or not the alleged lunatic is at the time of the inquisition of unsound mind, and incapable of managing himself and his affairs” (a special verdict may, however, be found that the lunatic is capable of managing himself, although not his affairs, and that he is not dangerous to others); and without the direction of the person holding the inquisition, no evidence as to the lunatic’s conduct at any time being more than two years before the inquisition is to be receivable. This limitation, both of the issue and of the evidence, was imposed with a view to preventing the recurrence of such cases as that of Mr Windham in 1861-1862, when the inquiry ranged over the whole life of an alleged lunatic, forty-eight witnesses being examined on behalf of the petitioners and ninety-one on behalf of the respondents, while the hearing lasted for thirty-four days. For the purpose of assisting the Master or jury in arriving at a decision, provision is made for the personal examination of the alleged lunatic by them on oath or otherwise, and either in open court or in private, as may be directed. The proceedings on inquisition are open to the public. When a person has been found lunatic by inquisition he becomes subject to the jurisdiction in lunacy, and remains so (unless he succeeds in setting aside the verdict by a “traverse”—a proceeding which ultimately comes before, and is determined by, the King’s Bench Division in London or at the assizes) until his recovery, when the inquisition may be put an end to by a procedure technically known as “supersedeas,” or by his death. The results of the inquisition are worked out in the Lunacy Office. The control of the estate, and, except where he was found incapable of managing his property only, of the person of the lunatic is entrusted to committees of the estate and person, who are appointed by, and accountable to, the Master in Lunacy, and whose legal position corresponds roughly with that of the tutors and curators of the civil law. The committee of the estate in particular exercises over the property of the lunatic, with the sanction or by the order of the Master, very wide powers of management and administration, including the raising of money by sale, charge or otherwise, to pay the lunatic’s debts, or provide for his past or future maintenance, charges for permanent improvements, the sale of any property belonging to the lunatic, the execution of powers vested in him and the performance of contracts relating to property.

The alternative method of bringing a person of unsound mind under lunacy jurisdiction was created by § 116 of the Lunacy Act 1890. The effect of that section briefly is to enable the Master, on a summons being taken out in his chambers and heard before him, to apply the powers of management and administration summarized in the last preceding paragraph, without any inquisition, to the following classes of cases: lunatics not so found by inquisition, for the protection or administration of whose property any order was made under earlier acts; every person lawfully detained, within the jurisdiction of the English courts, as a lunatic, though not so found by inquisition; persons not coming within the foregoing categories who are “through mental infirmity arising from disease or age” incapable of managing their affairs; persons of unsound mind whose property does not exceed £2000 in value, or does not yield an annual income of more than £100; and criminal lunatics continuing insane and under confinement.

In Scotland the insane are brought under the jurisdiction in lunacy by alternative methods, similar to the English inquisition and summary procedure, viz. “cognition,” the trial taking place before the Lord President of the Court of Session, or any judge of that court to whom he may remit it, and a jury of twelve—see 31 & 32 Vict. c. 100, and Act of Sederunt of 3rd December 1868—and an application to the Junior Lord Ordinary of the Court of Session or (43 & 44 Vict. c. 4, § 4) to the Sheriff Court, when the estate in question does not exceed £100 a year, for the appointment of a *curator bonis* or judicial factor.

The powers of the Lord Chancellor of Ireland with regard to lunatics are generally similar to those of the English Chancellor (see the Lunacy Regulations (Ireland) Act 1871, 34 & 35 Vict. c. 22, and the Lunacy (Ireland) Act 1901, 1 Ed. VII. c. 17; also Colles on *The Lunacy Regulation* (*Ireland*) *Act*.

The main feature of the French system is the provision made by the Civil Code (arts. 489-512) for the interdiction of an insane person by the Tribunal of First Instance, with a right of appeal to the Court of Appeal, after a preliminary inquiry and a report by a family council (arts. 407, 408), consisting of six blood relatives in as near a degree of relationship to the lunatic as possible, or, in default of such relatives, of six relatives by marriage. The family council is presided over by the *Juge de Paix* of the district in which the lunatic is domiciled. This system is also in force in Mauritius.

There are provisions, it may be noted, in Scots law for the interdiction of lunatics, either voluntarily or judicially (see Bell’s *Principles*, § 2123). The German Civil Code provides for insane persons being made subject to guardianship (*vormundung*), on conditions similar to those of Scots and French law (see Civil Code, §§ 6, 104 (1896, 1906), 645-679). In the United States the fundamental procedure is an inquisition conducted on practically the same lines as in England. (Cf. Indiana, *Rev. Stats*. (1894) §§ 2715 et seq.; Missouri, Annot. Code (1892) §§ 2835 et seq.; New Mexico, *General Laws* (1880) c. 74 §§ 1 et seq.).

4. *Asylum Administration*.—Asylum administration in England is now regulated by the Lunacy Acts 1890 and 1891. Receptacles for the insane are divisible into the following classes: (i.) Institutions for lunatics, including asylums, registered hospitals and licensed houses. The asylums are provided by counties or boroughs, or by union of counties or boroughs. Registered hospitals are hospitals holding certificates of registration from the Commissioners in Lunacy, where lunatics are received and supported wholly or partially by voluntary contributions or charitable bequests, or by applying the excess of the payments of some patients towards the maintenance of others. Licensed houses are houses

licensed by the Commissioners, or, beyond their immediate jurisdiction, by justices; (ii.) Workhouses—see article Poor Law; (iii.) Houses in which patients are boarded out; (iv.) Private houses (unlicensed) in which not more than a single patient may be received. A person, not being a pauper or a lunatic so found by inquisition, cannot, in ordinary cases, be received and detained as a lunatic in any institution for the insane, except under a "reception order" made by a county court judge or stipendiary magistrate or specially appointed justice of the peace. The order is made on a petition presented by a relative or friend of the alleged lunatic, and supported by two medical certificates, and after a private hearing by the judicial authority. The detention of a lunatic is, however, justifiable at common law, if necessary for his safety or that of others; and the Lunacy Act 1890, borrowing from the lunacy law of Scotland, provides for the reception of a lunatic not a pauper into an asylum, where it is expedient for his welfare or the public safety that he should be confined without delay, upon an "urgency order," made if possible by a near relative and accompanied by one medical certificate. The urgency order only justifies detention for seven days (the curtailment of this period to four days is proposed), and before the expiration of that period the ordinary procedure must be followed. "Summary reception orders" may be made by justices otherwise than on petition. There are four classes of cases in which such orders may be made, viz.: (i.) lunatics (not paupers and not wandering at large) who are not under proper care and control, or are cruelly treated or neglected; (ii.) resident pauper lunatics; (iii.) lunatics, whether pauper or not, wandering at large; (iv.) lunatics in workhouses. (As to pauper lunatics generally, see article Poor Law.) A lunatic may also be received into an institution under an order by the Commissioners in Lunacy; and a lunatic so found by inquisition under an order signed by the committee of his person.

The chief features of English asylum administration requiring notice are these. Mechanical restraint is to be applied only when necessary for surgical or medical purposes, or in order to prevent the lunatic from injuring himself or others. The privacy of the correspondence of lunatics with the Lord Chancellor, the Commissioners in Lunacy, &c., is secured. Provision is made for regular visits to patients by their relatives and friends. The employment of males for the custody of females is, except on occasions of urgency, prohibited. Pauper lunatics may be boarded out with relatives and friends. Elaborate provision is made for the official visitation of every class of receptacle for the insane. The duties of visitation are divided between the Commissioners in Lunacy, the Chancery Visitors and various other visitors and visiting committees. There are ten Commissioners in Lunacy—four unpaid and six paid, three of the latter being barristers of not less than five years' standing at the date of appointment, and three medical. The Commissioners in Lunacy, who are appointed by the Lord Chancellor, visit every class of lunatics except persons so found by inquisition. These are visited by the Chancery Visitors. There are three Chancery Visitors, two medical and one legal (a barrister of at least five years' standing at the date of his appointment), who are appointed and removable by the Lord Chancellor. The Chancery Visitors (together with the Master in Lunacy) form a Board, and have offices in the Royal Courts of Justice. In addition to these two classes of visitors, every asylum has a Visiting Committee of not less than seven members, appointed by the local authority; and the justices of every county and quarter-sessions borough not within the immediate jurisdiction of the Commissioners in Lunacy annually appoint three or more of their number as visitors of licensed houses.

Provision is made for the discharge of lunatics from asylums, &c., on recovery, or by *habeas corpus*, or by the various visiting authorities. Any person who considers himself to have been unjustly detained is entitled on discharge to obtain, free of expense, from the secretary to the Lunacy Commissioners a copy of the documents under which he was confined.

The Irish [Lunacy Acts 1821-1890; Lunacy (Ireland) Act 1901] and Scottish [Lunacy Acts 1857 (20 & 21 Vict. c. 71), 1887 (50 & 51 Vict. c. 39)] asylum systems present no feature sufficiently different from the English to require separate notice, except that in Scotland "boarding out" is a regular, and not merely an incidental, part of asylum administration. The "boarding out" principle has, however, received its most extended and most successful application in the Gheel colony in Belgium. The patients, after a few days' preliminary observation, are placed in families, and, except that they are under ultimate control by a superior commission, composed of the governor of the province, the Procureur du Roi and others, enjoy complete liberty indoors as well as out of doors. The patients are visited by nurses from the infirmary, to which they may be sent if they become seriously ill or unmanageable. They are encouraged to work. The accommodation provided for them is prescribed, and is to be of the same quality as that of the household in which they live. Clothing is provided by the administration.

In the French (see laws of 30th June 1838 and 18th December 1839) and German (see *Journal of Comparative Legislation*, n.s. vol. i. at pp. 271, 272) asylum systems the main features of English administration are also reproduced.

The lunacy laws of the British colonies have also closely followed English legislation (cf. Ontario, *R.S.* 1897, cc. 317, 318; Manitoba, *R.S.* 1902, c. 80; Victoria (No. 1113, 1890); New Zealand (No. 34 of 1882 and Amending Acts); Mauritius (No. 37 of 1858).

In America the different states of the Union have each their own lunacy legislation. The national government provides only for the insane of the army and navy, and for those residing in the District of Columbia and in Alaska. The various laws as to the reception, &c., of the insane into asylums closely resemble English procedure. But in several states the verdict of a jury finding lunacy is a necessary preliminary to the commitment of private patients (Kentucky, Act of 1883, c. 900, § 14; Maryland, *R.S.* 1878, c. 53, § 21; Illinois, *R.S.* 1874, c. 85, § 22).

Authorities.—The following works may be consulted: Collinson on the *Law of Lunatics and Idiots* (2 vols., London, 1812); Shelford on the *Law of Lunatics and Idiots* (London, 1847). On all points relating to the history and development of the law these two treatises are invaluable. Pope on *Lunacy* (2nd ed., London, 1890); Archbold's *Lunacy* (4th ed., London, 1895); Elmer on *Lunacy* (7th ed., London, 1892); Wood Renton on *Lunacy* (London and Edinburgh, 1896); Fry's *Lunacy Laws* (3rd ed., London, 1890); Pitt-Lewis, Smith and Hawke, *The Insane and the Law* (London, 1895); Hack-Tuke, *Dictionary of Psychological Medicine* (London, 1892), and the bibliographies attached to the various legal articles in that work; Clevenger, *Medical Jurisprudence of Insanity* (2 vols., New York, 1899); Semelaigne, *Les Aliénistes français* (Paris 1849); Bertrand, *Loi sur les aliénés* (Paris, 1872), presents a comparative view of English and foreign legislations. In forensic medicine the works of Taylor, *Medical Jurisprudence* (5th ed., London, 1905); Dixon Mann, *Foreign Medicine and Toxicology* (3rd ed., London, 1902); and Wharton and Stillé, *A Treatise on Medical Jurisprudence* (Philadelphia, 1873); Hamilton and Godkin, *System of Legal Medicine* (New York, 1895); are probably the English authorities in most common use. See also Casper and Liman, *Praktisches Handbuch der gerichtlichen Medicin* (Berlin, 6th ed., 1876); Tardieu, *Étude médico-légale sur la folie* (Paris, 1872); Legrand du Saulle, *La Folie devant les tribunaux* (Paris, 1864); Dubrac, *Traité de jurisprudence médicale* (Paris, 1894); Tourdes, *Traité de médecine légale* (Paris, 1897); and especially Krafft-Ebing, *Lehrbuch der gerichtlichen Psychopathologie* (Stuttgart, 1899).

(A. W. R.)

III. Hospital Treatment

The era of real hospitals for the insane began in the 19th century. There had been established here and there in different parts of the world, it is true, certain asylums or places of restraint before the beginning of the 19th century.

We find mention in history of such a place established by monks at Jerusalem in the latter part of the 5th century. There is evidence that even earlier than this in Egypt and Greece the insane were treated as individuals suffering from disease. Egyptian priests employed not only music and the beautiful in nature and art as remedial agents in insanity, but recreation and occupation as well. A Greek physician protested against mechanical restraint in the care of the insane, and advocated kindly treatment, the use of music, and of some sorts of manual labour. But these ancient beneficent teachings were lost sight of during succeeding centuries. The prevailing idea of the pathology of insanity in Europe during the middle ages was that of demoniacal possession. The insane were not sick, but possessed of devils, and these devils were only to be exorcised by moral or spiritual agencies. Medieval therapeutics in insanity adapted itself to the etiology indicated. Torture and the cruellest forms of punishment were employed. The insane were regarded with abhorrence, and were frequently cast into chains and dungeons. Milder forms of mental disease were treated by other spiritual means—such as pilgrimages to the shrines of certain saints who were reputed to have particular skill and success in the exorcism of evil spirits. The shrine of St Dymphna at Gheel, in Belgium, was one of these, and seems to have originated in the 7th century, a shrine so famed that lunatics from all over Europe were brought thither for miraculous healing. The little town became a resort for hundreds of insane persons, and as long ago as the 17th century acquired the reputation, which still exists to this day, of a unique colony for the insane. At the present time the village of Gheel and its adjacent farming hamlets (with a population of some 13,000 souls) provides homes, board and care for nearly 2000 insane persons under medical and government supervision. Numerous other shrines and holy wells in various parts of Europe were resorted to by the mentally afflicted—such as Glen-na-Galt in Ireland, the well of St Winifred, St Nun’s Pool, St Fillans, &c. At St Nun’s the treatment consisted of plunging the patient backwards into the water and dragging him to and fro until mental excitement abated. Not only throughout the middle ages, but far down into the 17th century, demonology and witchcraft were regarded as the chief causes of insanity. And the insane were frequently tortured, scourged, and even burned to death.

Until as late as the middle of the 18th century, mildly insane persons were cared for at shrines, or wandered homeless about the country. Such as were deemed a menace to the community were sent to ordinary prisons or chained in dungeons. Thus large numbers of lunatics accumulated in the prisons, and slowly there grew up a sort of distinction between them and criminals, which at length resulted in a separation of the two classes. In time many of the insane were sent to cloisters and monasteries, especially after these began to be abandoned by their former occupants. Thus “Bedlam” (Bethlehem Royal Hospital) was originally founded in 1247 as a priory for the brethren and sisters of the Order of the Star of Bethlehem. It is not known exactly when lunatics were first received into Bedlam, but some were there in 1403. Bedlam was rebuilt as an asylum for the insane in 1676. In 1815 a committee of the House of Commons, upon investigation, found it in a disgraceful condition, the medical treatment being of the most antiquated sort, and actual inhumanity practised upon the patients. Similarly the Charenton Asylum, just outside Paris, near the park of Vincennes, was an old monastery which had been given over to the insane. Numerous like instances could be cited, but the interesting point to be borne in mind is, that with a general tendency to improvement in the condition of imbeciles upon public charge, idiots and insane persons came gradually to be separated from criminals and other paupers, and to be segregated. The process of segregation was, however, very slow. Even after it had been accomplished in the larger centres of civilization, the condition of these unfortunates in provincial districts remained the same. Furthermore, the transfer to asylums provided especially for them was not followed by any immediate improvement in the patients.

Twenty-five years after Pinel had, in 1792, struck the chains from the lunatics huddled in the Salpétrière and Bicêtre of Paris, and called upon the world to realize the horrible injustice done to this wretched and suffering class of humanity, a pupil of Pinel, Esquirol, wrote of the insane in France and all Europe: “These unfortunate people are treated worse than criminals, reduced to a condition worse than that of animals. I have seen them naked, covered with rags, and having only straw to protect them against the cold moisture and the hard stones they lie upon; deprived of air, of water to quench thirst, and all the necessaries of life; given up to mere gaolers and left to their surveillance. I have seen them in their narrow and filthy cells, without light and air, fastened with chains in these dens in which one would not keep wild beasts. This I have seen in France, and *the insane are everywhere in Europe treated in the same way*.” It was not until 1838 that the insane in France were all transferred from small houses of detention, workhouses and prisons to asylums specially constructed for this purpose.

In Belgium, in the middle ages, the public executioner was ordered to expel from the towns, by flogging, the poor lunatics who were wandering about the streets. In 1804 the Code Napoleon “punished those who allowed the insane and mad criminals to run about free.” In 1841 an investigation showed in Belgium thirty-seven establishments for the insane, only six of which were in good order. In fourteen of them chains and irons were still being used. In Germany, England and America, in 1841, the condition of the insane was practically the same as in Belgium and France.

These facts show that no great advance in the humane and scientific care of the insane was made till towards the middle of the 19th century. Only then did the actual metamorphosis of asylums for detention into hospitals for treatment begin to take place. Hand in hand with this progress there has grown, and still is growing, a tendency to subdivision and specialization of hospitals for this purpose. There are now hospitals for the acutely insane, others for the chronic insane, asylums for the criminal insane, institutions for the feeble-minded and idiots, and colonies for epileptics. There are public institutions for the poor, and well-appointed private retreats and homes for the rich. All these are presided over by the best of medical authorities, supervised by unsalaried boards of trustees or managers, and carefully inspected by Government lunacy commissioners, or boards of charities—a contrast, indeed, to the gaols, shrines, holy wells, chains, tortures, monkish exorcisms, &c., of the past!

The statistics of insanity have been fairly well established. The ratio of insane to normal population is about 1 to 300 among civilized peoples. This proportion varies within narrow limits in different races and countries. It is probable that intemperance in the use of alcohol and drugs, the spread of venereal diseases, and the over-stimulation in many directions induced by modern social conditions, have caused an increase of insanity in the 19th as compared with past centuries. The amount of such increase is probably very small, but on superficial examination might seem to be large, owing to the accumulation of the chronic insane and the constant upbuilding of asylums in new communities. The imperfections of census-taking in the past must also be taken into account.

The modern hospital for the insane does credit to latter-day civilization. Physical restraint is no longer practised. The day of chains—even of wristlets, covered cribs and strait-jackets—is past. Neat dormitories, cosy single rooms, and sitting- and dining-rooms please the eye. In the place of bare walls and floors and curtainless windows, are pictures, plants, rugs, birds, curtains, and in many asylums even the barred windows have been abolished. Some of the wards for milder patients have unlocked doors. Many patients are trusted alone about the grounds and on visits to neighbouring towns. An air of busy occupation is observed in sewing-rooms, schools, shops, in the fields and gardens, employment contributing not only to economy in administration, but to improvement in mental and physical conditions. The general progress of medical science in all directions has been manifested in the department of psychiatry by improved methods of treatment, in the way of sleep-producing and alleviating drugs, dietetics, physical culture, hydrotherapy and the like. There are few asylums now without pathological and clinical laboratories. While it is a far cry from the prisons and monasteries of the past to the modern hospital for the insane, it is still possible to trace a resemblance in many of our

older asylums to their ancient prototypes, particularly in those asylums built upon the so-called corridor plan. Though each generation contributed something new, antecedent models were more or less adhered to. Progress in asylum architecture has hence advanced more slowly in countries where monasteries and cloisters abounded than in countries where fixed models did not exist. Architects have had a freer hand in America, Australia and Germany, and even in Great Britain, than in the Catholic countries of Europe.

Germany approaches nearest to an ideal standard of provision for the insane. The highest and best idea which has yet been attained is that of small hospitals for the acutely insane in all cities of more than 50,000 inhabitants, and of colonies for the chronic insane in the rural districts adjacent to centres of population. The psychopathic hospital in the city gives easy and speedy access to persons taken suddenly ill with mental disease, aids in early diagnosis, places the patients within reach of the best specialists in all departments of medicine, and associated, as it should be, with a medical school or university, affords facilities not otherwise available for scientific research and for instruction in an important branch of medical learning. A feature of the psychopathic hospital should be the reception of patients for a reasonable period of time, as sufferers from disease, without the formality of legal commitment papers. Such papers are naturally required for the detention and restraint of the insane for long periods of time, but in the earlier stages they should be spared the stigma, delay and complicated procedure of commitment for at least ten days or two weeks, since in that time many may convalesce or recover, and in this way escape the public record of their infirmities, unavoidable by present judicial procedures.

There should be associated with such hospitals for the acutely insane in cities out-door departments or dispensaries, to which patients may be brought in still earlier stages of mental disorder, at a period when early diagnosis and preventive therapeutics may have their best opportunities to attain good results. In Germany a psychopathic hospital now exists in every university town, under the name of Psychiatrische Klinik.

Colonies for the chronic insane are established in the country, but in the neighbourhood of the cities having psychopathic hospitals, to receive the overflow of the latter when the acute stage has passed. The true colony is constructed on the principle of a farming hamlet, without barracks, corridored buildings, or pavilions. It is similar in most respects to any agricultural community. The question here is one of humane care and economical administration. Humane care includes medical supervision, agreeable home-life, recreation, and, above all things, regular manual and out-of-door occupation in garden, farm and dairy, in the quarry, clay-pit or well-ventilated shop. Employment for the patients is of immense remedial importance, and of great value from the standpoint of economical administration. In the colony system the small cottage homes of the patients are grouped about the centres of industry. The workers in the farmstead live in small families about the farmstead group of buildings; the tillers of the soil adjacent to the fields, 618
meadows and gardens; the brickmakers, quarrymen and artizans in still other cottages in the neighbourhood of the scenes of their activities. In addition to these groups of cottages, which constitute the majority of the buildings in the village, an infirmary for bedridden, excited and crippled patients is required, and a small hospital for the sick. All the inhabitants of the colony are under medical supervision. A laboratory for scientific researches forms a highly important part of the equipment. The colony is not looked upon as a refuge for the incurable; it is still a hospital for the sick, where treatment is carried on under the most humane and most suitable conditions, and wherein the percentage of recoveries will be larger than in asylums and hospitals as now conducted. In respect of the establishment of colonies for the insane upon the plan outlined here, Germany has, as in the case of the psychopathic hospital, led the world. It has been less difficult for that country to set the example, because she had fewer of the conditions of the past to fight, and with her the progress of medical science and of methods of instruction in all departments of medicine has been more pronounced and rapid.

Among the German colonies for the insane, that at Alt-Scherbitz, near Leipzig, is the oldest and most successful, and is pre-eminent in its close approach to the ideal village or colony system. In 1899 Professor Kraeplin of Heidelberg stated (*Psychiatrie*, 6th edition) that the effort was made everywhere in Germany to give the exterior of asylums, by segregation of the patients in separate home-like villas, rather the appearance of hamlets for working-people than prisons for the insane, and he said, further, that the whole question of the care of the insane had found solution in the colony system, the best and cheapest method of support. “I have myself,” he writes, “had opportunity to see patients, who had lived for years in a large closed asylum, improve in the most extraordinary manner under the influence of the freer movement and more independent occupation of colony life.”

In America the colony scheme has been successfully adopted by the state of New York at the Craig Colony for Epileptics at Sonyea and elsewhere.

That the tendency nowadays, even outside of Germany, in the direction of the ideal standard of provision for the insane is a growing one is manifested in all countries by a gradual disintegration of the former huge cloister-like abodes. More asylums are built on the pavilion plan. Many asylums have, as it were, thrown off detached cottages for the better care of certain patients. Some asylums have even established small agricultural colonies a few miles away from the parent plant, like a vine throwing out feelers. What is called the boarding-out system is an effort in a similar direction. Patients suffering from mild forms of insanity are boarded out in families in the country, either upon public or private charge. Gheel is an example of the boarding-out system practised on a large scale. But the ideal system is that of the psychopathic hospital and the colony for the insane.

Authorities.—Sir J. B. Tuke, *Dictionary of Psychological Medicine*, (London and Philadelphia, 1892); W. P. Letchworth, *The Insane in Foreign Countries* (New York, 1889); *Care and Treatment of Epileptics* (New York, 1900); F. Peterson, *Mental Diseases* (Philadelphia, 1899); “Annual Address to the American Medico-Psychological Association,” *Proceedings* (1899).

(F. P.*)

1 The word for “lunatic” in several other languages has a similar etymology. Cp. Ital. *lunatico*, Span. *alunado*, Gr. σεληνιακός (epileptic), Ger. *mondsüchtig*.

2 It has sometimes been stated that this power, which ought clearly, in the interests alike of prisoners and of the public, to be exercised with caution, is in fact exerted in an unduly large number of cases. The following figures, taken from the respective volumes of the *Criminal Judicial Statistics*, show the number of criminal lunatics certified insane before trial. In 1884-1885, out of a total of 938 criminal lunatics, 169 were so certified; in 1885-1886, 149 out of 890; in 1889-1890, 108 out of 926; in 1890-1891, 95 out of 900; in 1894, 78 out of 738; in 1895, 84 out of 757; in 1896, 88 out of 769; in 1897, 85 out of 764; in 1898, 17 out of 209; in 1899, 13 out of 159; in 1900, 12 out of 185; in 1901, 15 out of 205; in 1902, 7 out of 233; in 1903, 11 out of 229.

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