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THE ENCYCLOPÆDIA BRITANNICA

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VOLUME IX SLICE III

Electrostatics to Engis

Articles in This Slice

ELECTROSTATICS, the name given to that department of electrical science in which the phenomena of electricity at rest are considered. Besides their ordinary condition all bodies are capable of being thrown into a physical state in which they are said to be electrified or charged with electricity. When in this condition they become sources of electric force, and the space round them in which this force is manifested is called an "electric field" (see ELECTRICITY). Electrified bodies exert mechanical forces on each other, creating or tending to create motion, and also induce electric charges on neighbouring surfaces. 240

The reader possessed of no previous knowledge of electrical phenomena will best appreciate the meaning of the terms employed by the aid of a few simple experiments. For this purpose the following apparatus should be provided:—(1) two small metal tea-trays and some clean dry tumblers, the latter preferably varnished with shellac varnish made with alcohol free from water; (2) two sheets of ebonite rather larger than the tea-trays; (3) a rod of sealing-wax or ebonite and a glass tube, also some pieces of silk and flannel; (4) a few small gilt pith balls suspended by dry silk threads; (5) a gold-leaf electroscope, and, if possible, a simple form of quadrant electrometer (see Electroscope and Electrometer); (6) some brass balls mounted on the ends of ebonite penholders, and a few tin canisters. With the aid of this apparatus, the principal facts of electrostatics can be experimentally verified, as follows:—

Experiment I.—Place one tea-tray bottom side uppermost upon three warm tumblers as legs. Rub the sheet of ebonite vigorously with warm flannel and lay it rubbed side downwards on the top of the tray. Touch the tray with the finger for an instant, and lift up the ebonite without letting the hand touch the tray a second time. The tray is then found to be electrified. If a suspended gilt pith ball is held near it, the ball will first be attracted and then repelled. If small fragments of paper are scattered on the tray and then the other tray held in the hand over them, they will fly up and down rapidly. If the knuckle is approached to the electrified tray, a small spark will be seen, and afterwards the tray will be found to be discharged or unelectrified. If the electrified tray is touched with the sealing-wax or ebonite rod, it will not be discharged, but if touched with a metal wire, the hand, or a damp thread, it is discharged at once. This shows that some bodies are *conductors* and others *non-conductors* or *insulators* of electricity, and that bodies can be electrified by friction and impart their electric charge to other bodies. A charged conductor supported on a non-conductor retains its charge. It is then said to be insulated.

Experiment II.—Arrange two tea-trays, each on dry tumblers as before. Rub the sheet of ebonite with flannel, lay it face downwards on one tray, touch that tray with the finger for a moment and lift up the ebonite sheet, rub it again, and lay it face downwards on the second tray and leave it there. Then take two suspended gilt pith balls and touch them (*a*) both against one tray; they will be found to repel each other; (*b*) touch one against one tray and the other against the other tray, and they will be found to attract each other. This proves the existence of two kinds of electricity, called *positive* and *negative*. The first tea-tray is positively electrified, and the second negatively. If an insulated brass 241
ball is touched against the first tray and then against the knob or plate of the electroscope, the gold leaves will diverge. If the ball is discharged and touched against the other tray, and then afterwards against the previously charged electroscope, the leaves will collapse. This shows that the two electricities neutralize each other's effect when imparted equally to the same conductor.

Experiment III.—Let one tray be insulated as before, and the electrified sheet of ebonite held over it, but not allowed to touch the tray. If the ebonite is withdrawn without touching the tray, the latter will be found to be unelectrified. If whilst holding the ebonite sheet over the tray the latter is also touched with an insulated brass ball, then this ball when removed and tested with the electroscope will be found to be negatively electrified. The sign of the electrification imparted to the electroscope when so charged—that is, whether positive or negative—can be determined by rubbing the sealing-wax rod with flannel and the glass rod with silk, and approaching them gently to the electroscope one at a time. The sealing-wax so treated is electrified negatively or *resinously*, and the glass with positive or *vitreous* electricity. Hence if the electrified sealing-wax rod makes the leaves collapse, the electroscopic charge is positive, but if the glass rod does the same, the electroscopic charge is negative. Again, if, whilst holding the electrified ebonite over the tray, we touch the latter for a moment and then withdraw the ebonite sheet, the tray will be found to be positively electrified. The electrified ebonite is said to act by "electrostatic induction" on the tray, and creates on it two induced charges, one of positive and the other of negative electricity. The last goes to earth when the tray is touched, and the first remains when the tray is insulated and the ebonite withdrawn.

Experiment IV.—Place a tin canister on a warm tumbler and connect it by a wire with the gold-leaf electroscope. Charge positively a brass ball held on an ebonite stem, and introduce it, without touching, into the canister. The leaves of the electroscope will diverge with positive electricity. Withdraw the ball and the leaves will collapse. Replace the ball again and touch the outside of the canister; the leaves will collapse. If then the ball be withdrawn, the leaves will diverge a second time with negative electrification. If, before withdrawing the ball, after touching the outside of the canister for a moment the ball is touched against the inside of the canister, then on withdrawing it the ball and canister are found to be discharged. This experiment proves that when a charged body acts by induction on an insulated conductor it causes an electrical separation to take place; electricity of opposite sign is drawn to the side nearest the inducing body, and that of like sign is repelled to the remote side, and these quantities are equal in amount.

Seat of the Electric Charge.—So far we have spoken of electric charge as if it resided on the conductors which are electrified. The work of Benjamin Franklin, Henry Cavendish, Michael Faraday and J. Clerk Maxwell demonstrated, however, that all electric charge or electrification of conductors consists simply in the establishment of a physical state in the surrounding insulator or dielectric, which state is variously called *electric strain*, *electric displacement* or *electric polarization*. Under the action of the same or identical electric forces the intensity of this state in various insulators is determined by a quality of them called their *dielectric constant*, *specific inductive capacity* or *inductivity*. In the next place we must notice that electrification is a measurable magnitude and in electrostatics is estimated in terms of a unit called the *electrostatic unit* of electric quantity. In the absolute C.G.S. system this unit quantity is defined as follows:—If we consider a very small electrified spherical conductor, experiment shows that it exerts a repulsive force upon another similar and similarly electrified body. Cavendish and C.A. Coulomb proved that this mechanical force varies inversely as the square of the distance between the centres of the spheres. The unit of mechanical force in the “centimetre, gramme, second” (C.G.S.) system of units is the *dyne*, which is approximately equal to 1/981 part of the weight of one gramme. A very small sphere is said then to possess a charge of one electrostatic unit of quantity, when it repels another similar and similarly electrified body with a force of one dyne, the centres being at a distance of one centimetre, provided that the spheres are *in vacuo* or immersed in some insulator, the dielectric constant of which is taken as unity. If the two small conducting spheres are placed with centres at a distance d centimetres, and immersed in an insulator of dielectric constant K, and carry charges of Q and Q′ electrostatic units respectively, measured as above described, then the mechanical force between them is equal to QQ'/Kd^2 dynes. For constant charges and distances the mechanical force is inversely as the dielectric constant.

Electric Force.—If a small conducting body is charged with Q electrostatic units of electricity, and placed in any electric field at a point where the electric force has a value E, it will be subject to a mechanical force equal to QE dynes, tending to move it in the direction of the resultant electric force. This provides us with a definition of a unit of electric force, for it is the strength of an electric field at that point where a small conductor carrying a unit charge is acted upon by unit mechanical force, assuming the dielectric constant of the surrounding medium to be unity. To avoid unnecessary complications we shall assume this latter condition in all the following discussion, which is equivalent simply to assuming that all our electrical measurements are made in air or *in vacuo*.

Owing to the confusion introduced by the employment of the term force, Maxwell and other writers sometimes use the words *electromotive intensity* instead of electric force. The reader should, however, notice that what is generally called electric force is the analogue in electricity of the so-called acceleration of gravity in mechanics, whilst electrification or quantity of electricity is analogous to mass. If a mass of M grammes be placed in the earth’s field at a place where the acceleration of gravity has a value g centimetres per second, then the mechanical force acting on it and pulling it downwards is Mg dynes. In the same manner, if an electrified body carries a positive charge Q electrostatic units and is placed in an electric field at a place where the electric force or electromotive intensity has a value E units, it is urged in the direction of the electric force with a mechanical force equal to QE dynes. We must, however, assume that the charge Q is so small that it does not sensibly disturb the original electric field, and that the dielectric constant of the insulator is unity.

Faraday introduced the important and useful conception of *lines* and *tubes* of electric force. If we consider a very small conductor charged with a unit of positive electricity to be placed in an electric field, it will move or tend to move under the action of the electric force in a certain direction. The path described by it when removed from the action of gravity and all other physical forces is called a line of electric force. We may otherwise define it by saying that a line of electric force is a line so drawn in a field of electric force that its direction coincides at every point with the resultant electric force at that point. Let *any* line drawn in an electric field be divided up into small elements of length. We can take the sum of all the products of the length of each element by the resolved part of the electric force in its direction. This sum, or integral, is called the “line integral of electric force” or the *electromotive force* (E.M.F.) along this line. In some cases the value of this electromotive force between two points or conductors is independent of the precise path selected, and it is then called the *potential difference* (P.D.) of the two points or conductors. We may define the term potential difference otherwise by saying that it is the work done in carrying a small conductor charged with one unit of electricity from one point to the other in a direction opposite to that in which it would move under the electric forces if left to itself.

Electric Potential.—Suppose then that we have a conductor charged with electricity; we may imagine its surface to be divided up into small unequal areas, each of which carries a unit charge of electricity. If we consider lines of electric force to be drawn from the boundaries of these areas, they will cut up the space round the conductor into tubular surfaces called tubes of electric force, and each 242
tube will spring from an area of the conductor carrying a unit electric charge. Hence the charge on the conductor can be measured by the number of unit electric tubes springing from it. In the next place we may consider the charged body to be surrounded by a number of closed surfaces, such that the potential difference between any point on one surface and the earth is the same. These surfaces are called “equipotential” or “level surfaces,” and we may so locate them that the potential difference between two adjacent surfaces is one unit of potential; that is, it requires one absolute unit of work (1 erg) to move a small body charged with one unit of electricity from one surface to the next. These enclosing surfaces, therefore, cut up the space into shells of potential, and divide up the tubes of force into electric cells. The surface of a charged conductor is an equipotential surface, because when the electric charge is in equilibrium there is no tendency for electricity to move from one part to the other.

We arbitrarily call the potential of the earth zero, since all potential difference is relative and there is no absolute potential any more than absolute level. We call the difference of potential between a charged conductor and the earth the potential of the conductor. Hence when a body is charged positively its potential is raised above that of the earth, and when negatively it is lowered beneath that of the earth. Potential in a certain sense is to electricity as difference of level is to liquids or difference of temperature to heat. It must be noted, however, that potential is a mere mathematical concept, and has no objective existence like difference of level, nor is it capable per se of producing physical changes in bodies, such as those which are brought about by rise of temperature, apart from any question of difference of temperature. There is, however, this similarity between them. Electricity tends to flow from places of high to places of low potential, water to flow down hill, and heat to move from places of high to places of low temperature. Returning to the case of the charged body with the space around it cut up into electric cells by the tubes of force and shells of potential, it is obvious that the number of these cells is represented by the product QV, where Q is the charge and V the potential of the body in electrostatic units. An electrified conductor is a store of energy, and from the definition of potential it is clear that the work done in increasing the charge q of a conductor whose potential is v by a small amount dq, is vdq, and since this added charge increases in turn the potential, it is easy to prove that the work done in charging a conductor with Q units to a potential V units is ½QV units of work. Accordingly the number of electric cells into which the space round is cut up is equal to twice the energy stored up, or each cell contains half a unit of energy. This harmonizes with the fact that the real seat of the energy of electrification is the dielectric or insulator surrounding the charged conductor.[1]

We have next to notice three important facts in electrostatics and some consequences flowing therefrom.

(i) *Electrical Equilibrium and Potential.*—If there be any number of charged conductors in a field, the electrification on them being in equilibrium or at rest, the surface of each conductor is an equipotential surface. For since electricity tends to move between points or conductors at different potentials, if the electricity is at rest on them the potential must be everywhere the same. It follows from this that the electric force at the surface of the conductor has no component along the surface, in other words, the electric force at the bounding surface of the conductor and insulator is everywhere at right angles to it.

By the *surface density* of electrification on a conductor is meant the charge per unit of area, or the number of tubes of electric force which spring from unit area of its surface. Coulomb proved experimentally that the electric force just outside a conductor at any point is proportional to the electric density at that point. It can be shown that the resultant electric force normal to the surface at a point just outside a conductor is equal to $4\pi\sigma$, where σ is the surface density at that point. This is usually called Coulomb’s Law.[2]

(ii) *Seat of Charge.*—The charge on an electrified conductor is wholly on the surface, and there is no electric force in the interior of a closed electrified conducting surface which does not contain any other electrified bodies. Faraday proved this experimentally (see *Experimental Researches*, series xi. § 1173) by constructing a large chamber or box of paper covered with tinfoil or thin metal. This was insulated and highly electrified. In the interior no trace of electric charge could be found when tested by electroscopes or other means. Cavendish proved it by enclosing a metal sphere in two hemispheres of thin metal held on insulating supports. If the sphere is charged and then the jacketing hemispheres fitted on it and removed, the sphere is found to be perfectly discharged.[3] Numerous other demonstrations of this fact were given by Faraday. The thinnest possible spherical shell of metal, such as a sphere of insulator coated with gold-leaf, behaves as a conductor for static charge just as if it were a sphere of solid metal. The fact that there is no electric force in the interior of such a closed electrified shell is one of the most certainly ascertained facts in the science of electrostatics, and it enables us to demonstrate at once that particles of electricity attract and repel each other with a force which is inversely as the square of their distance.

We may give in the first place an elementary proof of the converse proposition by the aid of a simple lemma:—

Lemma.—If particles of matter attract one another according to the law of the inverse square the attraction of all sections of a cone for a particle at the vertex is the same. *Definition.*—The solid angle subtended by any surface at a point is measured by the quotient of its apparent surface by the square of its distance from that point. Hence the total solid angle round any point is 4π. The solid angles subtended by all normal sections of a cone at the vertex are therefore equal, and since the attractions of these sections on a particle at the vertex are proportional to their distances from the vertex, they are numerically equal to one another and to the solid angle of the cone.

Let us then suppose a spherical shell O to be electrified. Select any point P in the interior and let a line drawn through it sweep out a small double cone (see fig. 1). Each cone cuts out an area on the surface equally inclined to the cone axis. The electric density on the sphere being uniform, the quantities of electricity on these areas are proportional to the areas, and if the electric force varies inversely as the square of the distance, the forces exerted by these two surface charges at the point in question are proportional to the solid angle of the little cone. Hence the forces due to the two areas at opposite ends of the chord are equal and opposed.

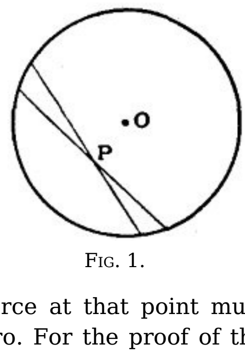


Fig. 1.

Hence we see that if the whole surface of the sphere is divided into pairs of elements by cones described through any interior point, the resultant force at that point must consist of the sum of pairs of equal and opposite forces, and is therefore zero. For the proof of the converse proposition we must refer the reader to the *Electrical Researches of the Hon. Henry*

Cavendish, p. 419, or to Maxwell's *Treatise on Electricity and Magnetism*, 2nd ed., vol. i. p. 76, where Maxwell gives an elegant proof that if the force in the interior of a closed conductor is zero, the law of the force must be that of the inverse square of the distance.[4] From this fact it follows that we can shield any conductor entirely from external influence by other charged conductors by enclosing it in a metal case. It is not even necessary that this envelope should be of solid metal; a cage made of fine metal wire gauze which permits objects in its interior to be seen will yet be a perfect electrical screen for them. Electroscopes and electrometers, therefore, standing in proximity to electrified bodies can be perfectly shielded from influence by enclosing them in cylinders of metal gauze. 243

Even if a charged and insulated conductor, such as an open canister or deep cup, is not perfectly closed, it will be found that a proof-plane consisting of a small disk of gilt paper carried at the end of a rod of gum-lac will not bring away any charge if applied to the deep inside portions. In fact it is curious to note how large an opening may be made in a vessel which yet remains for all electrical purposes "a closed conductor." Maxwell (*Elementary Treatise*, &c., p. 15) ingeniously applied this fact to the insulation of conductors. If we desire to insulate a metal ball to make it hold a charge of electricity, it is usual to do so by attaching it to a handle or stem of glass or ebonite. In this case the electric charge exists at the point where the stem is attached, and there leakage by creeping takes place. If, however, we employ a hollow sphere and let the stem pass through a hole in the side larger than itself, and attach the end to the interior of the sphere, then leakage cannot take place.

Another corollary of the fact that there is no electric force in the interior of a charged conductor is that the potential in the interior is constant and equal to that at the surface. For by the definition of potential it follows that the electric force in any direction at any point is measured by the space rate of change of potential in that direction or $E = \pm dV/dx$. Hence if the force is zero the potential V must be constant.

(iii.) *Association of Positive and Negative Electricities.*—The third leading fact in electrostatics is that positive and negative electricity are always created in equal quantities, and that for every charge, say, of positive electricity on one conductor there must exist on some other bodies an equal total charge of negative electricity. Faraday expressed this fact by saying that no absolute electric charge could be given to matter. If we consider the charge of a conductor to be measured by the number of tubes of electric force which proceed from it, then, since each tube must end on some other conductor, the above statement is equivalent to saying that the charges at each end of a tube of electric force are equal.

The facts may, however, best be understood and demonstrated by considering an experiment due to Faraday, commonly called the ice pail experiment, because he employed for it a pewter ice pail (*Exp. Res.* vol. ii. p. 279, or *Phil. Mag.* 1843, 22). On the plate of a gold-leaf electroscope place a metal canister having a loose lid. Let a metal ball be suspended by a silk thread, and the canister lid so fixed to the thread that when the lid is in place the ball hangs in the centre of the canister. Let the ball and lid be removed by the silk, and let a charge, say, of positive electricity (+Q) be given to the ball. Let the canister be touched with the finger to discharge it perfectly. Then let the ball be lowered into the canister. It will be found that as it does so the gold-leaves of the electroscope diverge, but collapse again if the ball is withdrawn. If the ball is lowered until the lid is in place, the leaves take a steady deflection. Next let the canister be touched with the finger, the leaves collapse, but diverge again when the ball is withdrawn. A test will show that in this last case the canister is left negatively electrified. If before the ball is withdrawn, after touching the outside of the canister with the finger, the ball is tilted over to make it touch the inside of the canister, then on withdrawing it the canister and ball are found to be perfectly discharged. The explanation is as follows: the charge (+Q) of positive electricity on the ball creates by induction an equal charge (−Q) on the inside of the canister when placed in it, and repels to the exterior surface of the canister an equal charge (+Q). On touching the canister this last charge goes to earth. Hence when the ball is touched against the inside of the canister before withdrawing it a second time, the fact that the system is found subsequently to be completely discharged proves that the charge − Q induced on the inside of the canister must be exactly equal to the charge +Q on the ball, and also that the inducing action of the charge +Q on the ball created equal quantities of electricity of opposite sign, one drawn to the inside and the other repelled to the outside of the canister.

Electrical Capacity.—We must next consider the quality of a conductor called its electrical capacity. The potential of a conductor has already been defined as the mechanical work which must be done to bring up a very small body charged with a unit of positive electricity from the earth's surface or other boundary taken as the place of zero potential to the surface of this conductor in question. The mathematical expression for this potential can in some cases be calculated or predetermined.

Potential of a sphere.

Thus, consider a sphere uniformly charged with Q units of positive electricity. It is a fundamental theorem in attractions that a thin spherical shell of matter which attracts according to the law of the inverse square acts on all external points as if it were concentrated at its centre. Hence a sphere having a charge Q repels a unit charge placed at a distance x from its centre with a force Q/x^2 dynes, and therefore the work W in ergs expended in bringing the unit up to that point from an infinite distance is given by the integral

$$W = \int_{\infty}^{x} Qx^{-2}dx = Q/x \quad (1).$$

Hence the potential at the surface of the sphere, and therefore the potential of the sphere, is Q/R, where R is the radius of the sphere in centimetres. The quantity of electricity which must be given to the sphere to raise it to unit potential is therefore R electrostatic units. The capacity of a conductor is defined to be the charge required to raise its potential to unity, all other charged conductors being at an infinite distance. This capacity is then a function of the geometrical dimensions of the conductor, and can be mathematically determined in certain cases. Since the potential of a small charge of electricity dQ at a distance r is equal to dQ/r, and since the potential of all parts of a conductor is the same in those cases in which the distribution of surface density of electrification is uniform or symmetrical with respect to some point or axis in the conductor, we can calculate the potential by simply summing up terms like σdS/r, where dS is an element of surface, σ the surface density of electricity on it, and r the distance from the symmetrical centre. The capacity is then obtained as the quotient of the whole charge by this potential. Thus the distribution of electricity on a sphere in free space must be uniform, and all parts of the charge are at an equal distance R from the centre. Accordingly the potential *at* the centre is Q/R. But this must be the potential *of* the sphere, since all parts are at the same potential V. Since the capacity C is the ratio of charge to potential, the capacity of the sphere in free space is Q/V = R, or is numerically the same as its radius reckoned in centimetres.

Capacity of a sphere.

We can thus easily calculate the capacity of a long thin wire like a telegraph wire far removed from the earth, as follows: Let 2r be the diameter of the wire, l its length, and σ the uniform surface electric density. Then consider a thin annulus of the wire of width dx; the charge on it is equal to 2πrσ/dx units, and the potential V at a point on the axis at a distance x from the annulus due to this elementary charge is

Capacity of a thin rod.

$$V = 2\int_0^{l/2} \frac{2\pi r\sigma}{\sqrt{(r^2 + x^2)}}\, dx = 4\pi r\sigma \left\{ \log_e(\tfrac{1}{2}l + \sqrt{r^2 + \tfrac{1}{4}l^2}) - \log_e r \right\}.$$

If, then, r is small compared with l, we have $V = 4\pi r\sigma \log_e l/r$. But the charge is $Q = 2\pi r\sigma$, and therefore the capacity of the thin wire is given by

$$C = \tfrac{1}{2} \log_e l/r \qquad (2).$$

A more difficult case is presented by the ellipsoid[5]. We have first to determine the mode in which electricity distributes itself on a conducting ellipsoid in free space. It must be such a distribution that the potential in the interior will be constant, since the electric force must be zero. It is a well-known theorem in attractions that if a shell is made of gravitative matter whose inner and outer surfaces are similar ellipsoids, it exercises no attraction on a particle of matter in its interior[6]. Consider then an ellipsoidal shell the axes of whose bounding surfaces are (a, b, c) and (a + da), (b + db), (c + dc), where da/a = db/b = dc/c = μ. The potential of such a shell at any internal point is constant, and the equipotential surfaces for external space are ellipsoids confocal with the ellipsoidal shell. Hence if we distribute electricity over an ellipsoid, so that its density is everywhere proportional to the thickness of a shell formed by describing round the ellipsoid a similar and slightly larger one, that distribution will be in equilibrium and will 244 produce a constant potential throughout the interior. Thus if σ is the surface density, δ the thickness of the shell at any point, and ρ the assumed volume density of the matter of the shell, we have σ = Aδρ. Then the quantity of electricity on any element of surface dS is A times the mass of the corresponding element of the shell; and if Q is the whole quantity of electricity on the ellipsoid, Q = A times the whole mass of the shell. This mass is equal to 4πabcρμ; therefore Q = A4πabcρμ and δ = μp, where p is the length of the perpendicular let fall from the centre of the ellipsoid on the tangent plane. Hence

Potential of an ellipsoid.

$$\sigma = Qp / 4\pi abc \qquad (3).$$

Accordingly for a given ellipsoid the surface density of free distribution of electricity on it is everywhere proportional to the length of the perpendicular let fall from the centre on the tangent plane at that point. From this we can determine the capacity of the ellipsoid as follows: Let p be the length of the perpendicular from the centre of the ellipsoid, whose equation is $x^2/a^2 + y^2/b^2 + z^2/c^2 = 1$ to the tangent plane at x, y, z. Then it can be shown that $1/p^2 = x^2/a^4 + y^2/b^4 + z^2/c^4$ (see Frost's *Solid Geometry*, p. 172). Hence the density σ is given by

Capacity of an ellipsoid.

$$\sigma = \frac{Q}{4\pi abc} \quad \frac{1}{\sqrt{(x^2/a^4 + y^2/b^4 + z^2/c^4)}}.$$

and the potential at the centre of the ellipsoid, and therefore its potential as a whole is given by the expression,

$$V = \int \frac{\sigma dS}{r} = \frac{Q}{4\pi abc} \int \frac{dS}{r\sqrt{(x^2/a^4 + y^2/b^4 + z^2/c^4)}} \qquad (4).$$

Accordingly the capacity C of the ellipsoid is given by the equation

$$\frac{1}{C} = \frac{1}{4\pi abc} \int \frac{dS}{\sqrt{(x^2 + y^2 + z^2)}\sqrt{(x^2/a^4 + y^2/b^4 + z^2/c^4)}} \qquad (5).$$

It has been shown by Professor Chrystal that the above integral may also be presented in the form,[7]

$$\frac{1}{C} = \tfrac{1}{2}\int_0^\infty \frac{d\lambda}{\sqrt{\{(a^2 + \lambda)(b^2 + \lambda)(c^2 + \lambda)\}}} \qquad (6).$$

The above expressions for the capacity of an ellipsoid of three unequal axes are in general elliptic integrals, but they can be evaluated for the reduced cases when the ellipsoid is one of revolution, and hence in the limit either takes the form of a long rod or of a circular disk.

Thus if the ellipsoid is one of revolution, and ds is an element of arc which sweeps out the element of surface dS, we have

$$dS = 2\pi y ds = 2\pi y dx \,/\, \left(\frac{dx}{ds} \right) = 2\pi y dx \,/\, \left(\frac{py}{b} \right) = \frac{2\pi b^2}{p} dx.$$

Hence, since $\sigma = Qp / 4\pi ab^2$, $\sigma dS = Qdx / 2a$.

Accordingly the distribution of electricity is such that equal parallel slices of the ellipsoid of revolution taken normal to the axis of revolution carry equal charges on their curved surface.

The capacity C of the ellipsoid of revolution is therefore given by the expression

$$\frac{1}{C} = \frac{1}{2a} \int \frac{dx}{\sqrt{(x^2 + y^2)}} \quad (7).$$

If the ellipsoid is one of revolution round the major axis a (prolate) and of eccentricity e, then the above formula reduces to

$$\frac{1}{C_1} = \frac{1}{2ae} \log_\varepsilon \left(\frac{1 + e}{1 - e} \right) \quad (8).$$

Whereas if it is an ellipsoid of revolution round the minor axis b (oblate), we have

$$\frac{1}{C^2} = \frac{\sin^{-1} ae}{ae} \quad (9).$$

In each case we have C = a when e = 0, and the ellipsoid thus becomes a sphere.

In the extreme case when e = 1, the prolate ellipsoid becomes a long thin rod, and then the capacity is given by

$$C_1 = a / \log_\varepsilon 2a/b \quad (10),$$

which is identical with the formula (2) already obtained. In the other extreme case the oblate spheroid becomes a circular disk when e = 1, and then the capacity $C_2 = 2a/\pi$. This last result shows that the capacity of a thin disk is $2/\pi = 1/1.571$ of that of a sphere of the same radius. Cavendish (*Elec. Res.* pp. 137 and 347) determined in 1773 experimentally that the capacity of a sphere was 1.541 times that of a disk of the same radius, a truly remarkable result for that date.

Three other cases of practical interest present themselves, viz. the capacity of two concentric spheres, of two coaxial cylinders and of two parallel planes.

Capacity of two concentric spheres.

Consider the case of two concentric spheres, a solid one enclosed in a hollow one. Let R_1 be the radius of the inner sphere, R_2 the inside radius of the outer sphere, and R_2 the outside radius of the outer spherical shell. Let a charge +Q be given to the inner sphere. Then this produces a charge −Q on the inside of the enclosing spherical shell, and a charge +Q on the outside of the shell. Hence the potential V at the centre of the inner sphere is given by $V = Q/R_1 - Q/R_2 + Q/R_3$. If the outer shell is connected to the earth, the charge +Q on it disappears, and we have the capacity C of the inner sphere given by

$$C = 1/R_1 - 1/R_2 = (R_2 - R_1) / R_1R_2 \quad (11).$$

Such a pair of concentric spheres constitute a condenser (see Leyden Jar), and it is obvious that by making R_2 nearly equal to R_1, we may enormously increase the capacity of the inner sphere. Hence the name *condenser*.

Capacity of two coaxial cylinders.

The other case of importance is that of two coaxial cylinders. Let a solid circular sectioned cylinder of radius R_1 be enclosed in a coaxial tube of inner radius R_2. Then when the inner cylinder is at potential V_1 and the outer one kept at potential V_2 the lines of electric force between the cylinders are radial. Hence the electric force E in the interspace varies inversely as the distance from the axis. Accordingly the potential V at any point in the interspace is given by

$$E = -dV/dR = A/R \text{ or } V = -A \int R^{-1}\, dR, \quad (12),$$

where R is the distance of the point in the interspace from the axis, and A is a constant. Hence $V_2 - V_1 = -A \log R_2/R_1$. If we consider a length l of the cylinder, the charge Q on the inner cylinder is $Q = 2\pi R_1 l\sigma$, where σ is the surface density, and by Coulomb's law $\sigma = E_1/4\pi$, where $E_1 = A/R_1$ is the force at the surface of the inner cylinder.

Accordingly $Q = 2\pi R_1 lA / 4\pi R_1 = Al/2$. If then the outer cylinder be at zero potential the potential V of the inner one is

$$V = A \log (R_2/R_1), \text{ and its capacity } C = l/2 \log R_2/R_1.$$

This formula is important in connexion with the capacity of electric cables, which consist of a cylindrical conductor (a wire) enclosed in a conducting sheath. If the dielectric or separating insulator has a constant K, then the capacity becomes K times as great.

Capacity of two parallel planes.

The capacity of two parallel planes can be calculated at once if we neglect the distribution of the lines of force near the edges of the plates, and assume that the only field is the uniform field between the plates. Let V_1 and V_2 be the potentials of the plates, and let a charge Q be given to one of them. If S is the surface of each plate, and d their distance, then the electric force E in the space between them is $E = (V_1 - V_2)/d$. But if σ is the surface density, $E = 4\pi\sigma$, and $\sigma = Q/S$. Hence we have

$$(V_1 - V_2)\, d = 4\pi Q / S \text{ or } C = Q / (V_1 - V_2) = S / 4\pi d \qquad (13).$$

"Edge effect."

In this calculation we neglect altogether the fact that electric force distributed on curved lines exists outside the interspace between the plates, and these lines in fact extend from the back of one plate to that of the other. G.R. Kirchhoff (*Gesammelte Abhandl.* p. 112) has given a full expression for the capacity C of two circular plates of thickness t and radius r placed at any distance d apart in air from which the edge effect can be calculated. Kirchhoff's expression is as follows:—

$$C = \frac{\pi r^2}{4\pi d} + \frac{r}{4\pi d}\left\{ d \log_\varepsilon \frac{16\pi r\,(d+t)}{\varepsilon d^2} + t \log_\varepsilon \frac{d+t}{t} \right\} \qquad (14).$$

In the above formula ε is the base of the Napierian logarithms. The first term on the right-hand side of the equation is the expression for the capacity, neglecting the curved edge distribution of electric force, and the other terms take into account, not only the uniform field between the plates, but also the non-uniform field round the edges and beyond the plates.

Guard plates.

In practice we can avoid the difficulty due to irregular distribution of electric force at the edges of the plate by the use of a guard plate as first suggested by Lord Kelvin.[8] If a large plate has a circular hole cut in it, and this is nearly filled up by a circular plate lying in the same plane, and if we place another large plate parallel to the first, then the electric field between this second plate and the small circular plate is nearly uniform; and if S is the area of the small plate and d its distance from the opposed plate, its capacity may be calculated by the simple formula $C = S / 4\pi d$. The outer larger plate in which the hole is cut is called the "guard plate," and must be kept at the same potential as the smaller inner or "trap-door plate." The same arrangement can be supplied to a pair of coaxial cylinders. By placing metal plates on either side of a larger sheet of dielectric or insulator we can construct a condenser of relatively large capacity. The instrument known as a Leyden jar (*q.v.*) consists of a glass bottle coated within and without for three parts of the way up with tinfoil.

Systems of condensers.

If we have a number of such condensers we can combine them in "parallel" or in "series." If all the 245
plates on one side are connected together and also those on the other, the condensers are joined in parallel. If C_1, C_2, C_3, &c., are the separate capacities, then $\Sigma(C) = C_1 + C_2 + C_3 +$ &c., is the total capacity in parallel. If the condensers are so joined that the inner coating of one is connected to the outer coating of the next, they are said to be in series. Since then they are all charged with the same quantity of electricity, and the total over all potential difference V is the sum of each of the individual potential differences V_1, V_2, V_3, &c., we have

$$Q = C_1V_1 = C_2V_2 = C_3V_3 = \text{\&c., and } V = V_1 + V_2 + V_3 + \text{\&c.}$$

The resultant capacity is $C = Q/V$, and

$$C = 1 / (1/C_1 + 1/C_2 + 1/C_3 + \text{\&c.}) = 1 / \Sigma(1/C) \qquad (15).$$

These rules provide means for calculating the resultant capacity when any number of condensers are joined up in any way.

If one condenser is charged, and then joined in parallel with another uncharged condenser, the charge is divided between them in the ratio of their capacities. For if C_1 and C_2 are the capacities and Q_1 and Q_2 are the charges after contact, then Q_1/C_1 and Q_2/C_2 are the potential differences of the coatings and must be equal. Hence $Q_1/C_1 = Q_2/C_2$ or $Q_1/Q_2 = C_1/C_2$. It is worth noting that if we have a charged sphere we can perfectly discharge it by introducing it into the interior of another hollow insulated conductor and making contact. The small sphere then becomes part of the interior of the other and loses all charge.

Measurement of Capacity.—Numerous methods have been devised for the measurement of the electrical capacity of conductors in those cases in which it cannot be determined by calculation. Such a measurement may be an *absolute* determination or a *relative* one. The dimensions of a capacity in electrostatic measure is a length (see Units, Physical). Thus the capacity of a sphere in electrostatic units (E.S.U.) is the same as the number denoting its radius in centimetres. The unit of electrostatic capacity is therefore that of a sphere of 1 cm. radius.[9] This unit is too small for practical purposes, and hence a unit of capacity 900,000 greater, called a microfarad, is generally employed. Thus for instance the capacity in free space of a sphere 2 metres in diameter would be 100/900,000 = 1/9000 of a microfarad. The electrical capacity of the whole earth considered as a sphere is about 800 microfarads. An absolute measurement of capacity means, therefore, a determination in E.S. units made directly without reference to any other condenser. On the other hand there are numerous methods by which the capacities of condensers may be compared and a relative measurement made in terms of some standard.

One well-known comparison method is that of C.V. de Sauty. The two condensers to be compared are connected in the branches of a Wheatstone's Bridge (*q.v.*) and the other two arms completed with variable resistance boxes. These arms are then altered until on raising or depressing the battery key there is no sudden deflection either way of the galvanometer. If R_1 and R_2 are the arms' resistances and C_1 and C_2 the condenser capacities, then when the bridge is balanced we have $R_1 : R_2 = C_1 : C_2$.

Relative determinations.

Another comparison method much used in submarine cable work is the method of mixtures, originally due to Lord Kelvin and usually called Thomson and Gott's method. It depends on the principle that if two condensers of capacity C_1 and C_2 are respectively charged to potentials V_1 and V_2, and then joined in parallel with terminals of opposite charge together, the resulting potential difference of the two condensers will be V, such that

$$V = \frac{(C_1V_1 - C_2V_2)}{(C + C)} \qquad (16);$$

and hence if V is zero we have $C_1 : C_2 = V_2 : V_1$.

The method is carried out by charging the two condensers to be compared at the two sections of a high resistance joining the ends of a battery which is divided into two parts by a movable contact.[10] This contact is shifted until such a point is found by trial that the two condensers charged at the different sections and then joined as above described and tested on a galvanometer show no charge. Various special keys have been invented for performing the electrical operations expeditiously.

A simple method for condenser comparison is to charge the two condensers to the same voltage by a battery and then discharge them successively through a ballistic galvanometer (*q.v.*) and observe the respective "throws" or deflections of the coil or needle. These are proportional to the capacities. For the various precautions necessary in conducting the above tests special treatises on electrical testing must be consulted.

In the absolute determination of capacity we have to measure the ratio of the charge of a condenser to its plate potential difference. One of the best methods for doing this is to charge the condenser by the known voltage of a battery, and then discharge it through a galvanometer and repeat this process rapidly and successively. If a condenser of capacity C is charged to potential V, and discharged n times per second through a galvanometer, this series of intermittent discharges is equivalent to a current nCV. Hence if the galvanometer is calibrated by a potentiometer (*q.v.*) we can determine the value of this current in amperes, and knowing the value of n and V thus determine C. Various forms of commutator have been devised for effecting this charge and discharge rapidly by J.J. Thomson, R.T. Glazebrook, J.A. Fleming and W.C. Clinton and others.[11] One form consists of a tuning-fork electrically maintained in vibration of known period, which closes an electric contact at every vibration and sets another electromagnet in operation, which reverses a switch and moves over one terminal of the condenser from a battery to a galvanometer contact. In another form, a revolving contact is used driven by an electric motor, which consists of an insulating disk having on its surface slips of metal and three wire brushes a, b, c (see fig. 2) pressing against them. The metal slips are so placed that, as the disk revolves, the middle brush, connected to one terminal of the condenser C, is alternately put in conductive connexion with first one and then the other outside brush, which are joined respectively to the battery B and galvanometer G terminals. From the speed of this motor the number of commutations per second can be determined. The above method is especially useful for the determinations of very small capacities of the order of 100 electrostatic units or so and upwards.

Absolute determinations.

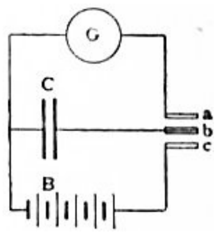


FIG. 2.

Dielectric constant.—Since all electric charge consists in a state of strain or polarization of the dielectric, it is evident that the physical state and chemical composition of the insulator must be of great importance in determining electrical phenomena. Cavendish and subsequently Faraday discovered this fact, and the latter gave the name "specific inductive capacity," or "dielectric constant," to that quality of an insulator which determines the charge taken by a conductor embedded in it when charged to a given potential. The simplest method of determining it numerically is, therefore, that adopted by Faraday.[12] He constructed two equal condensers, each consisting of a metal ball enclosed in a hollow metal sphere, and he provided also certain hemispherical shells of shellac, sulphur, glass, resin, &c., which he could so place in one condenser between the ball and enclosing sphere that it formed a condenser with solid dielectric. He then determined the ratio of the capacities of the two condensers, one with air and the other with the solid dielectric. This gave the dielectric constant K of the material. Taking the dielectric constant of air as unity he obtained the following values, for shellac K = 2.0, glass K = 1.76, and sulphur K = 2.24.

TABLE I.—*Dielectric Constants* (K) *of Solids* (K *for Air* = 1).

Substance.	K.	Authority.
Glass, double extra dense flint, density 4.5	9.896	J. Hopkinson
Glass, light flint, density 3.2	6.72	”
Glass, hard crown, density 2.485	6.61	”

Sulphur	2.24	M. Faraday
	2.88	Coullner
	3.84	L. Boltzmann
	4.0	P.J. Curie
	2.94	P.R. Blondlot
Ebonite	2.05	Rosetti
	3.15	Boltzmann
	2.21	Schiller
	2.86	Elsas
India-rubber, pure brown	2.12	Schiller
India-rubber, vulcanized, grey	2.69	”
Gutta-percha	2.462	J.E. H. Gordon
Paraffin	1.977	Gibson and Barclay
	2.32	Boltzmann
	2.29	J. Hopkinson
	1.99	Gordon
Shellac	2.95	Wällner
	2.74	Gordon
	3.04	A.A. Winkelmann
Mica	6.64	I. Klemenčič
	8.00	P.J. Curie
	7.98	E.M.L. Bouty
	5.97	Elsas
Quartz—		
along optic axis	4.55	P.J. Curie
perp. to optic axis	4.49	P.J. Curie
Ice at −23°	78.0	Bouty

Since Faraday’s time, by improved methods, but depending essentially upon the same principles, an 246
enormous number of determinations of the dielectric constants of various insulators, solid, liquid and gaseous, have been made (see tables I., II., III. and IV.). There are very considerable differences between the values assigned by different observers, sometimes no doubt due to differences in method, but in most cases unquestionably depending on variations in the quality of the specimens examined. The value of the dielectric constant is greatly affected by the temperature and the frequency of the applied electric force.

Table II.—*Dielectric Constant* (K) *of Liquids.*

Liquid.	K.	Authority.
Water at 17° C.	80.88	F. Heerwagen
” ” 25° C.	75.7	E.B. Rosa
” ” 25.3° C.	78.87	Franke
Olive oil	3.16	Hopkinson
Castor oil	4.78	”
Turpentine	2.15	P.A. Silow
”	2.23	Hopkinson
Petroleum	2.072	Silow
”	2.07	Hopkinson
Ethyl alcohol at 25° C.	25.7	Rosa
Ethyl ether	4.57	Doule
” ”	4.8	Bouty
Acetic acid	9.7	Franke

Table III.—*Dielectric Constant of some Bodies at a very low Temperature* (−185° C.) (*Fleming and Dewar*).

Substance.	K at 15° C.	K at −185°C.
Water	80	2.4 to 2.9
Formic acid	62	2.41
Glycerine	56	3.2
Methyl alcohol	34	3.13
Nitrobenzene	32	2.6
Ethyl alcohol	25	3.1
Acetone	21.85	2.62
Ethyl nitrate	17.7	2.73
Amyl alcohol	16	2.14
Aniline	7.5	2.92
Castor oil	4.78	2.19
Ethyl ether	4.25	2.31

The above determinations at low temperature were made with either a steady or a slowly alternating electric force applied a hundred times a second. They show that the dielectric constant of a liquid generally undergoes great reduction in value when the liquid is frozen and reduced to a low temperature.[13]

The dielectric constants of gases have been determined by L. Boltzmann and I. Klemenčič as follows:—

Table IV.—*Dielectric Constants* (K) *of Gases at* 15° *C. and* 760 *mm. Vacuum* = 1.

Gas.	Dielectric Constant K.	$\sqrt{K}$.	Optical Refractive Index. μ.
Air	1.000590	1.000295	1.000293
Hydrogen	1.000264	1.000132	1.000139
Carbon dioxide	1.000946	1.000475	1.000454
Carbon monoxide	1.000690	1.000345	1.000335
Nitrous oxide	1.000994	1.000497	1.000516
Ethylene	1.001312	1.000656	1.000720
Marsh gas (methane)	1.000944	1.000478	1.000442
Carbon bisulphide	1.002900	1.001450	1.001478
Sulphur dioxide	1.00954	1.004770	1.000703
Ether	1.00744	1.003720	1.00154
Ethyl chloride	1.01552	1.007760	1.001174
Ethyl bromide	1.01546	1.007730	1.00122

In general the dielectric constant is reduced with decrease of temperature towards a certain limiting value it would attain at the absolute zero. This variation, however, is not always linear. In some cases there is a very sudden drop at or below a certain temperature to a much lower value, and above and below the point the temperature variation is small. There is also a large difference in most cases between the value for a steadily applied electric force and a rapidly reversed or intermittent force—in the last case a decrease with increase of frequency. Maxwell (*Elec. and Magn.* vol. ii. § 788) showed that the square root of the dielectric constant should be the same number as the refractive index for waves of the same frequency (see Electric Waves). There are very few substances, however, for which the optical refractive index has the same value as K for steady or slowly varying electric force, on account of the great variation of the value of K with frequency.

There is a close analogy between the variation of dielectric constant of an insulator with electric force frequency and that of the rigidity or stiffness of an elastic body with the frequency of applied mechanical stress. Thus pitch is a soft and yielding body under steady stress, but a bar of pitch if struck gives a musical note, which shows that it vibrates and is therefore stiff or elastic for high frequency stress.

Residual Charges in Dielectrics.—In close connexion with this lies the phenomenon of residual charge in dielectrics.[14] If a glass Leyden jar is charged and then discharged and allowed to stand awhile, a second discharge can be obtained from it, and in like manner a third, and so on. The reappearance of the residual charge is promoted by tapping the glass. It has been shown that this behaviour of dielectrics can be imitated by a mechanical model consisting of a series of perforated pistons placed in a tube of oil with spiral springs between each piston.[15] If the pistons are depressed and then released, and then the upper piston fixed awhile, a second discharge can be obtained from it, and the mechanical stress-strain diagram of the model is closely similar to the discharge curve of a dielectric. R.H.A. Kohlrausch called attention to the close analogy between residual charge and the elastic recovery of strained bodies such as twisted wire or glass threads. If a charged condenser is suddenly discharged and then insulated, the reappearance of a potential difference between its coatings is analogous to the reappearance of a torque in the case of a glass fibre which has been twisted, released suddenly, and then gripped again at the ends.

For further information on the qualities of dielectrics the reader is referred to the following sources:—J. Hopkinson, “On the Residual Charge of the Leyden Jar,” *Phil. Trans.*, 1876, 166 [ii.], p. 489, where it is shown that tapping the glass of a Leyden jar permits the reappearance of the residual charge; “On the Residual Charge of the Leyden Jar,” *ib.* 167 [ii.], p. 599, containing many valuable observations on 247 the residual charge of Leyden jars; W.E. Ayrton and J. Perry, “A Preliminary Account of the Reduction of Observations on Strained Material, Leyden Jars and Voltameters,” *Proc. Roy. Soc.*, 1880, 30, p. 411, showing experiments on residual charge of condensers and a comparison between the behaviour of dielectrics and glass fibres under torsion. In connexion with this paper the reader may also be referred to one by L. Boltzmann, “Zur Theorie der elastischen Nachwirkung,” *Wien. Acad. Sitz.-Ber.*, 1874, 70.

Distribution of Electricity on Conductors.—We now proceed to consider in more detail the laws which govern the distribution of electricity at rest upon conductors. It has been shown above that the potential due to a charge of *q* units placed on a very small sphere, commonly called a point-charge, at any distance x is q/x. The mathematical importance of this function called the potential is that it is a scalar quantity, and the potential at any point due to any number of point charges q_1, q_2, q_3, &c.,

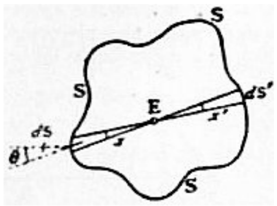
distributed in any manner, is the sum of them separately, or

$$q_1/x_1 + q_2/x_2 + q_3/x_3 + \&c. = \Sigma\,(q/x) = V \qquad (17),$$

where x_1, x_2, x_3, &c., are the distances of the respective point charges from the point in question at which the total potential is required. The resultant electric force E at that point is then obtained by differentiating V, since $E = -dV / dx$, and E is in the direction in which V diminishes fastest. In any case, therefore, in which we can sum up the elementary potentials at any point we can calculate the resultant electric force at the same point.

We may describe, through all the points in an electric field which have the same potential, surfaces called equipotential surfaces, and these will be everywhere perpendicular or orthogonal to the lines of electric force. Let us assume the field divided up into tubes of electric force as already explained, and these cut normally by equipotential surfaces. We can then establish some important properties of these tubes and surfaces. At each point in the field the electric force can have but one resultant value. Hence the equipotential surfaces cannot cut each other. Let us suppose any other surface described in the electric field so as to cut the closely compacted tubes. At each point on this surface the resultant force has a certain value, and a certain direction inclined at an angle θ to the normal to the selected surface at that point. Let dS be an element of the surface. Then the quantity $E \cos \theta dS$ is the product of the normal component of the force and an element of the surface, and if this is summed up all over the surface we have the total electric flux or induction through the surface, or the surface integral of the normal force mathematically expressed by $\int E \cos \theta dS$, provided that the dielectric constant of the medium is unity.

We have then a very important theorem as follows:—If any closed surface be described in an electric field which wholly encloses or wholly excludes electrified bodies, then the total flux through this surface is equal to 4π- times the total quantity of electricity within it.[16] This is commonly called Stokes's theorem. The proof is as follows:—Consider any point-charge E of electricity included in any surface S, S, S (see fig. 3), and describe through it as centre a cone of small solid angle dω cutting out of the enclosing surface in two small areas dS and dS′ at distances x and x′. Then the electric force due to the point charge q at distance x is q/x, and the resolved part normal to the element of surface dS is $q \cos\theta / x^2$. The normal section of the cone at that point is equal to $dS \cos\theta$, and the solid angle dω is equal to $dS \cos\theta / x^2$. Hence the flux through dS is qdω. Accordingly, since the total solid angle round a point is 4π, it follows that the total flux through the closed surface due to the single point charge q is 4πq, and what is true for one point charge is true for any collection forming a total charge Q of any form. Hence the total electric flux due to a charge Q through an enclosing surface is 4πQ, and therefore is zero through one enclosing no electricity.



Stokes's theorem becomes an obvious truism if applied to an incompressible fluid. Let a *source* of fluid be a point from which an incompressible fluid is emitted in all directions. Close to the source the stream lines will be radial lines. Let a very small sphere be described round the source, and let the strength of the source be defined as the total flow per second through the surface of this small sphere. Then if we have any number of sources enclosed by any surface, the total flow per second through this surface is equal to the total strengths of all the sources. If, however, we defined the strength of the source by the statement that the strength divided by the square of the distance gives the velocity of the liquid at that point, then the total flux through any enclosing surface would be 4π times the strengths of all the sources enclosed. To every proposition in electrostatics there is thus a corresponding one in the hydrokinetic theory of incompressible liquids.

Let us apply the above theorem to the case of a small parallel-epipedon or rectangular prism having sides dx, dy, dz respectively, its centre having co-ordinates (x, y, z). Its angular points have then co-ordinates ($x \pm \frac{1}{2}dx$, $y \pm \frac{1}{2}dy$, $z \pm \frac{1}{2}dz$). Let this rectangular prism be supposed to be wholly filled up with electricity of density ρ; then the total quantity in it is ρ dx dy dz. Consider the two faces perpendicular to the x-axis. Let V be the potential at the centre of the prism, then the normal forces on the two faces of area dy·dx are respectively

$$-\left(\frac{dV}{dx} + \frac{1}{2}\frac{d^2V}{dx^2}dx\right) \text{ and } \left(\frac{dV}{dx} - \frac{1}{2}\frac{d^2V}{dx^2}dx\right),$$

and similar expressions for the normal forces to the other pairs of faces dx·dy, dz·dx. Hence, multiplying these normal forces by the areas of the corresponding faces, we have the total flux parallel to the x-axis given by $-(d^2V / dx^2)\,dx\,dy\,dz$, and similar expressions for the other sides. Hence the total flux is

$$-\left(\frac{d^2V}{dx^2} + \frac{d^2V}{dy^2} + \frac{d^2V}{dz^2}\right) dx\,dy\,dz,$$

and by the previous theorem this must be equal to 4πρdx dy dz.

Hence

$$\frac{d^2V}{dx^2} + \frac{d^2V}{dy^2} + \frac{d^2V}{dz^2} + 4\pi\rho = 0 \qquad (18).$$

This celebrated equation was first given by S.D. Poisson, although previously demonstrated by Laplace for the case when ρ = 0. It defines the condition which must be fulfilled by the potential at any and every point in an electric field, through which ρ is finite and the electric force continuous. It may be looked upon as an equation to determine ρ when V is given or vice versa. An exactly similar expression holds good in hydrokinetics, provided that for the electric potential we substitute velocity potential, and for the electric force the velocity of the liquid.

The Poisson equation cannot, however, be applied in the above form to a region which is partly within and partly without an electrified conductor, because then the electric force undergoes a sudden change in value from zero to a finite value, in passing outwards through the bounding surface of the conductor. We can, however, obtain another equation called the “surface characteristic equation” as follows:—Suppose a very small area dS described on a conductor having a surface density of electrification σ. Then let a small, very short cylinder be described of which dS is a section, and the generating lines are normal to the surface. Let V_1 and V_2 be the potentials at points just outside and inside the surface dS, and let n_1 and n_2 be the normals to the surface dS drawn outwards and inwards; then $-dV_1 / dn_1$ and $-dV_2 / dn_2$ are the normal components of the force over the ends of the imaginary small cylinder. But the force perpendicular to the curved surface of this cylinder is everywhere zero. Hence the total flux through the surface considered is $-\{(dV_1 / dn_1) + (dV_2 / dn_2)\}$ dS, and this by a previous theorem must be equal to 4πσdS, or the total included electric quantity. Hence we have the surface characteristic equation,[17]

$$(dV_1 / dn_1) + (dV_2 / dn_2) + 4\pi\sigma = 0 \qquad (19).$$

Let us apply these theorems to a portion of a tube of electric force. Let the part selected not include any charged surface. Then since the generating lines of the tube are lines of force, the component of the electric force perpendicular to the curved surface of the tube is everywhere zero. But the electric force is normal to the ends of the tube. Hence if dS and dS′ are the areas of the ends, and +E and -E′ the oppositely directed electric forces at the ends of the tube, the surface integral of normal force on the flux over the tube is

$$EdS - E'dS' \qquad (20),$$

and this by the theorem already given is equal to zero, since the tube includes no electricity. Hence the characteristic quality of a tube of electric force is that its section is everywhere inversely as the electric force at that point. A tube so chosen that EdS for one section has a value unity, is called a unit tube, since the product of force and section is then everywhere unity for the same tube.

In the next place apply the surface characteristic equation to any point on a charged conductor at which the surface density is σ. The electric force outward from that point is −dV/dn, where dn is a distance measured along the outwardly drawn normal, and the force within the surface is zero. Hence we have

$$-dV/dn = 4.0\pi\sigma \text{ or } \sigma = -(1/4\pi)\, dV/dn = E/4\pi.$$

The above is a statement of Coulomb’s law, that *the electric force at the surface of a conductor is proportional to the surface density of the charge at that point and equal to 4π times the density*.[18]

If we define the positive direction along a tube of electric force as the direction in which a small body charged with positive electricity would tend to move, we can summarize the above facts in a 248
simple form by saying that, *if we have any closed surface described in any manner in an electric field, the excess of the number of unit tubes which leave the surface over those which enter it is equal to 4π-times the algebraic sum of all the electricity included within the surface*.

Every tube of electric force must therefore begin and end on electrified surfaces of opposite sign, and the quantities of positive and negative electricity on its two ends are equal, since the force E just outside an electrified surface is normal to it and equal to σ/4π, where σ is the surface density; and since we have just proved that for the ends of a tube of force EdS = E′dS′, it follows that σdS = σ′dS′, or Q = Q′, where Q and Q′ are the quantities of electricity on the ends of the tube of force. Accordingly, since every tube sent out from a charged conductor must end somewhere on another charge of opposite sign, it follows that the two electricities always exist in equal quantity, and that it is impossible to create any quantity of one kind without creating an equal quantity of the opposite sign.

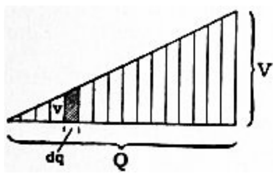


Fig. 4.

We have next to consider the energy storage which takes place when electric charge is created, *i.e.* when the dielectric is strained or polarized. Since the potential of a conductor is defined to be the work required to move a unit of positive electricity from the surface of the earth or from an infinite distance from all electricity to the surface of the conductor, it follows that the work done in putting a small charge dq into a conductor at a potential v is v dq. Let us then suppose that a conductor originally at zero potential has its potential raised by administering to it small successive doses of electricity dq. The first raises its potential to v, the second to v′ and so on, and the nth to V. Take any horizontal line and divide it into small elements of length each representing dq, and draw vertical lines representing the potentials v, v′, &c., and after each dose. Since the potential rises proportionately to the quantity in the conductor, the ends of these ordinates will lie on a straight line and define a triangle whose base line is a length equal to the total quantity Q and height a length equal to the final potential V. The element of work done in introducing the quantity of electricity dq at a potential v is represented by the element of area of this triangle (see fig. 4), and hence the work done in charging the conductor with quantity Q to final potential V is ½QV, or since Q = CV, where C is its capacity, the work done is represented by $\frac{1}{2}CV^2$ or by $\frac{1}{2}Q^2 / C$.

If σ is the surface density and dS an element of surface, then $\int \sigma dS$ is the whole charge, and hence $\frac{1}{2}\int V\sigma dS$ is the expression for the energy of charge of a conductor.

We can deduce a remarkable expression for the energy stored up in an electric field containing electrified bodies as follows:[19] Let V denote the potential at any point in the field. Consider the integral

$$W = \frac{1}{8\pi} \int\int\int \left\{ \left(\frac{dV}{dx}\right)^2 + \left(\frac{dV}{dy}\right)^2 + \left(\frac{dV}{dz}\right)^2 \right\} dx\, dy\, dz. \qquad (21)$$

where the integration extends throughout the whole space unoccupied by conductors. We have by partial integration

$$\int\int\int \left(\frac{dV}{dx}\right)^2 dx\, dy\, dz = \int\int V \frac{dV}{dx} dy\, dz - \int\int\int V \frac{d^2V}{dx^2} dx\, dy\, dz,$$

and two similar equations in y and z. Hence

$$\frac{1}{8\pi} \int\int\int \left\{ \left(\frac{dV}{dx}\right)^2 + \left(\frac{dV}{dy}\right)^2 + \left(\frac{dV}{dz}\right)^2 \right\} dx\, dy\, dz = \frac{1}{8\pi} \int\int V \frac{dV}{dn} dS - \frac{1}{8\pi} \int\int\int V\nabla V\, dx\, dy\, dz \qquad (22)$$

where dV/dn means differentiation along the normal, and ∇ stands for the operator $d^2/dx^2 + d^2/dy^2 + d^2/dz^2$. Let E be the resultant electric force at any point in the field. Then bearing in mind that $\sigma = (1/4\pi)\, dV/dn$, and $\rho = -(1/4\pi)\, \nabla V$, we have finally

$$\frac{1}{8\pi} \int\int\int E^2 dv = \frac{1}{2} \int\int V\sigma\, dS + \frac{1}{2} \int\int\int V\rho\, dv.$$

The first term on the right hand side expresses the energy of the surface electrification of the conductors in the field, and the second the energy of volume density (if any). Accordingly the term on the left hand side gives us the whole energy in the field.

Suppose that the dielectric has a constant K, then we must multiply both sides by K and the expression for the energy per unit of volume of the field is equivalent to ½DE where D is the displacement or polarization in the dielectric.

Furthermore it can be shown by the application of the calculus of variations that the condition for a minimum value of the function W, is that $\nabla V = 0$. Hence that distribution of potential which is necessary to satisfy Laplace’s equation is also one which makes the potential energy a minimum and therefore the energy stable. Thus the actual distribution of electricity on the conductor in the field is not merely *a* stable distribution, it is *the only* possible stable distribution.

Method of Electrical Images.—A very powerful method of attacking problems in electrical distribution was first made known by Lord Kelvin in 1845 and is described as the method of electrical images.[20] By older mathematical methods it had only been possible to predict in a few simple cases the distribution of electricity at rest on conductors of various forms. The notion of an electrical image may be easily grasped by the following illustration: Let there be at A (see fig. 5) a point-charge of positive electricity +q and an infinite conducting plate PO, shown in section, connected to earth and therefore at zero potential. Then the charge at A together with the induced surface charge on the plate makes a certain field of electric force on the left of the plate PO, which is a zero equipotential surface. If we remove the plate, and yet by any means can keep the identical surface occupied by it a plane of zero potential, the boundary conditions will remain the same, and therefore the field of force to the left of PO will remain unaltered. This can be done by placing at B an equal negative point-charge −q in the place which would be occupied by the optical image of A if PO were a mirror, that is, let −q be placed at B, so that the distance BO is equal to the distance AO, whilst AOB is at right angles to PO. Then the potential at any point P in this ideal plane PO is equal to $q/AP - q/BP = O$, whilst the resultant force at P due to the two point charges is $2qAO/AP^3$, and is parallel to AB or normal to PO. Hence if we remove the charge −q at B and distribute electricity over the surface PO with a surface density σ, according to the Coulomb-Poisson law, $\sigma = qAO / 2\pi AP^3$, the field of force to the left of PD will fulfil the required boundary conditions, and hence will be the law of distribution of the induced electricity in the case of the actual plate. The point-charge −q at B is called the “electrical image” of the point-charge +q at A.

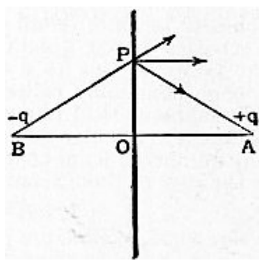


Fig. 5.

We find a precisely analogous effect in optics which justifies the term “electrical image.” Suppose a room lit by a single candle. There is everywhere a certain illumination due to it. Place across the room a plane mirror. All the space behind the mirror will become dark, and all the space in front of the mirror will acquire an exalted illumination. Whatever this increased illumination may be, it can be precisely imitated by removing the mirror and placing a second lighted candle at the place occupied by the optical image of the first candle in the mirror, that is, as far behind the plane as the first candle was in front. So the potential distribution in the space due to the electric point-charge +q as A together with −q at B is the same as that due to +q at A and the negative induced charge erected on the infinite plane (earthed) metal sheet placed half-way between A and B.

The same reasoning can be applied to determine the electrical image of a point-charge of positive electricity in a spherical surface, and therefore the distribution of induced electricity over a metal sphere connected to earth produced by a point-charge near it. Let +q be any positive point-charge placed at a point A outside a sphere (fig. 6) of radius r, and centre at C, and let P be any point on it. Let CA = d. Take a point B in CA such that CB·CA = r^2, or CB = r^2/d. It is easy then to show that PA : PB = d : r. If then we put a negative point-charge −qr/d at B, it follows that the spherical surface will be a zero potential surface, for

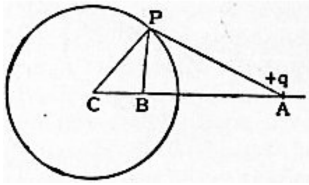


FIG. 6.

$$\frac{q}{PA} - \frac{rq}{d} \cdot \frac{1}{PB} = 0 \qquad (24).$$

Another equipotential surface is evidently a very small sphere described round A. The resultant force due to these two point-charges must then be in the direction CP, and its value E is the vector sum of the two forces along AP and BP due to the two point-charges. It is not difficult to show that

$$E = -(d^2 - r^2)\, q / rAP^3 \qquad (25),$$

in other words, the force at P is inversely as the cube of the distance from A. Suppose then we remove the negative point-charge, and let the sphere be supposed to become conductive and be connected to earth. If we make a distribution of negative electricity over it, which has a density σ varying according to the law

$$\sigma = -(d^2 - r^2)\, q / 4\pi rAP^3 \qquad (26),$$

that distribution, together with the point-charge +q at A, will make a distribution of electric force at all points outside the sphere exactly similar to that which would exist if the sphere were removed and 249 a negative point charge −qr/d were placed at B. Hence this charge is the electrical image of the charge +q at A in the spherical surface.

We may generalize these statements in the following theorem, which is an important deduction from a wider theorem due to G. Green. Suppose that we have any distribution of electricity at rest over conductors, and that we know the potential at all points and consequently the level or equipotential surfaces. Take any equipotential surface enclosing the whole of the electricity, and suppose this to become an actual sheet of metal connected to the earth. It is then a zero potential surface, and every point outside is at zero potential as far as concerns the electric charge on the conductors inside. Then if U is the potential outside the surface due to this electric charge inside alone, and V that due to the opposite charge it induces on the inside of the metal surface, we must have U + V = 0 or U = −V at all points outside the earthed metal surface. Therefore, whatever may be the distribution of electric force produced by the charges inside taken alone, it can be exactly imitated for all space outside the metal surface if we suppose the inside charge removed and a distribution of electricity of the same sign made over the metal surface such that its density follows the law

$$\sigma = -(\tfrac{1}{4}\pi)\, dU / dn \qquad (27),$$

where dU/dn is the electric force at that point on the closed equipotential surface considered, due to the original charge alone.

BIBLIOGRAPHY.—For further developments of the subject we must refer the reader to the numerous excellent treatises on electrostatics now available. The student will find it to be a great advantage to read through Faraday’s three volumes entitled *Experimental Researches on Electricity*, as soon as he has mastered some modern elementary book giving in compact form a general account of electrical phenomena. For this purpose he may select from the following books: J. Clerk Maxwell, *Elementary Treatise on Electricity* (Oxford, 1881); J.J. Thomson, *Elements of the Mathematical Theory of Electricity and Magnetism* (Cambridge, 1895); J.D. Everett, *Electricity*, founded on part iii. of Deschanel’s *Natural Philosophy* (London, 1901); G.C. Foster and A.W. Porter, *Elementary Treatise on Electricity and Magnetism* (London, 1903); S.P. Thompson, *Elementary Lessons on Electricity and Magnetism* (London, 1903)·

When these elementary books have been digested, the advanced student may proceed to study the following: J. Clerk Maxwell, *A Treatise on Electricity and Magnetism* (1st ed., Oxford, 1873; 2nd ed. by W.D. Niven, 1881; 3rd ed. by J.J. Thomson, 1892); Joubert and Mascart, *Electricity and Magnetism*, English translation by E. Atkinson (London, 1883); Watson and Burbury, *The Mathematical Theory of Electricity and Magnetism* (Oxford, 1885); A. Gray, *A Treatise on Magnetism and Electricity* (London, 1898). In the collected *Scientific Papers* of Lord Kelvin (3 vols., Cambridge, 1882), of James Clerk Maxwell (2 vols., Cambridge, 1890), and of Lord Rayleigh (4 vols., Cambridge, 1903), the advanced student will find the means for studying the historical development of electrical knowledge as it has been evolved from the minds of some of the master workers of the 19th century.

(J. A. F.)

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1 See Maxwell, *Elementary Treatise on Electricity* (Oxford, 1881), p. 47.

2 See Maxwell, *Treatise on Electricity and Magnetism* (3rd ed., Oxford, 1892), vol. i. p. 80.

3 Maxwell, Ibid. vol. i. § 74a; also *Electrical Researches of the Hon. Henry Cavendish*, edited by J. Clerk Maxwell (Cambridge, 1879), p. 104.

4 Laplace (*Mec. Cel.* vol. i. ch. ii.) gave the first direct demonstration that no function of the distance except the inverse square can satisfy the condition that a uniform spherical shell exerts no force on a particle within

it.

5 The solution of the problem of determining the distribution on an ellipsoid of a fluid the particles of which repel each other with a force inversely as the nth power of the distance was first given by George Green (see Ferrer's edition of Green's *Collected Papers*, p. 119, 1871).

6 See Thomson and Tait, *Treatise on Natural Philosophy*, § 519.

7 See article "Electricity," *Encyclopaedia Britannica* (9th edition), vol. viii. p. 30. The reader is also referred to an article by Lord Kelvin (*Reprint of Papers on Electrostatics and Magnetism*, p. 178), entitled "Determination of the Distribution of Electricity on a Circular Segment of a Plane, or Spherical Conducting Surface under any given Influence," where another equivalent expression is given for the capacity of an ellipsoid.

8 See Maxwell, *Electricity and Magnetism*, vol. i. pp. 284-305 (3rd ed., 1892).

9 It is an interesting fact that Cavendish measured capacity in "globular inches," using as his unit the capacity of a metal ball, 1 in. in diameter. Hence multiplication of his values for capacities by 2.54 reduces them to E.S. units in the C.G.S. system. See *Elec. Res.* p. 347.

10 For fuller details of these methods of comparison of capacities see J.A. Fleming, *A Handbook for the Electrical Laboratory and Testing Room*, vol. ii. ch. ii. (London, 1903).

11 See Fleming, *Handbook for the Electrical Laboratory*, vol. ii. p. 130.

12 Faraday, *Experimental Researches on Electricity*, vol. i. § 1252. For a very complete set of tables of dielectric constants of solids, liquids and gases see A. Winkelmann, *Handbuch der Physik*, vol. iv. pp. 98-148 (Breslau, 1905); also see Landolt and Börnstein's *Tables of Physical Constants* (Berlin, 1894).

13 See the following papers by J.A. Fleming and James Dewar on dielectric constants at low temperatures: "On the Dielectric Constant of Liquid Oxygen and Liquid Air," *Proc. Roy. Soc.*, 1897, 60, p. 360; "Note on the Dielectric Constant of Ice and Alcohol at very low Temperatures," *ib.*, 1897, 61, p. 2; "On the Dielectric Constants of Pure Ice, Glycerine, Nitrobenzol and Ethylene Dibromide at and above the Temperature of Liquid Air," id. *ib.* p. 316; "On the Dielectric Constant of Certain Frozen Electrolytes at and above the Temperature of Liquid Air," id. *ib.* p. 299—this paper describes the cone condenser and methods used; "Further Observations on the Dielectric Constants of Frozen Electrolytes at and above the Temperature of Liquid Air," id. *ib.* p. 381; "The Dielectric Constants of Certain Organic Bodies at and below the Temperature of Liquid Air," id. *ib.* p. 358; "On the Dielectric Constants of Metallic Oxides dissolved or suspended in Ice cooled to the Temperature of Liquid Air," id. *ib.* p. 368.

14 See Faraday, *Experimental Researches*, vol. i. § 1245; R.H.A. Kohlrausch, *Pogg. Ann.*, 1854, 91; see also Maxwell, *Electricity and Magnetism*, vol. i. § 327, who shows that a composite or stratified dielectric composed of layers of materials of different dielectric constants and resistivities would exhibit the property of residual charge.

15 Fleming and Ashton, "On a Model which imitates the behaviour of Dielectrics." *Phil. Mag.*, 1901 [6], 2, p. 228.

16 The beginner is often puzzled by the constant appearance of the factor 4π in electrical theorems. It arises from the manner in which the unit quantity of electricity is defined. The electric force due to a point-charge q at a distance r is defined to be q/r^2, and the total flux or induction through the sphere of radius r is therefore $4\pi q$. If, however, the unit point charge were defined to be that which produces a unit of electric flux through a circumscribing spherical surface or the electric force at distance r defined to be $1/4\pi r^2$, many theorems would be enunciated in simpler forms.

17 See Maxwell, *Electricity and Magnetism*, vol. i. § 78b (2nd ed.).

18 Id. *ib.* vol. i. § 80. Coulomb proved the proportionality of electric surface force to density, but the above numerical relation $E = 4\pi\sigma$ was first established by Poisson.

19 See Maxwell, *Electricity and Magnetism*, vol. i. § 99a (3rd ed., 1892), where the expression in question is deduced as a corollary of Green's theorem.

20 See Lord Kelvin's *Papers on Electrostatics and Magnetism*, p. 144.

ELECTROTHERAPEUTICS, a general term for the use of electricity in therapeutics, *i.e.* in the alleviation and cure of disease. Before the different forms of medical treatment are dealt with, a few points in connexion with the machines and currents, of special interest to the medical reader, must first be given.

Faradism.—For the battery required either for faradism or galvanism, cells of the Leclanché type are the most satisfactory. Being dry they can be carried in any position, are lighter, and there is no trouble from the erosion of wires and binding screws, such as so often results from wet cells. The best method of producing a smooth current in the secondary coil is for the interruptor hammer to vibrate directly against the iron core of the primary coil. For this it is best that the interruptor be made of a piece of steel spring, as a high rate of interruption can then be maintained, with a fairly smooth current in the secondary coil. This form of interruptor necessitates that the iron core be fixed, and variation in the primary induced current is arranged for by slipping a brass tube more or less over the iron core, thus cutting off the magnetic field from the primary coil. The secondary current (that obtained from the secondary coil) can be varied by keeping the secondary coil permanently fixed over the primary and varying the strength of the primary current. Where, as suggested above, the iron core is fixed, the primary and secondary induced currents will be at their strongest when the brass tube is completely withdrawn. As there is no simple means of measuring the strength of the faradic current, it is best to start with a very weak current, testing it on the muscles of one’s own hand until these begin to contract and a definite sensory effect is produced; the current can then be applied to the part, being strengthened only very gradually.

Galvanism.—For treatment by galvanism a large battery is needed, the simplest form being known as a “patient’s battery,” consisting of a variable number of dry cells arranged in series. The cells used are those of Leclanché, with E.M.F. (or voltage) of 1.5 and an internal resistance of .3 ohm. Thus the exact strength of the current is known; the number of cells usually employed is 24, and when new give an E.M.F. of about 36 volts. By using the formula C = E/R, where E is the voltage of the battery, R the total resistance of battery, electrodes and the patient’s skin and tissues, and C the current in amperes, the number of cells required for any particular current can be worked out. The resistance of the patient’s skin must be made as low as possible by thoroughly wetting both skin and electrodes with sodium bicarbonate solution, and keeping the electrodes in very close apposition to the skin. A galvanometer is always fitted to the battery, usually of the d’Arsonval type, with a shunt by means of which, on turning a screw, nine-tenths of the inducing current can be short-circuited away, and the solenoid only influenced by one-tenth of the current which is being used on the patient. In districts where electric power is available the continuous current can be used by means of a switchboard. A current of much value for electrotherapeutic purposes is the sinusoidal current, by which is meant an alternating current whose curve of electromotive force, in both positive and negative phase, varies constantly and smoothly in what is known as the sine curve. In those districts supplied by an alternating current, the sinusoidal current can be obtained from the mains by passing it through various transformers, but where the main supply is the direct or constant current, a motor transformer is needed.

Static Electricity.—For treatment by static electricity the Wimshurst type of machine is the one most generally used. A number of electrodes are required; thus for the application of sparks a brass ball and brass roller electrode, for the “breeze” a single point and a multiple point electrode, and another multiple point electrode in the form of a metal cap that can be placed over the patient’s head. The polarity of the machine must always be tested, as either knob may become positive or negative, though the polarity rarely changes when once the machine is in action. The oldest method of subjecting a patient to electric influence is that in which static electricity is employed. The patient is insulated on a suitable platform and treated by means of charges and discharges from an electrical machine. The effect is to increase the regularity and frequency of the pulse, raise the blood pressure and increase the action of the skin. The nervous system is quieted, sleep being promoted, the patient often becoming drowsy during the application. If while the patient is being treated a point electrode is brought towards him he feels the sensation of a wind blowing from that point; this is an electric breeze or brush discharge. The breeze is negative if the patient is positively charged and vice versa. The “breeze discharge” treatment is especially valuable in subduing pain of the superficial cutaneous nerves, and also in the treatment of chronic indolent ulcers. Quite recently this form of treatment has been applied with much success to various skin lesions—psoriasis, eczema and pruritus. Static electricity is also utilized for medical purposes by means of “sparks,” which are administered with a ball electrode, the result being a sudden muscular contraction at the point of application. The electrode must be rapidly withdrawn before a second spark has time to leap across, as this is a severe form of treatment and must be administered slowly. It is mainly employed for muscular stimulation, and the contractions resulting from spark stimulation can be produced in cases of nerve injury and degeneration, even when the muscles have lost their reaction to faradism. The sensory stimulation of this form of treatment is also strong, and is useful in hysterical anaesthesia and functional paralysis. Where a milder sensory stimulation is required friction can be used, the electrode being in the form of a metal roller which is moved rapidly outside the patient’s clothing over the spine or other part to be treated. The clothing must be dry and of wool, and each additional woollen layer intensifies the effect.

Another method of employing electricity at high potential is by the employment of high frequency currents. There are two methods of application: that in which brush discharges are made use of, with undoubtedly good effects in many of the diseases affecting the surface of the body, and that in which the currents of the solenoid are made to traverse the patient directly. The physiological value of the latter method is not certain, though one point of interest in connexion with it is that whereas statical applications raise the blood pressure, high frequency applications lower it. It has been used in the case of old people with arterio-sclerosis, and the reduction of blood pressure produced is said to have shown considerable permanence.

The Faradic Current.—G.B. Duchenne was the first physician to make use of the induced current for treatment, and the term “faradization” is supposed to be due to him. But in his day the differences between the two currents available, the primary and the secondary, were not worked out, and they were used somewhat indiscriminately. Nowadays it is generally accepted that the primary current should be used for the stimulation of deep-lying organs, as stomach and intestines, &c., while the secondary current is employed for stimulation of the limb muscles and the cutaneous sensory nerves. The faradic current is also used as a means of diagnosis for neuro-muscular conditions. When the interrupted current is used to stimulate the skin over a motor nerve, all the muscles supplied by that nerve are thrown into rapid tetanic contraction, the contraction both beginning and ceasing sharply and suddenly with the current. This is the normal reaction of the nerve to faradism. If the muscle be wasted from disuse or some local cause unconnected with its nerve-supply, the contraction is smaller, and both arises and relaxes more slowly. But if the lesion lies in the nerve itself, as in Bell's palsy, the muscles no longer show any response when the nerve is stimulated, and this is known as the reaction of degeneration in the nerve. It is usually preceded by a condition of hyperexcitability. These results are applied to distinguish between functional paralysis and that due to some organic lesion, as in the former case the reaction of faradism will be as brisk as usual. Also at the beginning of most cases of infantile paralysis many more groups of muscles appear to be affected than ultimately prove to be, and faradism enables the physician to distinguish between those groups of muscles that are permanently paralysed owing to the destruction of their trophic centre, and those muscles which are only temporarily inhibited from shock, and which with proper treatment will later regain their full power. In the testing of muscles electrically that point on the skin which on stimulation gives the maximum contraction for that muscle is known as the "motor point" for that muscle. It usually corresponds to the entry of the motor nerve. Faradic treatment may be employed in the weakness and emaciation depending on any long illness, rickets, anaemia, &c. For these cases it is best to use the electric bath, the patient being placed in warm water, and the two electrodes, one at the patient's back and the other at his feet, being connected with the secondary coil. The patient's general metabolism is stimulated, he eats and sleeps better and soon begins to put on weight. This is especially beneficial in severe cases of rickets. In the weakness and emaciation due to neurasthenia, especially in those cases being treated by the Weir Mitchell method (isolation, absolute confinement to bed, massage and overfeeding), a similar faradic bath is a very helpful adjunct. In tabes dorsalis faradic treatment will often diminish the anaesthesia and numbness in the legs, with resulting benefit to the ataxy. Perhaps the most beneficial use of the faradic current is in the treatment of chronic constipation—especially that so frequently met with in young women and due to deficient muscular power of the intestinal walls. In long-standing cases the large intestine becomes permanently dilated, and its muscular fibres so attenuated as to have no power over the intestinal contents. But faradism causes contraction at the point of stimulation, and the peristaltic wave thus started slowly progresses along the bowel. All that is needed is a special electrode for introduction into the bowel and an ordinary roller electrode. The rectal electrode consists of a 6-inch wire bearing at one end a small metal knob and fitted at the other into a metal cup which screws into the handle of the electrode. The only part exposed is the metallic knob; the rest is coated with some insulating material. The patient reclines on a couch on his back, the rectal electrode is connected, and having been vaselined is passed some three inches into the rectum. A current is started with the secondary coil in such a position as to give only an extremely weak current. The roller electrode is then wetted with hot water and applied to the front of the abdomen. At first the patient should feel nothing, but the current should slowly be increased until a faint response is perceptible from the abdominal muscles. This gives the required strength, and the roller electrode, pressed well into the abdominal wall, should very slowly be moved along the course of the large intestine beginning at the right iliac fossa. Thus a combination of massage and faradic current is obtained, and the results are particularly satisfactory. Treatment should be given on alternate days immediately after breakfast, and should be persevered with for six or eight weeks. The patient can be taught to administer it to himself.

The Galvanic, Continuous or Direct Current.—In using the galvanic or direct current the electrode must be covered with padded webbing or some other absorbent material, the metal of the electrode never being allowed to come in contact with the skin. The padding by retaining moisture helps to make good contact, and also helps to guard against burning the skin. But when a continuous current of 3 am. or more is passed for more than 5 min. the electrodes must be raised periodically and the skin inspected. If the current be too strong or applied for too long a time, small blisters are raised which break and are very troublesome to heal. Nor does the patient always feel much pain when this occurs. Also the electrodes must be remoistened every five or six minutes, as they soon become dry, and the skin will then be burnt. It is best to use a solution of sodium bicarbonate. Again, the danger of burning the skin depends on the density of the current per sq. in. of electrode, so that a strong current through a small electrode will burn the skin, whereas the same current through a larger electrode will produce a beneficial effect. If the patient be immersed up to his neck in an electric bath, much stronger currents can be passed without causing either pain or injury, as in this case the whole area of the skin in contact with the water acts as an electrode. In passing the current it must be remembered that the negative electrode or kathode is the more painful of the two, and its action more stimulating than the positive electrode or anode, which is sedative. If a muscle be stimulated over its motor point, it will contract with a sharp twitch and then become quiescent. With normal muscle the KCC (kathodal closure contraction) is stronger than that produced by the closure of the current at the anode ACC (anodal closure contraction). And if the muscle be normal the opening contraction KOC and AOC are not seen. When a galvanic current is passed along a nerve its excitability is increased at the kathode and diminished at the anode. The increased excitability at the kathode is katelectrotonus, and the lowered excitability at the anode anelectrotonus. But since in a patient the electrode cannot be applied directly to the nerve, the lines of force from the electrode pass into the nerve both in an upward and downward direction, and hence there are two poles produced by each electrode. If the current be suddenly reversed, so that what was the anode becomes the kathode, a stronger contraction is obtained than by simply making and breaking the current. To avoid the four poles on the nerve to be tested, it is found most satisfactory to have one electrode placed at some distance, on the back or chest, not on the same limb.

As explained above, when the nerve supplying a muscle is diseased it no longer responds to the faradic current. On further testing this with the galvanic or continuous current it responds, but the contraction is not brisk but begins slowly and relaxes slowly, though the contraction as a whole may be larger than that of a normal muscle. This excessive contraction is known as hyperexcitability to galvanism. This form of contraction is that obtained when the muscle fibre itself is stimulated. Again, whereas in normal muscle KCC > ACC, when the nerve is degenerated KCC = ACC or ACC > KCC. Also in the more severe forms of nerve injury tetanic contractions may be set up in the paralysed muscles, by closure of the current either at the anode or kathode. These charges are known as the reaction of degeneration or RD, and are of great value in diagnosis. They occur only after sudden or acute damage to the nerve cells of the anterior horn of the spinal cord, or to the motor nerve fibres proceeding from these cells. Thus RD is present in infantile paralysis, acute neuritis, &c., but absent in progressive muscular atrophy where the wasting of nerve and muscle takes place extremely slowly. The reaction of degeneration in the nerve is shown by disappearance of reaction to either kind of current, preceded for some days by hyperexcitability to either current. Where the muscle wasting is due to a lesion in the muscle alone, as in ischaemic myositis (usually due to injury from tight bandaging or badly applied splints), no reaction of degeneration is found; the only change is a loss of power in the contraction. If the damage to the anterior horn cells be only very slight, there may only be partial RD, and the prognosis is given according to the extent of RD. From this account it is clear that the greatest value of the continuous current lies in its use in diagnosis. But it is also applied extremely successfully, in combination with massage, to cases of infantile paralysis. Wrist drop from lead poisoning and lead neuritis of all kinds, reflex muscular atrophy and the muscular wasting of hemiplegia, are all benefited by the continuous current; the severe pain of sciatica, and the inflammation of the nerve sheath in these cases, can be arrested more quickly by galvanic treatment than in any other way. Nearly all forms of neuritis, both of the cranial and other nerves, are best treated by the continuous current. The action in all cases is to stimulate the natural tendency to repair, very largely by improving the circulation through the injured parts.

Another effect of an electric current is electrolysis, and the phenomena of electrolytic conduction involve not merely the ionization of the compounds, but also the setting in motion of the ions towards their respective poles. Solutions which conduct electric currents are called electrolytes, and in the case of the human body the electrolyte is the whole mass of the saline constituents in solution throughout the body. When a current is passed through an electrolyte, dissociation into ions takes place, the ions which are freed round the anode being called anions and those which are freed round the kathode being called kations. The anions carry negative charges and are consequently attracted by the positive electricity of the anode. The kations carry positive charges, hence they are repelled by the anode and attracted by the kathode. But a certain number of molecules do not dissociate, and hence in an electrolytic solution there are neutral molecules, anions and kations. The chemical actions, and thus the antiseptic, remedial or toxic effects of electrolytes, are due to the actions of their ions. The phosphides and phosphates may be taken as examples. Some are extremely toxic, while others are quite harmless. But it is to the phosphorus ion that the toxic or therapeutic effect is due. In the phosphates the phosphorus is part of a complex ion possessing quite different properties to those of the phosphorus ion of the phosphides. The strikingly different effects of the sulphates and sulphides are due to similar conditions, as also of many other compounds. There are certain solvents, as alcohol, chloroform, glycerin and vaseline which do not dissociate electrolytes, and consequently the latter become inert when mixed with these solvents. These solutions do not conduct electricity, and hence ionic effects are extremely slow. A vaseline ointment containing 5% of phenol makes a good dressing for an ulcer of the leg, and produces no irritant effect, but a 5% aqueous solution may be both caustic and toxic. Since the toxic or therapeutic action of a solution is due to its ions, the action must be proportional to the number of ions in a given volume, that is, the action of an electrolyte depends on the degree of dissociation. Thus a strong acid is one that is much dissociated, a weak acid one that has undergone but little dissociation and so on. In 1896-1897 it was shown that the bactericidal action of salts varies with their degree of dissociation and therefore depends on the concentration of the active ions. In the medical application of these facts it must be remembered that when an ion is introduced into the body by electrolysis, it is probably forced into the actual cellular constituents of the body, whereas the drug administered by one of the usual methods though circulating in the blood may perhaps never gain access to the cell itself. Hence the different effects that have been recorded between a drug administered by the mouth or subcutaneously and the same administered by electrolysis. Thus a solution of cocaine injected subcutaneously produces quite different effects to that introduced by electrolysis. By the latter method it produces anaesthesia but does not diffuse, and the anaesthesia remains strictly limited to the surface covered by the electrode. It would appear that the ion is never introduced into the general circulation but into the cell plasma.

In the technical working of medical electrolysis the most minute precautions are required. The solution of the drug must be made with as pure water as possible, recently distilled. The spongy substance forming the electrode must be free from any trace of electrolytic substances. Hence all materials used must be washed in distilled water. Absorbent cotton answers all requirements and is easily procured. The area of introduction can be exactly circumscribed by cutting a hole in a sheet of adhesive plaster which is applied to the skin and on which the electrolytic electrodes are pressed. The great advantage of electrolytic methods is that it enables general treatment to be replaced by a strictly local treatment, and the cells can be saturated exactly to the degree and depth required. Strong antiseptics and materials that coagulate albumen cannot be introduced locally by ordinary methods, as the skin is impermeable to them, but by electrolysis they can be introduced to the exact depth required. The local effects of the ions depend on the dosage; thus a feeble dose of the ions of zinc stimulates the growth of hair, but a stronger dose produces the death of the tissue. Naturally the different ions produce different effects. Thus the ions of the alkalis and magnesium are caustic, those of the alkaline earthy metals produce actual mortification of the tissue and so on. According to the ion chosen the effect may be caustic in various degrees, antiseptic, coagulating, producing vascular or nervous changes, &c., &c. And again electrolysis can also be used for extracting from the body such ions as are injurious, as uric and oxalic acid from a patient suffering from gout.

One of the latest advances is the treatment of ankylosed joints by the electrolytic method, the electrolyte used being chloride of sodium, and the marvellous results being attributed to the introduction of the chlorine ions. This sclerolytic property of the current is applicable to all parts of the body accessible to the current. Old cases of rheumatic scleritis, entirely unaffected by the routine treatment of salicylates and iodide, have often cleared up entirely under electrolytic treatment. Cases of chronic iritis with adhesions and old pleural adhesions are also suited for this method of procedure. Certain menstrual troubles of women and also endometritis yield rapidly to electrolysis with a zinc anode. Before this method of introduction, the zinc salts, though excellent disinfectants, acted only on the surface in consequence of their coagulating action on the albuminoids, but by the electric current, under the influence of a difference of potential, the zinc iron will penetrate to any desired depth. Cases of rodent ulcer unaffected by all other methods of treatment have been cured by electric kataphoresis with zinc ions, and the method is now being applied to the treatment of inoperable malignant tumours. As very strong currents are required for this latter, the patient has first to be anaesthetized by a general anaesthetic. Another direction in which electric ions are being used is that of the induction of local anaesthesia before minor surgical operations. Cocaine is the drug used, the resulting anaesthesia is absolute, and the operation can be made almost bloodless by the admixture of suprarenal extract.

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ELECTROTYPING, an application of the art of electroplating (*q.v.*) to typography (*q.v.*). In copying engraved plates for printing purposes, copper may be deposited upon the original plate, the surface of which is first rendered slightly dirty, by means of a weak solution of wax in turpentine or otherwise, to prevent adhesion. The reversed plate thus produced is then stripped from the first and used as cathode in its turn, with the result that even the finest lines of the original are faithfully reproduced. The electrolyte commonly contains about 1½ ℔ of copper sulphate and ½ ℔ of strong sulphuric acid per gallon, and is worked with a current density of about 10 amperes per sq. ft., which should give a thickness of 0.000563 in. of copper per hour. As time is an object, the conditions alluded to in the article on Copper as being favourable to the use of high current densities should be studied, bearing in mind that a tough copper deposit of high quality is essential. Moulds for reproducing plates or art-work are often taken in plaster, beeswax mixed with Venice turpentine, fusible metal, or gutta-percha, and the surface being rendered conductive by powdered black-lead, copper is deposited upon it evenly throughout. For statuary, and "undercut" work generally, an elastic mould—of glue and treacle (80 : 20 parts)—may be used; the mould, when set, is waterproofed by immersion in a solution of potassium bichromate followed by exposure to sunlight, or in some other way. The best results, however, are obtained by taking a wax cast from the elastic mould, and then from this a plaster mould, which may be waterproofed with wax, black-leaded, and used as cathode. In art-work of this nature the principal points to be looked to in depositing are the electrical connexions to the cathode, the shape of the anode (to secure uniformity of deposition), the circulation of the electrolyte, and, in some cases, the means for escape of anode oxygen. Silver electrotyping is occasionally resorted to for special purposes.

ELECTRUM, ELECTRON (Gr. ἤλεκτρον, amber), an alloy of gold and silver in use among the ancients, described by Pliny as containing one part of silver to four of gold. The term is also applied in mineralogy to native argentiferous gold containing from 20 to 50% of silver. In both cases the name is derived from the pale yellow colour of electrum, resembling that of amber.

ELEGIT (Lat. for "he has chosen"), in English law, a judicial writ of execution, given by the Statute of Westminster II. (1285), and so called from the words of the writ, that the plaintiff has chosen (*elegit*) this mode of satisfaction. Previously to the Statute of Westminster II., a judgment creditor could only have the profits of lands of a debtor in satisfaction of his judgment, but not the possession of the lands themselves. But this statute provided that henceforth it should be *in the election* of the party having recovered judgment to have a writ of *fieri facias* (*q.v.*) unto the sheriff on lands and goods or else all the chattels of the debtor and the one half of his lands until the judgment be satisfied. Since the Bankruptcy Act 1883 the writ of *elegit* has extended to lands and hereditaments only. (See further Execution.)

ELEGY, a short poem of lamentation or regret, called forth by the decease of a beloved or revered person, or by a general sense of the pathos of mortality. The Greek word ἐλεγεία is of doubtful signification; it is usually interpreted as meaning a mournful or funeral song. But there seems to be no proof that this idea of regret for death entered into the original meaning of ἐλεγεία. The earliest Greek elegies which have come down to us are not funereal, although it is possible that the primitive ἐλεγεία may have been a set of words liturgically used, with music, at a burial. When the elegy appears in surviving Greek literature, we find it dedicated, not to death, but to war and love. Callinus of Ephesus, who flourished in the 7th century, is the earliest elegist of whom we possess fragments. A little later Tyrtaeus was composing his famous elegies in Sparta. Both of these writers were, so far as we know, exclusively warlike and patriotic. On the other hand, the passion of love inspires Mimnermus, whose elegies are the prototypes not only of the later Greek pieces, and of the Latin poems of the school of Tibullus and Propertius, but of a great deal of the formal erotic poetry of modern Europe. In the 6th century B.C., the elegies of Solon were admired; they are mainly lost. But we possess more of the work of Theognis of Megara than of any other archaic elegist, and in it we can observe the characteristics of Greek elegy best. Here the Dorian spirit of chivalry reaches its highest expression, and war is combined with manly love.

The elegy, in its calm movement, seems to have begun to lose currency when the ecstasy of emotion was more successfully interpreted by the various rhythmic and dithyrambic inventions of the Aeolic lyrists. The elegy, however, rose again to the highest level of merit in Alexandrian times. It was reintroduced by Philetas in the 3rd cent. B.C., and was carried to extreme perfection by Callimachus. Other later Greek elegists of high reputation were Asclepiades and Euphorion. But it is curious to notice that all the elegies of these poets were of an amatory nature, and that antiquity styled the funeral dirges of Theocritus, Bion and Moschus—which are to us the types of elegy—not elegies at all, but idylls. When the poets of Rome began their imitative study of Alexandrian models, it was natural that the elegies of writers such as Callimachus should tempt them to immediate imitation. Gallus, whose works are unhappily lost, is known to have produced a great sensation in Rome by publishing his translation of the poems of Euphorion; and he passed on to the composition of erotic elegies of his own, which were the earliest in the Latin language. If we possessed his once-famous *Cytheris*, we should be able to decide the question of how much Propertius, who is now the leading figure among Roman elegists, owed to the example of Gallus. His brilliantly emotional *Cynthia*, with its rich and unexampled employment of that alternation of hexameter and pentameter which had now come to be known as the elegiac measure, seems, however, to have settled the type of Latin elegy. Tibullus is always named in conjunction with Propertius, who was his contemporary, although in their style they were violently contrasted. The sweetness of Tibullus was the object of admiration and constant imitation by the Latin poets of the Renaissance, although Propertius has more austerely pleased a later taste. Finally, Ovid wrote elegies of great variety in subject, but all in the same form, and his dexterous easy metre closed the tradition of elegiac poetry among the ancients. What remains in the decline of Latin literature is all founded on a study of those masters of the Golden Age.

When the Renaissance found its way to England, the word “elegy” was introduced by readers of Ovid and Propertius. But from the beginning of the 16th century, it was used in English, as it has been ever since, to describe a funeral song or lament. One of the earliest poems in English which bears the title of elegy is *The Complaint of Philomene*, which George Gascoigne began in 1562, and printed in 1576. The *Daphnaida* of Spenser (1591) is an elegy in the strict modern sense, namely a poem of regret pronounced at the obsequies of a particular person. In 1579 Puttenham had defined an elegy as being a song “of long lamentation.” With the opening of the 17th century the composition of elegies became universal on every occasion of public or private grief. Dr Johnson’s definition, “*Elegy*, a short poem without points or turns,” is singularly inept and careless. By that time (1755) English literature had produced many great elegies, of which the *Lycidas* of Milton is by far the most illustrious. But even Cowley’s on Crashaw, Tickell’s on Addison, Pope’s on an Unfortunate Lady, those of Quarles, and Dryden, and Donne, should have warned Johnson of his mistake. Since the 18th century the most illustrious examples of elegy in English literature have been the *Adonais* of Shelley (on Keats), the *Thyrsis* of Matthew Arnold (on Clough), and the *Ave atque Vale* of Mr Swinburne (on Baudelaire). It remains for us to mention what is the most celebrated elegy in English, that written by Gray in a Country Churchyard. This, however, belongs to a class apart, as it is not addressed to the memory of any particular person. A writer of small merit, James Hammond (1716-1742), enjoyed a certain success with his *Love Elegies* in which he endeavoured to introduce the erotic elegy as it was written by Ovid and Tibullus. This experiment took no hold of English literature, but was welcomed in France in the amatory works of Parny (1753-1814), in those of Chênedollé (1769-1833), and of Millevoye (1782-1816). The melancholy and sentimental elegies of the last named are the typical examples of this class of poetry in French literature. Lamartine must be included among the elegists, and his famous “Le Lac” is as eminent an elegy in French as Gray’s “Country Churchyard” is in English. The elegy has flourished in Portugal, partly because it was cultivated with great success by Camoens, the most illustrious of the Portuguese poets. In Italian, Chiabrera and Filicaia are named among the leading national elegists. In German literature, the notion of elegy as a poem of lamentation does not exist. The famous Roman Elegies of Goethe imitate in form and theme those of Ovid; they are not even plaintive in character.

Elegiac Verse has commonly been adopted by German poets for their elegies, but by English poets never. Schiller defines this kind of verse, which consists of a distich of which the first line is a hexameter and the second a pentameter, in the following pretty illustration:—

“In the hexameter rises the fountain’s silvery column.
In the pentameter aye falling in melody back.”

The word “elegy,” in English, is one which is frequently used very incorrectly; it should be remembered that it must be mournful, meditative and short without being ejaculatory. Thus Tennyson’s *In Memoriam* is excluded by its length; it may at best be treated as a collection of elegies. Wordsworth’s *Lucy*, on the other hand, is a dirge; this is too brief a burst of emotion to be styled an elegy. *Lycidas* and *Adonais* remain the two unapproachable types of what a personal elegy ought to be in English.

(E. G.)

ELEMENT (Lat. *elementum*), an ultimate component of anything, hence a fundamental principle. *Elementum* was used in Latin to translate the Greek στοιχεῖον (that which stands in a στοῖχος, or row), and is a word of obscure origin and etymology. The root of Lat. *alere*, to nourish, has been suggested, thus making it a doublet of *alimentum*, that which supports life; another explanation is that the word represents LMN., the first three letters of the second part of the alphabet, a parallel use to that of ABC. Apart from its application in chemistry, which is treated below, the word is used of the rudiments or *principia* of any science or subject, as in Euclid’s *Elements of Geometry*, or in the “beggarly elements” (τὰπτωχὰ στοιχεῖα, of St Paul in Gal. iv. 9); in mathematics, of a fundamental concept involved in an investigation, as the “elements” of a determinant; and in electricity, of a galvanic (or voltaic) “element” in an electric cell (see Battery: *Electric*). In astronomy, “element” is used of any one of the numerical or geometrical data by which the course of a varying phenomenon is computed; it is applied especially to orbital motion and eclipses. The “elements of an orbit” are the six data by which the position of a moving body in its orbit at any time may be determined. The “elements of an eclipse” express and determine the motion of the centre of the shadow-axis, and are the data necessary to compute the phenomena of an eclipse during its whole course, as seen at any place. In architecture the term “element” is applied to the outline of the design of a Decorated window, on which the centres for the tracery are found. These centres will all be found to fall on points which, in some way or other, will be equimultiples of parts of the openings.

Chemical Elements.

Ancient ideas.

Like all other scientific concepts, that of an element has changed its meaning many times in many ways during the development of science. Owing to their very small amount of real chemical knowledge, the generalizations of the ancients were necessarily rather superficial, and could not stand in the face of the increasing development of practical chemistry. Nevertheless we find the concept of an element as “a substance from which all bodies are made or derived” held at the very beginning of occidental philosophy. Thales regarded “water” as the element of all things; his followers accepted his idea of a primordial substance as the basis of all bodies, but they endeavoured to determine some other general element or elements, like “fire” or “spirit,” or “love” and “hatred,” or “fire,” “water,” “air” and “earth.” We find in this development an exact parallelism to the manner in which scientific ideas generally arise, develop and change. They are created to point out the common part in a variety of observed phenomena, in order to get some leading light in the chaos of events. At first almost any idea will do, if only it promises some comprehensive arrangement of the facts; afterwards, the inconsistencies of the first trial make themselves felt; the first idea is then changed to meet better the new requirements. For a shorter or longer time the facts and ideas may remain in accord, but the uninterrupted increase of empirical knowledge involves sooner or later new fundamental alterations of the general idea, and in this way there is a never-ceasing process of adaptation of the ideas to the facts. As facts are unchangeable by themselves, the adaptation can be only one-sided; the ideas are compelled to change according to the facts. We must therefore educate ourselves to regard the ideas or theories as the changing part of science, and keep ourselves ready to accept even the most fundamental revision of current theories.

The first step in the development of the idea of elements was to recognize that a *single* principle would not prove sufficient to cover the manifoldness of facts. Empedocles therefore conceived a double or binary elementary principle; and Aristotle developed this idea a stage further, stating two sets of binary antagonistic principles, namely “dry-wet” and “hot-cold.” The Aristotelian or peripatetic elements, which played such a great rôle in the whole medieval philosophy, are the representatives of the several binary combinations of these fundamental properties, “fire” being hot and dry, “air” hot and wet, “water” cold and wet, “earth” cold and dry. According to the amount of these properties found in any body, these elements were regarded as having taken part in forming this body. Concerning the reason why only these properties were regarded as fundamental, we know nothing. They seem to be taken at random rather than carefully selected; they relate only to the sense of touch, and not to vision or any other sense, possibly because deceptions in the sense of touch were regarded as non-existent, while the other senses were apparently not so trustworthy. At any rate, the Aristotelian elements soon proved to be rather inadequate to meet the requirements of the increasing chemical knowledge; other properties had therefore to be selected to represent the general behaviour of chemical substances, and in this case we find them already much more “chemical” in the modern sense.

Elements of the alchemists.

Among the various substances recognized by the chemists, certain classes or groups readily distinguished themselves. First the metals, by their lustre, their heaviness, and a number of other common properties. According to the general principle of selecting a single substance as a representative of the group, the metallic properties were represented by “mercury.” The theoreticians of the middle ages were rather careful to point out that common mercury (the liquid metal of to-day) was not at all to be identified with “philosophical” mercury, the last being simply the *principle* of metallic behaviour. In the same way combustibility was represented by “sulphur,” solubility by “salt,” and occasionally the chemically indifferent or refractory character by “earth.” According to the subsistence and preponderance of these properties in different bodies, these were regarded as containing the corresponding elements; conversely, just as experience teaches the chemist every day that by proper treatment the properties of given bodies may be changed in the most various ways, the observed changes of properties were ascribed to the gain or loss of the corresponding elements. According to this theory, which accounted rather well for a large number of facts, there was no fundamental objection against trying to endow base metals with the properties of the precious ones; to make artificial gold was a task quite similar to the modern problem of, *e.g.* making artificial quinine. The realization that there is a certain natural law preventing such changes is of much later date. It is therefore quite unjust to consider the work of the alchemists, who tried to make artificial gold, as 254 consummate nonsense. *A priori* there was no reason why a change from lead to gold should be less possible than a change from iron to rust; indeed there is no *a priori* reason against it now. But experience has taught us that lead and gold are chemical elements in the modern sense, and that there is a general experimental law that elements are not transformable one into another. So experience taught the alchemists irresistibly that in spite of the manifoldness of chemical changes it is not always possible to change any given substance into another; the possibilities are much more limited, and there is only a certain range of substances to be obtained from a given one. The impossibility of transforming lead or copper into noble metals proved to be only one case out of many, and it was recognized generally that there are certain chemical families whose members are related to one another by their mutual transformability, while it is impossible to bridge the boundaries separating these families.

Work of Robert Boyle.

The man who brought all these experiences and considerations into scientific form was Robert Boyle. He stated as a general principle, that only tangible and ponderable substances should be recognized as elements, an element being a substance from which other substances may be made, but which cannot be separated into different substances. He showed that neither the peripatetic nor the alchemistic elements satisfied this definition. But he was more of a critical than of a synthetical turn of mind; although he established the correct principles, he hesitated to point out what substances, among those known at his time, were to be considered as elements. He only paved the way to the goal by laying the foundations of analytical chemistry, *i.e.* by teaching how to characterize and to distinguish different chemical individuals. Further, by adopting and developing the corpuscular hypothesis of the constitution of the ponderable substances, he foreshadowed, in a way, the law of the conservation of the elements, viz. that no element can be changed into another element; and he considered the compound substances to be made up from small particles or corpuscles of their elements, the latter retaining their essence in all combinations. This hypothesis accounts for the fact that only a limited number of other substances can be made from a given one—namely, only those which contain the elements present in the given substance. But it is characteristic of Boyle’s critical mind that he did not shut his eyes against a serious objection to his hypothesis. If the compound substance is made up of parts of the elements, one would expect that the properties of the compound substance would prove to be the sum of the properties of the elements. But this is not the case, and chemical compounds show properties which generally differ very considerably from those of the compounds. On the one hand, the corpuscular hypothesis of Boyle was developed into the atomic hypothesis of Dalton, which was considered at the beginning of the 19th century as the very best representation of chemical facts, while, on the other hand, the difficulty as to the properties of the compounds remained the same as Boyle found it, and has not yet been removed by an appropriate development of the atomic hypothesis. Thus Boyle considered, *e.g.* the metals as elements. However, it is interesting to note that he considered the mutual transformation of the metals as not altogether impossible, and he even tells of a case when gold was transformed into base metal. It is a common psychological fact that a reformer does not generally succeed in being wholly consistent in his reforming ideas; there remains invariably some point where he commits exactly the same fault which he set out to abolish. We shall find the same inconsistency also among other chemical reformers. Even earlier than Boyle, Joachim Jung (1587-1657) of Hamburg developed similar ideas. But as he did not distinguish himself, as Boyle did, by experimental work in science, his views exerted only a limited influence amongst his pupils.

Phlogiston theory.

In the times following Boyle’s work we find no remarkable outside development of the theory of elements, but a very important inside one. Analytical chemistry, or the art of distinguishing different chemical substances, was rapidly developing, and the necessary foundation for such a theory was thus laid. We find the discussions about the true elements disappearing from the text-books, or removed to an insignificant corner, while the description of observed chemical changes of different ways of preparing the same substance, as identified by the same properties, and of the methods for recognizing and distinguishing the various substances, take their place. The similarity of certain groups of chemical changes, as, for example, combustion, and the inverse process, reduction, was observed, and thus led to an attempt to shape these most general facts into a common theory. In this way the theory of “phlogiston” was developed by G.E. Stahl, phlogiston being (according to the usual way of regarding general properties as being due to a principle or element) the “principle of combustibility,” similar to the “sulphur” of the alchemists. This again must be regarded as quite a legitimate step justified by the knowledge of the time. For experience taught that combustibility could be *transferred* by chemical action, *e.g.* from charcoal to litharge, the latter being changed thereby into combustible metallic lead; and according to Boyle’s principle, that only *bodies* should be recognized as chemical elements, phlogiston was considered as a body. From the fact that all leading chemists in the second half of the 18th century used the phlogiston theory and were not hindered by it in making their great discoveries, it is evident that a sufficient amount of truth and usefulness was embodied in this theory. It states indeed quite correctly the mutual relations between oxidation and reduction, as we now call these very general processes, and was erroneous only in regard to one question, which at that time had not aroused much interest, the question of the change of weight during chemical processes.

Lavoisier’s reform.

It was only after Isaac Newton’s discovery of universal gravitation that weight was considered as a property of paramount interest and importance, and that the question of the changes of weight in chemical reactions became one worth asking. When in due time this question was raised, the fact became evident at once, that combustion means not loss but gain of weight. To be sure of this, it was necessary to know first the chemical and physical properties of gases, and it was just at the same time that this knowledge was developed by Priestley, Scheele and others. Lavoisier was the originator and expounder of the necessary reform. Oxygen was just discovered at that time, and Lavoisier gathered evidence from all sides that the theory of phlogiston had to be turned inside out to fit the new facts.

He realized that the sum total of the weights of all substances concerned within a chemical change is not altered by the change. This principle of the “conservation of weight” led at once to a simple and unmistakable definition of a chemical element. As the weight of a compound substance is the sum of the weights of its elements, the compound necessarily weighs more than any of its elements. An element is therefore a substance which, by being changed into another substance, invariably increases its weight, and never gives rise to substances of less weight. By the help of this criterion Lavoisier composed the first table of chemical elements similar to our modern ones. According to the knowledge of his time he regarded the alkalis as elements, although he remarked that they are rather similar to certain oxides, and therefore may possibly contain oxygen; the truth of this was proved at a later date by Humphry Davy. But the inconsistency of the reformer, already referred to, may be observed with Lavoisier. He included “heat and light” in his list of elements, although he knew that neither of them had weight, and that neither fitted his definition of an element; this atavistic survival was subsequently removed from the table of the elements by Berzelius in the beginning of the 19th century. In this way the question of what substances are to be regarded as chemical elements had been settled satisfactorily in a qualitative way, but it is interesting to realize that the last step in this development, the theory of Lavoisier, was based on quantitative considerations. Such considerations became of paramount interest at once, and led to the concept of the *combining weights of the* 255
elements.

J.B. Richter’s work.

The first discoveries in this field were made in the last quarter of the 18th century by J.B. Richter. The point at issue was a rather commonplace one: it was the fact that when two neutral salt solutions were mixed to undergo mutual chemical decomposition and recombination, the resulting liquid was neutral again, *i.e.* it did not contain any excess of acid or base. In other words, if two salts, A’B’ and A” B”, composed of the acids A’ and A” and the bases B’ and B”, undergo mutual decomposition, the amount of the base B’ left by the first salt, when its acid A’ united with the base B” to form a new salt A’B”, was just enough to make a neutral salt A”B’ with the acid A” left by the second salt. At first sight this looks quite simple and self-evident,—that neutral salts should form neutral ones again and not acid or basic ones,—but if this fact is once stated very serious quantitative inferences may be drawn from it, as Richter showed. For if the symbols A’, A”, B’, B” denote at the same time such quantities of the acids and bases as form neutral salts, then if three of these quantities are determined, the fourth may be calculated from the others. This follows from the fact that by decomposing A’B’ with just the proper amount of the other salt to form A’B”, the remaining quantities B’ and A” exist in exactly the ratio to form a neutral salt A” B’. It is possible, therefore, to ascribe to each acid and base a certain relative weight or “combining weight” by which they will combine one with the other to form neutral salts. The same reasoning may be extended to any number of acids and bases.

It is true that Richter did not find out by himself this simplest statement of the law of neutrality which he discovered, but he expressed the same consequence in a rather clumsy way by a table of the combining weights of different bases related to the unit amount of a certain acid, and doing the same thing for the unit weight of every other acid. Then he observed that the numbers in these different tables are proportionate one to another. The same holds good if the corresponding series of the combining weights of acids for unit weights of different bases were tabulated. It was only a little later that a Berlin physicist, G.E. Fischer, united the whole system of Richter’s numbers simply into a double table of acids and bases, taking as unit an arbitrarily chosen substance, namely sulphuric acid. The following table by Fischer is therefore the first table of combining weights.

Bases.		*Acids.*	
Alumina	525	Fluoric	427
Magnesia	615	Carbonic	577
Ammoniac	672	Sebacic	706
Lime	793	Muriatic (hydrochloric)	712
Soda	859	Oxalic	755
Strontiane	1329	Phosphoric	979
Potash	1605	Formic	988
Baryte	2222	Sulphuric	1000
		Succinic	1209
		Nitric	1405
		Acetic	1480
		Citric	1683
		Tartaric	1694

It is interesting again to notice how difficult it is for the discoverer of a new truth to find out the most simple and complete statement of his discovery. It looks as if the amount of work needed to get to the top of a new idea is so great that not enough energy remains to clear the very last few steps. It is noteworthy also to observe how difficult it was for the chemists of that time to understand the bearing of Richter’s work. Although a summary of his results was published in Berthollet’s *Essai de statique chimique*, one of the most renowned chemical books of that time, nobody dared for a long time to take up the scientific treasure laid open for all the world.

John Dalton’s atomic theory.

At the beginning of the 19th century the same question was taken up from quite another standpoint. John Dalton, in his investigations of the behaviour of gases, and in order to understand more easily what happened when gases were absorbed by liquids, used the corpuscular hypothesis already mentioned in connexion with Boyle. While he depicted to himself how the corpuscles, or, as he preferred to call them, the “atoms” of the gases, entered the interstices of the atoms of the liquids in which they dissolved, he asked himself: Are the several atoms of the same substance exactly alike, or are there differences as between the grains of sand? Now experience teaches us that it is impossible to separate, for example, a quantity of pure water into two samples of somewhat different properties. When a pure substance is fractionated by partial distillation or partial crystallization or partial change into another substance by chemical means, we find constantly that the residue is not changed in its properties, as it would be if the atoms were slightly different, since in that case *e.g.* the lighter atoms would distil first and leave behind the heavier ones, &c. Therefore we must conclude that all atoms of the same kind are exactly alike in shape and weight. But, if this be so, then all combinations between different atoms must proceed in certain invariable ratios of the weights of the elements, namely by the ratio of the weights of the atoms. Now it is impossible to weigh the atoms directly; but if we determine the ratio of the weights in which oxygen and hydrogen combine to form water, we determine in this way also the relative weight of their atoms. By a proper number of analyses of simple chemical compounds we may determine the ratios between the weights of all elementary atoms, and, selecting one of them as a standard or unit, we may express the weight of all other atoms in terms of this unit. The following table is Dalton’s (*Mem. of the Lit. and Phil. Soc. of Manchester* (II.), vol. i. p. 287, 1805).

Table of the Relative Weights of the Ultimate Particles of Gaseous and other Bodies.

Hydrogen	1	Nitrous oxide	13.7
Azot	4.2	Sulphur	14.4
Carbone	4.3	Nitric acid	15.2
Ammonia	5.2	Sulphuretted hydrogen	15.4
Oxygen	5.5	Carbonic acid	15.3
Water	6.5	Alcohol	15.1
Phosphorus	7.2	Sulphureous acid	19.9
Phosphuretted hydrogen	8.2	Sulphuric acid	25.4
Nitrous gas	9.3	Carburetted hydrogen from stagnant water	6.3
Ether	9.6		
Gaseous oxide of carbone	9.8	Olefiant gas	5.3

Dalton at once drew a peculiar inference from this view. If two elements combine in different ratios, one must conclude that different numbers of atoms unite. There must be, therefore, a simple ratio between the quantities of the one element united to the same quantity of the other. Dalton showed at once that the analysis of carbon monoxide and of carbonic acid satisfied this consequence, the quantity of oxygen in the second compound being double the quantity in the first one. A similar relation holds good between marsh gas and olefiant gas (ethylene). This is the "law of multiple proportions" (see Atom). By these considerations Dalton extended the law of combining weights, which Richter had demonstrated only for neutral salts, to all possible chemical compounds. While the scope of the law was enormously extended, its experimental foundation was even smaller than with Richter. Dalton did not concern himself very much with the experimental verification of his ideas, and the first communication of his theory in a paper on the absorption of gases by liquids (1803) attracted as little notice as Richter's discoveries. Even when T. Thomson published Dalton's views in an appendix to his widely read text-book of chemistry, matters did not change very much. It was only by the work of J.J. Berzelius that the enormous importance of Dalton's views was brought to light.

Work of J.J. Berzelius.

Berzelius was at that time busy in developing a trustworthy system of chemical analysis, and for this purpose he investigated the composition of the most important salts. He then went over the work of Richter, and realized that by his law he could check the results of his analyses. He tried it and found the law to hold good in most cases; when it did not, according to his analyses, he found that the error was on his own side and that better analyses fitted Richter's law. Thus he was prepared to understand the importance of Dalton's views and he proceeded at once to test its exactness. The result was the best possible. The law of the combining weights of the atoms, or of the atomic weights, proved to hold good in every case in which it was tested. All chemical combinations between the several elements are therefore regulated by weight according to certain numbers, one for each element, and combinations between the elements occur only in ratios given by these weights or by simple multiples thereof. Consequently Berzelius regarded Dalton's atomic hypothesis as proved by experiment, and became a strong believer in it. 256

At the same time W.H. Wollaston had discovered independently the law of multiple proportions in the case of neutral and acid salts. He gave up further work when he learned of Dalton's ideas, but afterwards he pointed out that it was necessary to distinguish the *hypothetical* part in Dalton's views from their *empirical* part. The latter is the law of combining weights, or the law that chemical combination occurs only according to certain numbers characteristic for each element. Besides this purely experimental law there is the hypothetical explanation by the assumption of the existence of atoms. As it is not proved that this explanation is the only one possible, the existence of the law is not a proof of the existence of the atoms. He therefore preferred to call the characteristic combining numbers of the elements not "atomic weights" but "chemical equivalents."

Although there were at all times chemists who shared Wollaston's cautious views, the atomic hypothesis found general acceptance because of its ready adaptability to the most diverse chemical facts. In our time it is even rather difficult to separate, as Wollaston did, the empirical part from the hypothetical one, and the concept of the atom penetrates the whole system of chemistry, especially organic chemistry.

If we compare the work of Dalton with that of Richter we find a fundamental difference. Richter's inference as to the existence of combining weights in salts is based solely on an experimental observation, namely, the persistence of neutrality after double decomposition; Dalton's theory, on the contrary, is based on the hypothetical concept of the atom. Now, however favourably one may think of the probability of the existence of atoms, this existence is really not an observed fact, and it is necessary therefore to ask: Does there exist some general fact which may lead directly to the inference of the existence of combining weights of the elements, just as the persistence of neutrality leads to the same consequence as to acids and bases? The answer is in the affirmative, although it took a whole century before this question was put and answered. In a series of rather difficult papers (*Zeits. f. Phys. Chem.* since 1895, and *Annalen der Naturphilosophie* since 1902), Franz Wald (of Kladno, Bohemia) developed his investigations as to the genesis of this general law. Later, W. Ostwald (Faraday lecture, *Trans. Chem. Soc.*, 1904) simplified Wald's reasoning and made it more evident.

The general fact upon which the necessary existence of combining weights of the elements may be based is the shifting character of the boundary between elements and compounds. It has already been pointed out that Lavoisier considered the alkalis and the alkaline earths as elements, because in his time they had not been decomposed. As long as the decomposition had not been effected, these compounds could be considered and treated like elements without mistake, their combining weight being the sum of the combining weights of their (subsequently discovered) elements. This means that compounds enter in reaction with other substances as a whole, just as elements do. In particular, if a compound AB combines with another substance (elementary or compound) C to form a ternary compound ABC, it enters this latter as a whole, leaving behind no residue of A or B. Inversely, if a ternary compound ABC be changed into a binary one AB by taking away the element C, there will not be found any excess of A or B, but both elements will exhibit just the same ratio in the binary as in the ternary compound.

Experimentally this important fact was proved first by Berzelius, who showed that by oxidizing lead sulphide, PbS, to lead sulphate, $PbSO_4$, no excess either of sulphur or lead could be found after oxidation; the same held good with barium sulphite, $BaSO_3$, when converted into barium sulphate, $BaSO_4$. On a much larger scale and with very great accuracy the inverse was proved half a century later by J.S. Stas, who reduced silver chlorate, $AgClO_3$, silver bromate, $AgBrO_3$, and silver iodate, $AgIO_3$, to the corresponding binary compounds, AgCl, AgBr and AgI, and searched in the residue of the reaction for any excess of silver or halogen. As the tests for these substances are among the most sensitive in analytical chemistry, the general law underwent a very severe test indeed. But the result was the same as was found by Berzelius—no excess of one of the elements could be discovered. We may infer, therefore, generally that compounds enter ulterior combinations without change of the ratio of their elements, or that the ratio between different elements in their compounds is the same in binary and ternary (or still more complicated) combinations.

This law involves the existence of general combining weights just in the same way as the law of neutrality with double decomposition of salts involves the law of the combining weights of acids and bases. For if the ratio between A and B is determined, this same ratio must obtain in all ternary and more complicated compounds, containing the same elements. The same is true for any other elements, C, D, E, F, &c., as related to A. But by applying the general law to the ternary compound ABC the same conclusion may be drawn as to the ratio A : C in all compounds containing A and C, or B : C in the corresponding compounds. By reasoning further in the same way, we come to the conclusion that only such compounds are possible which contain elements according to certain ratio-numbers, *i.e.* their combining weight. Any other ratio would violate the law of the integral reaction of compounds.

As to the law of multiple proportions, it may be deduced by a similar reasoning by considering the possible combinations between a compound, *e.g.* AB, and one of its elements, say B. AB and B can combine only according to their combining weights, and therefore the quantity of B combining with AB is equal to the quantity of AB which has combined with A to form AB. The new combination is therefore to be expressed by AB_2. By extending this reasoning in the same way, we get the general conclusion that any compounds must be composed according to the formula $A_mB_nC_p$..., where m, n, p, &c., are integers.

The bearing of these considerations on the atomic hypothesis is not to disprove it, but rather to show that the existence of the law of combining weights, which has been considered for so long as a proof of the truth of this hypothesis, does not necessarily involve such a consequence. Whether atoms may prove to exist or not, the law of combining weights is independent thereof.

Atomic weight determinations.

Two problems arose from the discoveries of Dalton and Berzelius. The first was to determine as exactly as possible the correct numbers of the combining weights. The other results from the fact that the same elements may combine in different ratios. Which of these ratios gives the true ratio of the atomic weights? And which is the multiple one? Both questions have had most ample experimental investigation, and are now answered rather satisfactorily. The first question was a purely technical one; its answer depended upon analytical skill, and Berzelius in his time easily took the lead, his numbers being readily accepted on the continent of Europe. In England there was a certain hesitation at first, owing to Prout’s assumption (see below), but when Turner, at the instigation of the British Association for the Advancement of Science, tested Berzelius’s numbers and found them entirely in accordance with his own measurements, these numbers were universally accepted. But then a rather large error in one of Berzelius’s numbers (for carbon) was discovered in 1841 by Dumas and Stas, and a kind of panic ensued. New determinations of the atomic weights were undertaken from all sides. The result was most satisfactory for Berzelius, for no other important error was discovered, and even Dumas remarked that repeating a determination by Berzelius only meant getting the same result, if one worked properly. In later times more exact measurements, corresponding to the increasing art in analysis, were carried out by various workers, amongst whom J.S. Stas distinguished himself. But even the classical work of Stas proved not to be entirely without error; for every period has its limit in accuracy, which extends slowly as science extends. In recent times American chemists have been especially prominent in work of this kind, and the determinations of E.W. Morley, T.W. Richards and G.P. Baxter rank among the first in this line of investigation.

During this work the question arose naturally: How far does the *exactness* of the law extend? It is well known that most natural laws are only approximations, owing to disturbing causes. Are there disturbing causes also with atomic weights? The answer is that as far as we know there are none. The law is still an exact one. But we must keep in mind that an absolute answer is never possible. Our exactness is in every case limited, and as long as the possible variations lie behind this limit, we cannot tell anything about them. In recent times H. Landolt has doubted and experimentally investigated the law of the conservation of weight.

Landolt’s experiments were carried out in vessels of the shape of an inverted U, each branch holding one of the substances to react one on the other. Two vessels were prepared as equal as possible and hung on both sides of a most sensitive balance. Then the difference of weight was determined in the usual way by exchanging both the vessels on the balance. After this set of weighings one of the vessels was inverted and the chemical reaction between the contained substances was performed; then the double weighing was repeated. Finally also the second vessel was inverted and a third set of weighings taken. From blank experiments where the vessels were filled with substances which did not react one on the other, the maximum error was determined to 0.03 milligramme. The reactions experimented with were: silver salts with ferrous sulphate; iron on copper sulphate; gold chloride and ferrous chloride; iodic acid and hydriodic acid; iodine and sodium sulphite; uranyl nitrate and potassium hydrate; chloral hydrate and potassium hydrate; electrolysis of cadmium iodide by an alternating current; solution of ammonium chloride, potassium bromide and uranyl nitrate in water, and precipitation of an aqueous solution of copper sulphate by alcohol. In most of these experiments a slight diminution of weight was observed which exceeded the limit of error distinctly in two cases, viz. silver nitrate with ferrous sulphate and iodic acid with hydriodic acid, the loss of weight amounting from 0.068 to 0.199 mg. with the first and 0.047 to 0.177 mg. with the second reaction on about 50 g. of substance. As each of these reactions had been tried in nine independent experiments, Landolt felt certain that there was no error of observation involved. But when the vessels were covered inside with paraffin wax, no appreciable diminution of weight was observed.

These experiments apparently suggested a small decrease of weight as a consequence of chemical processes. On repeating them, however, and making allowance for the different amounts of water absorbed on the surface of the vessel at the beginning and end of the experiment, Landolt found in 1908 (*Zeit. physik. Chem.* 64, p. 581) that the variations in weight are equally positive and negative, and he concluded that there was no change in weight, at least to the extent of 1 part in 10,000,000.

The periodic arrangement.

There is still another question regarding the numerical values of the atomic weights, namely: Are there relations between the numbers belonging to the several elements? Richter had arranged his combining weights according to their magnitude, and endeavoured to prove that they form a certain mathematical series. He also explained the incompleteness of his series by assuming that certain acids or bases requisite to the filling up of the gaps in the series, were not yet known. He even had the satisfaction that in his time a new base was discovered, which fitted rather well into one of his gaps; but when it turned out afterwards that this new base was only calcium phosphate, this way of reasoning fell into discredit and was resumed only at a much later date.

To obtain a correct table of atomic weights the second question already mentioned, viz. how to select the correct value in the case of multiple proportions, had to be answered. Berzelius was constantly on the look-out for means to distinguish the true atomic weights from their multiples or sub-multiples, but he could not find an unmistakable test. The whole question fell into a terrible disorder, until in the middle of the 19th century S. Cannizzaro showed that by taking together all partial evidences one could get a system of atomic weights consistent in itself and fitting the exigencies of chemical systematics. Then a startling discovery was made by the same method which Richter had tried in vain, by arranging all atomic weights in one series according to their numerical values.

The Periodic Law.—The history of this discovery is rather long. As early as 1817 J.W. Döbereiner of Jena drew attention to the fact that the combining weight of strontium lies midway between those of calcium and barium, and some years later he showed that such “triads” occurred in other cases too. L. Gmelin tried to apply this idea to all elements, but he realized that in many cases more than three elements had to be grouped together. While Ernst Lenssen applied the idea of triads to the whole table of chemical elements, but without any important result, the other idea of grouping more than three elements into series according to their combining weights proved more successful. It was the concept of homologous series just developed in organic chemistry which influenced such considerations. First Max von Pettenkofer in 1850 and then J.B.A. Dumas in 1851 undertook to show that such a series of similar elements could be formed, having nearly constant differences between their combining weights. It is true that this idea in all its simplicity did not hold good extensively enough; so J.P. Cooke and Dumas tried more complicated types of numerical series, but only with a temporary success.

The idea of arranging all elements in a single series in the order of the magnitude of their combining weights, the germ of which is to be found already in J.B. Richter’s work, appears first in 1860 in some tables published by Lothar Meyer for his lectures. Independently, A.E.B. de Chancourtois in 1862, J.A.R. Newlands in 1863, and D.I. Mendeléeff in 1869, developed the same idea with the same result, namely, that it is possible to divide this series of all the elements into a certain number of very similar parts. In their papers, which appeared in the same year, 1869, Lothar Meyer and Mendeléeff gave to all these trials the shape now generally adopted. They succeeded in proving beyond all doubt that this series was of a *periodic character*, and could be cut into shorter pieces of similar construction. Here again gaps were present to be filled up by elements to be discovered, and Mendeléeff, who did this, predicted from the general regularity of his table the properties of such unknown elements. In this case fate was more kind than with Richter, and science had the satisfaction of seeing these predictions turn out to be true.

The following table contains this periodic arrangement of the elements according to their atomic weight. By cutting the whole series into pieces of eight elements (or more in several cases) and arranging these one below another in the alternating way shown in the table, one finds similar elements placed in vertical series whose properties change gradually and with some regularity according to their place in the table. Not only the properties of the uncombined elements obey this rule, but also almost all properties of similar compounds of the elements.

He 4.0	Li 7.03	Be 9.1	B 11.0	C 12.00	N 14.01	O 16.00	F 19.0	..	..	..
Ne 20	Na 23.00	Mg 24.32	Al 27.1	Si 28.4	P 31.0	S 32.06	Cl 35.45	..	..	..
Ar 39.9	K 39.15	Ca 40.1	Sc 44.1	Ti 48.1	V 51.2	Cr 52.0	Mn 55.0	Fe 55.9,	Ni 58.7,	Co 59.0
..	Cu 63.6	In 65.4	Ga 70	Ge 72.5	As 75.0	Se 79.2	Br 79.96	..	..	..

Kr 83.0	Rb 85.5	Sr 87.6	Y 89.0	Zr 90.6	Cb(Nb) 94	Mo 96.0	..	Ru 101.7,	Rh 103.0,	Pd 106.5
..	Ag 107.93	Cd 112.4	In 115	Sn 119.0	Sb 120.2	Te 127.6	I 126.97	..	..	..
Xe 130.7	Cs 132.9	Ba 137.4	La 138.9	Ce &c. 140	Ta 181	W 184	..	Os 191,	Ir 193.0,	Pt 194.8
..	Au 197.2	Hg 200.0	Tl 204.1	Pb 206.9	Bi 208.0	..	..	..	..	..
..	..	Ra 225	..	Th 232.5	..	U 238.5	..	..	..	..

But upon closer investigation it must be confessed that these regularities can be called only rules, and not laws. In the first line one would expect that the steps in the values of the atomic weights should be regular, but it is not so. There are even cases when it is necessary to invert the order of the atomic weights to satisfy the chemical necessities. Thus argon has a larger number than potassium, but must precede it to fit into its proper place. The same is true of tellurium and iodine. It looks as if the real elements were scattered somewhat haphazard on a regular table, or as if some independent factor were active to disturb an existing regularity. It may be that the new facts mentioned above will lead also to an explanation of these irregularities; at present we must recognize them and not try to explain them away. Such considerations have to be kept in mind especially in regard to the very numerous attempts to express the series of combining weights in a mathematical form. In several cases rather surprising agreements were found, but never without exception. It looks as if some very important factor regulating the whole matter is still unknown, and before this has been elucidated no satisfactory treatment of the matter is possible. It seems therefore premature to enter into the details of these speculations.

Transmutation of elements.

In recent times not only our belief in the absolute exactness of the law of the conservation of weight has been shaken, but also our belief in the law of the conservation of the elements. The wonderful substance radium, whose existence has made us to revise quite a number of old and established views, seems to be a fulfilment of the old problem of the alchemists. It is true that by its help lead is not changed into gold, but radium not only changes itself into another element, helium (Ramsay), but seems also to cause other elements to change. Work in this line is of present day origin only and we do not know what new laws will be found to regulate these most unexpected reactions (see Radioactivity). But we realize once more that no law can be regarded as free from criticism and limitation; in the whole realm of exact sciences there is no such thing as the Absolute.

Prout's assumption.

Another question regarding the values of atomic weights was raised very soon after their first establishment. From the somewhat inexact first determinations William Prout concluded that all atomic weights are multiples of the atomic weight of hydrogen, thus suggesting all other elements to be probably made up from condensed hydrogen. Berzelius found his determinations not at all in accordance with this assumption, and strongly opposed the arbitrary rounding off of the numbers practised by the partisans of Prout's hypothesis. His hypothesis remained alive, although almost every chemist who did *exact* atomic weight determinations, especially Stas, contradicted it severely. Even in our time it seems to have followers, who hope that in some way the existing experimental differences may disappear. But one of the most important and best-known relations, that between *hydrogen* and *oxygen*, is certainly different from the simple ratio 1 : 16, for it has been determined by a large number of different investigators and by different methods to be undoubtedly lower, namely, 1 : 15.87. Therefore, if Prout's hypothesis contain an element of truth, by the act of condensation of some simpler substance into the present chemical elements a change of weight also must have occurred, such that the weight of the element did not remain exactly the weight of the simpler substance which changed into it. We have already remarked that such phenomena are not yet known with certainty, but they cannot be regarded as utterly impossible.

International table of atomic weights.

It may here be mentioned that the internationality of science has shown itself active also in the question of atomic weights. These numbers undergo incessantly small variations because of new work done for their determination. To avoid the uncertainty arising from this inevitable state of affairs, an international committee was formed by the co-operation of the leading chemical societies all over the world, and an international table of the most probable values is issued every year. The following table is that for 1910:—

International Atomic Weights, 1910.

Name.	Symbol.	Atomic Weights. **O = 16.**	Name.	Symbol.	Atomic Weights. **O = 16.**
Aluminium	Al	27.1	Mercury	Hg	200.0
Antimony	Sb	120.2	Molybdenum	Mo	96.0
Argon	Ar	39.9	Neodymium	Nd	144.3
Arsenic	As	74.96	Neon	Ne	20.0
Barium	Ba	137.37	Nickel	Ni	58.68
Beryllium (Glucinum)	Be Gl	9.1	Nitrogen	N	14.01
			Osmium	Os	190.9
Bismuth	Bi	208.0	Oxygen	O	16.00
Boron	B	11.0	Palladium	Pd	106.7
Bromine	Br	79.92	Phosphorus	P	31.0
Cadmium	Cd	112.40	Platinum	Pt	195.0

Caesium	Cs	132.81	Potassium	K	39.10
Calcium	Ca	40.09	Praseodymium	Pr	140.6
Carbon	C	12.00	Radium	Ra	226.4
Cerium	Ce	140.25	Rhodium	Rh	102.9
Chlorine	Cl	35.46	Rubidium	Rb	85.45
Chromium	Cr	52.0	Ruthenium	Ru	101.7
Cobalt	Co	58.97	Samarium	Sm	150.4
Columbium (Niobium)	Cb (Nb)	93.5	Scandium	Sc	44.1
			Selenium	Se	79.2
Copper	Cu	63.57	Silicon	Si	28.3
Dysprosium	Dy	162.5	Silver	Ag	107.88
Erbium	Er	167.4	Sodium	Na	23.00
Europium	Eu	152.0	Strontium	Sr	87.62
Fluorine	F	19.0	Sulphur	S	32.07
Gadolinium	Gd	157.3	Tantalum	Ta	181.0
Gallium	Ga	69.9	Tellurium	Te	127.5
Germanium	Ge	72.5	Terbium	Th	159.2
Gold	Au	197.2	Thallium	Tl	204.0
Helium	He	4.0	Thorium	Th	232.42
Hydrogen	H	1.008	Thulium	Tm	168.5
Indium	In	114.8	Tin	Sn	119.0
Iodine	I	126.92	Titanium	Ti	48.1
Iridium	Ir	193.1	Tungsten	W	184.0
Iron	Fe	55.85	Uranium	U	238.5
Krypton	Kr	83.0	Vanadium	V	51.2
Lanthanum	La	139.0	Xenon	Xe	130.7
Lead	Pb	207.10	Ytterbium (Neoytterbium)	Yb	172.0
Lithium	Li	7.00			
Lutecium	Lu	174.0	Yttrium	Y	89.0
Magnesium	Mg	24.32	Zinc	Zn	65.37
Manganese	Mn	54.93	Zirconium	Zr	90.6

Concluding remarks.

In the long and manifold development of the concept of the element one idea has remained prominent from the very beginning down to our times: it is the idea of a primordial matter. Since the naive statement of Thales that all things came from water, chemists could never reconcile themselves to the fact of the conservation of the elements. By an experimental investigation which extended over five centuries and more, the impossibility of transmuting one element into another—for example, lead into gold—was demonstrated in the most extended way, and nevertheless this law has so little entered the consciousness of the chemists that it is seldom explicitly stated even in carefully written text-books. On the other side the attempts to reduce the manifoldness of the actual chemical elements to one single primordial matter have never ceased, and the latest development of science seems to endorse such a view. It is therefore necessary to consider this question from a most general standpoint.

In physical science, the chemical elements may be compared with such concepts as *mass*, *momentum*, *quantity of electricity*, *entropy* and such like. While mass and entropy are determined univocally by a unit and a number, quantity of electricity has a unit, a number and a sign, for it can be positive as well as negative. Momentum has a unit, a number and a direction in space. Elements do not have a common unit as the former magnitudes, but every element has its own unit, and there is no transition from one to another. All these magnitudes underlie a law of conservation, but to a very different degree. While mass was considered as absolutely invariable in the classical mechanics, the 259
newer theories of the electrical constitution of matter make mass dependent on the velocity of the moving electron. Momentum also is not entirely conservative because it can be changed by light-pressure. Entropy is known as constantly increasing, remaining constant only in an ideal limiting case. With chemical elements we observe the same thing as with momentum; though till recently considered as conservative, there is now experimental evidence that they do not always show this character.

Generally the laws of the conservation of mass, weight and elements are expressed as the “law of the conservation of matter.” But this expression lacks scientific exactness because the term “matter” is generally not defined exactly, and because only the above-named properties of ponderable objects do not change, while all other properties do to a greater or less extent. Considered in the most general way, we may define matter as a complex of gravitational, kinetic and chemical energies, which are found to cling together in the same space. Of these energies the capacity factors, namely, weight, mass and elements, are conservative as described, while the intensity factors, potential, velocity and affinity, may change in wide limits. To explain why we find these energies constantly combined one with another, we only have to think of a mass without gravity or a ponderable body without mass. The first could not remain on earth because every movement would carry it into infinite space, and the second would acquire infinite velocity by the slightest push and would also disappear at once. Therefore only such objects which have both mass and weight can be handled and can be objects of our knowledge. In the same way all other energies come to our knowledge only by being (at least temporarily) associated with this combination of mass and weight. This is the true meaning of the term “matter.”

In this line of ideas matter appears not at all as a primary concept, but as a complex one; there is therefore no reason to consider matter as the last term of scientific analysis of chemical facts, and the idea of a primordial matter appears as a survival from the very first beginning of European natural philosophy. The most general concept science has developed to express the variety of experience is *energy*, and in terms of energy (combined with number, magnitudes, time and space) all observed and observable experiences are to be described.

(W. O.)

ELEMI, an oleo-resin (Manilla elemi) obtained in the Philippine Islands, probably from *Canarium commune* (nat. ord. Burseraceae), which when fresh and of good quality is a pale yellow granular substance, of honey-like consistency, but which gradually hardens with age. It is soluble in alcohol and ether, and has a spicy taste with a smell like fennel. In the 17th and 18th centuries the term elemi usually denoted an oleo-resin (American or Brazilian elemi) obtained from trees of the genus *Icica* in Brazil, and still earlier it meant oriental or African elemi, derived from *Boswellia Frereana*, which flourishes in the neighbourhood of Cape Gardafui. The word, like the older term *animi*, appears to have been derived from *enhaemon* (Gr. ἔναιμον), the name of a styptic medicine said by Pliny to contain tears exuded by the olive tree of Arabia.

ELEPHANT, the designation of the two existing representatives of the *Proboscidea*, a sub-order of ungulate mammals, and also extended to include their more immediate extinct relatives. As the distinctive characteristics of the sub-order, and also of the single existing genus *Elephas*, are given in the article Proboscidea, it will suffice to point out how the two existing species are distinguished from one another.

The more specialized of the two species is the Indian or Asiatic elephant, *Elephas maximus*, specially characterized by the extreme complexity of the structure of its molar teeth, which are composed of a great number of tall and thin plates of enamel and dentine, with the intervals filled by cement (see Proboscidea, fig. 1). The average number of plates of the six successive molar teeth may be expressed by the "ridge-formula" 4, 8, 12, 12, 16, 24. The plates are compressed from before backwards, the anterior and posterior surfaces (as seen in the worn grinding face of the tooth) being nearly parallel. Ears of moderate size. Upper margin of the end of the proboscis developed into a distinct finger-like process, much longer than the lower margins, and the whole trunk uniformly tapering and smooth. Five nails on the fore-feet, and four (occasionally five) on the hind-feet.

The Asiatic elephant inhabits the forest-lands of India, Burma, the Malay Peninsula, Cochin China, Ceylon and Sumatra. Elephants from the last-named islands present some variations from those of the mainland, and have been separated under the names of *E. zeylonicus* and *E. sumatranus*, but they are not more than local races, and the Ceylon animal, which is generally tuskless, may be the typical *E. maximus*, in which case the Indian race will be *E. maximus indicus*. The appearance of the Asiatic elephant is familiar to all. In the wild state it is gregarious, associating in herds of ten, twenty or more individuals, and, though it may under certain circumstances become dangerous, it is generally inoffensive and even timid, fond of shade and solitude and the neighbourhood of water. The height of the male at the shoulder when full grown is usually from 8 to 10 ft., occasionally as much as 11, and possibly even more. The female is somewhat smaller.

The following epitome of the habits of the Asiatic elephants is extracted from *Great and Small Game of India and Tibet*, by R. Lydekker:—

"The structure of the teeth is sufficient to indicate that the food consists chiefly of grass, leaves, succulent shoots and fruits; and this has been found by observation to be actually the case. In this respect the Asiatic species differs very widely from its African relative, whose nutriment is largely composed of boughs and roots. Another difference between the two animals is to be found in the great intolerance of the direct rays of the sun displayed by the Asiatic species, which never voluntarily exposes itself to their influence. Consequently, during the hot season in Upper India, and at all times except during the rains in the more southern districts, elephants keep much to the denser parts of the forests. In Southern India they delight in hill-forest, where the undergrowth is largely formed of bamboo, the tender shoots of which form a favourite delicacy; but during the rains they venture out to feed on the open grass tracts. Water is everywhere essential to

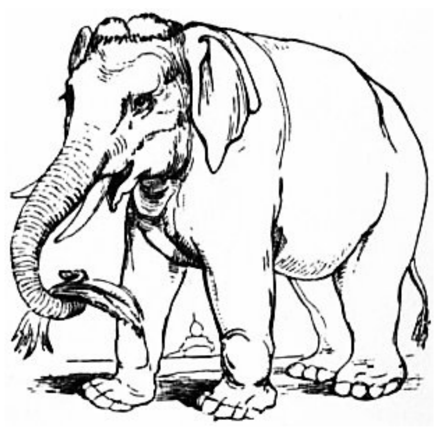


Fig. 1.
Asiatic Elephant (*Elephas maximus*).

their well-being; and no animals delight more thoroughly in a bath. Nor are they afraid to venture out of their depth, being excellent swimmers, and able, by means of their trunks, to breathe without difficulty when the entire body is submerged. The herds, which are led by females, appear in general to be family parties; and although commonly restricted to from thirty to fifty, may occasionally include as many as one hundred head. The old bulls are very generally solitary for a considerable portion of the year, but return to the herds during the pairing season. Some ‘rogue’ elephants—*gunda* of the natives—remain, however, permanently separated from the rest of their kind. All such solitary bulls, as their colloquial name indicates, are of a spiteful disposition; and it appears that with the majority the inducement to live apart is due to their partiality for cultivated crops, into which the more timid females are afraid to venture. ‘Must’ elephants are males in a condition of—probably sexual—excitement, when an abundant discharge of dark oily matter exudes from two pores in the forehead. In addition to various sounds produced at other times, an elephant when about to charge gives vent to a shrill loud ‘trumpet’; and on such occasions rushes on its adversary with its trunk safely rolled up 260
out of danger, endeavouring either to pin him to the ground with its tusks (if a male tusker) or to trample him to death beneath its ponderous knees or feet.”

Exact information in regard to the period of gestation of the female is still lacking, the length of the period being given from eighteen to twenty-two months by different authorities. The native idea, which may be true, is that the shorter period occurs in the case of female and the longer in that of male calves. In India elephants seldom breed in captivity, though they do so more frequently in Burma and Siam; the domesticated stock is therefore replenished by fresh captures. Occasionally two calves are produced at a birth, although the normal number is one. Calves suckle with their mouths and not with their trunks. Unlike the African species, the Indian elephant charges with its trunk curled up, and consequently in silence.

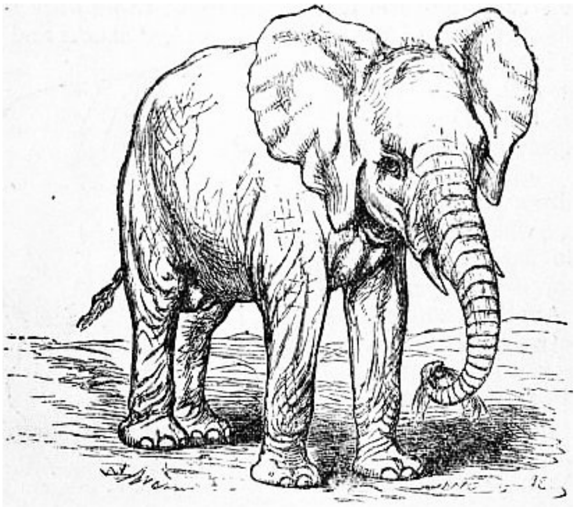


Fig. 2.—Immature African Elephant (*Elephas africanus*).

As regards their present distribution in India, elephants are found along the foot of the Himalaya as far west as the valley of Dehra-Dun, where the winter temperature falls to a comparatively low point. A favourite haunt used to be the swamp of Azufghur, lying among the sal-forests to the northward of Meerut. In the great tract of forest between the Ganges and Kistna rivers they occur locally as far west as Bilaspur and Mandla; they are met with in the Western Ghats as far north as between latitude 17° and 18°, and are likewise found in the hill-forests of Mysore, as well as still farther south. In this part of the peninsula they ascend the hills to a considerable height, as they do in the Newara Eliya district of Ceylon, where they have been encountered at an elevation of over 7000 ft. There is evidence that about three centuries ago elephants wandered in the forests of Malwa and Nimar, while they survived to a later date in the Chanda district of the Central Provinces. At the comparatively remote epoch when the Deccan was a forest tract, they were probably also met with there, but the swamps of the Bengal Sundarbans appear unsuited to their habits.

Of tusks, the three longest specimens on record respectively measure 8 ft. 9 in., 8 ft. 2 in. and 8 ft.; their respective weights being 81, 80 and 90 ℔. These are, however, by no means the heaviest—one, whose length is 7 ft. 3⅜ in., weighing 102 ℔; while a second, of which the length is 7 ft. 3¼ in., scaled 97½ ℔. Of the largest pair in the possession of the British Museum, which belonged to an elephant killed in 1866 by Colonel G.M. Payne in Madras, one tusk measures 6 ft. 8 in. in length, and weighs 77¾ ℔, the other being somewhat smaller. It should be added that some of these large tusks came from Ceylon; such tuskers being believed to be descended from mainland animals imported into the island. “White” elephants are partial or complete albinos, and are far from uncommon in Burma and Siam. Young Indian elephants are hairy, thus showing affinity with the mammoth.

The African elephant is a very different animal from its Asiatic cousin, both as regards structure and habits; and were it not for the existence of intermediate extinct species, might well be regarded as the representative of a distinct genus. Among its characteristics the following points are noticeable. The molar teeth are of coarse construction, with fewer and larger plates and thicker enamel; the ridge-formula being 3, 6, 7, 7, 8, 10; while the plates are not flattened, but thicker in the middle than at the edges, so that their worn grinding-surfaces are lozenge-shaped. Ears very large. The upper and lower margins of the end of the trunk form two nearly equal prehensile lips. Only three toes on the hind-foot. A very important distinction is to be found in the conformation of the trunk, which, as shown in fig. 2, looks as though composed of a number of segments, gradually decreasing in size from base to tip like the joints of a telescope, instead of tapering gradually and evenly from one extremity to the other. The females have relatively large tusks, which are essential in obtaining their food. Except where exterminated by human agency (and this has been accomplished to a deplorable extent), the African elephant is a native of the wooded districts of the whole of Africa south of the Sahara. It is hunted chiefly for the sake of the ivory of its immense tusks, of which it yields the principal source of supply to the European market, and the desire to obtain which is rapidly leading to the extermination of the species. In size the male African elephant often surpasses the Asiatic species, reaching nearly 12 ft. in some cases. The circumference of the fore-foot is half the height at the shoulder, a circumstance which enables sportsmen to estimate approximately the size of their quarry. A tusk in the British Museum measures 10 ft. 2 in. in length, with a basal girth of 24 in. and a weight of 226½ ℔; but a still longer, although lighter, tusk was brought to London in 1905.

Several local races of African elephant have been described, mainly distinguished from one another by the form and size of the ears, shape of the head, &c. The most interesting of these is the pigmy Congo race, *E. africanus pumilio*, named on the evidence of an immature specimen in the possession of C. Hagenbeck, the well-known animal-dealer of Hamburg, in 1905. According to Hagenbeck’s estimate, this elephant, which came from the French Congo, was about six years old at the time it came under scientific notice. Moreover, in the opinion of the same observer, it is in no wise an abnormally dwarfed or ill-grown representative of the normal type of African elephant, but a well-developed adolescent animal. In height it stood about the same as a young individual of the ordinary African elephant when about a year and a half old, the vertical measurement at the shoulder being only 4 ft., or merely a foot higher than a new-born Indian elephant. Hagenbeck’s estimate of its age was based on the presence of well-developed tusks, and the relative proportion of the fore and hind limbs, which are stated to show considerable differences in the case of the African elephant according to age. Nothing was stated as to the probability of an increase in the stature of the French Congo animal as it grows older; but even if we allow another foot, its height would be considerably less than half that of a large Central African bull of the ordinary elephant.

By Dr Paul Matschie several races of the African elephant have been described, mainly, as already mentioned, on certain differences in the shape of the ear. From the two West African races (*E. a. cyclotis* and *E. a. oxyotis*) the dwarf Congo elephant is stated to be distinguished by the shape of its ear; comparison in at least one instance having been made with an immature animal. The relatively small size of the ear is one of the most distinctive characteristics of the dwarf race. Further, the skin is stated to be much less rough, with fewer cracks, while a more important difference occurs in the trunk, which lacks the transverse ridges so distinctive of the ordinary African elephant, and thereby approximates to the Asiatic species.

If the differences in stature and form are constant, there can be no question as to the right of the dwarf Congo elephant to rank as a well-marked local race; the only point for consideration being whether it should not be called a species. The great interest in connexion with a dwarf West African race of elephant is in relation to the fossil pigmy elephants of the limestone fissures and caves of 261
Malta and Cyprus. Although some of these elephants are believed not to have been larger than donkeys, the height of others may be estimated at from 4 to 5 ft., or practically the same as that of the dwarf Congo race. By their describers, the dwarf European elephants were regarded as distinct species, under the names of *Elephas melitensis*, *E. mnaidriensis* and *E. cypriotes*; but since their molar teeth are essentially miniatures of those of the African elephant, it has been suggested by later observers that these animals are nothing more than dwarf races of the latter. This view may receive some support from the occurrence of a dwarf form of the African elephant in the Congo; and if we regard the latter as a subspecies of *Elephas africanus*, it seems highly probable that a similar position will have to be assigned to the pigmy European fossil elephants. If, on the other hand, the dwarf Congo elephant be regarded as a species, then the Maltese and Cyprian elephants may have to be classed as races of *Elephas pumilio*; or, rather, *E. pumilio* will have to rank as a race of the Maltese species. In this connexion it is of interest to note that, both in the Mediterranean islands and in West Africa, dwarf elephants of the African type are accompanied by pigmy species of hippopotamus, although we have not yet evidence to show that in Africa the two animals occupy actually the same area. Still, the close relationship of the existing Liberian pigmy hippopotamus to the fossil Mediterranean species is significant, in relation to the foregoing observations on the elephant.

It may be added that fossil remains of the African elephant have been obtained from Spain, Sicily, Algeria and Egypt, in strata of the Pleistocene age. Some of the main differences in the habits of the African as distinct from those of the Asiatic elephant have been mentioned under the heading of the latter species. The most important of these are the greater tolerance by the African animal of sunlight, and the hard nature of its food, which consists chiefly of boughs and roots. The latter are dug up with the tusks; the left one being generally employed in this service, and thus becoming much more worn than its fellow.

(R. L.*)

ELEPHANTA ISLE (called by the natives *Gharapuri*), a small island between Bombay and the mainland of India, situated about 6 m. from Bombay. It is nearly 5 m. in circumference, and the few inhabitants it contains are employed in the cultivation of rice, and in rearing sheep and poultry for the Bombay market. The island, till within recent times, was almost entirely overgrown with wood; it contains several springs of good water. There are also important quarries of building stone. But it owes its chief celebrity to the mythological excavations and sculptures of Hindu superstition which it contains. Opposite to the landing-place was a colossal statue of an elephant, cracked and mutilated, from which the island received from the Portuguese the name it still bears. The statue was removed in 1864, and may now be seen in the Victoria Gardens, Bombay. At a short distance from this spot is a cave, the entrance to which is nearly 60 ft. wide and 18 high, supported by pillars cut out of the rock; the sides are sculptured into numerous compartments, containing representations of the Hindu deities, but many of the figures have been defaced by the zeal of the Mahommedans and Portuguese. In the centre of the excavations is a remarkable *Trimurti* or bust, formerly thought to represent the Hindu Triad, namely, Brahma the Creator, Vishnu the Preserver, and Siva or Mahadeva the Destroyer, but now held to be a triform representation of Siva alone. The heads are from 4 to 5 ft. in length, and are well cut, and the faces, with the exception of the under lip, are handsome. The head-dresses are curiously ornamented; and one of the figures holds in it’s hand a cobra, while on the cap are, amongst other symbols, a human skull and an infant. On each side of the Trimurti is a pilaster, the front of which is filled up by a human figure leaning on a dwarf, both much defaced. There is a large compartment to the right, hollowed a little, and covered with a great variety of figures, the largest of which is 16 ft. high, representing the double figure of Siva and Parvati, named Viraj, half male and half female. On the right is Brahma, four-faced, on a lotus—one of the very few representations of this god which now exist in India; and on the left is Vishnu. On the other side of the Trimurti is another compartment with various figures of Siva and Parvati, the most remarkable of which is Siva in his vindictive character, eight-handed, with a collet of skulls round his neck. On the right of the entrance to the cave is a square apartment, supported by eight colossal figures, containing a gigantic symbol of Mahadeva or Siva cut out of the rock. In a ravine connected with the great cave are two other caves, also containing sculptures, which, however, have been much defaced owing to the action of damp and the falling of the rocks; and in another hill is a fourth cave. This interesting retreat of Hindu religious art is said to have been dedicated to Siva, but it contains numerous representations of other Hindu deities. It has, however, for long been a place not so much of worship as of archaeological and artistic interest alike to the European and Hindu traveller. It forms a wonderful monument of antiquity, and must have been a work of incredible labour. Archaeological authorities are of opinion that the cave must have been excavated about the 10th century of the Christian era, if not earlier. The island is much frequented by the British residents of Bombay; and during his tour in India in 1875 King Edward VII., then prince of Wales, was entertained there at a banquet.

ELEPHANTIASIS (*Barbadoes leg*; *Boucnemia*), is a disease dependent on chronic lymphatic obstruction, and characterized by hypertrophy of the skin and subcutaneous tissue. Two distinct forms are known, (1) elephantiasis arabum, due to the development of living parasites, filaria sanguinis hominis (or filaria Bancrofti), and (2) the non-filarial form due to lymphatic obstruction from any other cause whatsoever, as erysipelas, the deposit of tuberculous or cancerous material in the lymphatic glands, phlegmasia dolens (white leg), long-continued eczema, &c. The enlargement is limited to a particular part of the body, generally one, or in rare cases both of the lower limbs, occasionally the scrotum, one of the labiae or the mammary gland; far more rarely the face. An attack is usually ushered in by febrile disturbance (elephantoid fever), the part attacked becoming rapidly swollen, and the skin tense and red as in erysipelas. The subcutaneous tissues become firm, infiltrated and hard, pitting only on considerable pressure. The skin becomes roughened with a network of dilated lymphatics, and vesicles and bullae may form, discharging a chyle-like fluid when broken (lymphorrhoea). In a later stage still the skin may be coarse and wart-like, and there is a great tendency for varicose ulcers to form. At the end of a variable time enlargement ceases to take place, and the disease enters a quiescent state: but recrudescences occur at irregular intervals, always ushered in by elephantoid fever. At the end of some years the attacks of fever cease, and the affected part remains permanently swollen. The only difference in the history of the two forms of the disease lies in the fact that the non-filarial form progresses steadily, until either the underlying condition is cured, or in the case of cancer, &c., brings about a fatal issue. The elephantiasis due to filaria is spread by the agency of mosquitoes, in whose bodies the intermediate stage is passed. The dead mosquito falls upon the water, which thus becomes infected, and hence the ova reach the human stomach. The young worm develops, bores through the gastric mucous membrane and finally becomes lodged in the lymphatics, usually of one or other of the extremities. A large number of embryonic filariae are produced. Some remain in the lymphatic spaces and cause lymphatic obstruction, while others enter the blood stream by night (filaria nocturna), or by day (filaria diurna). It is supposed that a mosquito, biting an infected person, itself becomes infected with the blood it abstracts, and that so a new generation is developed.

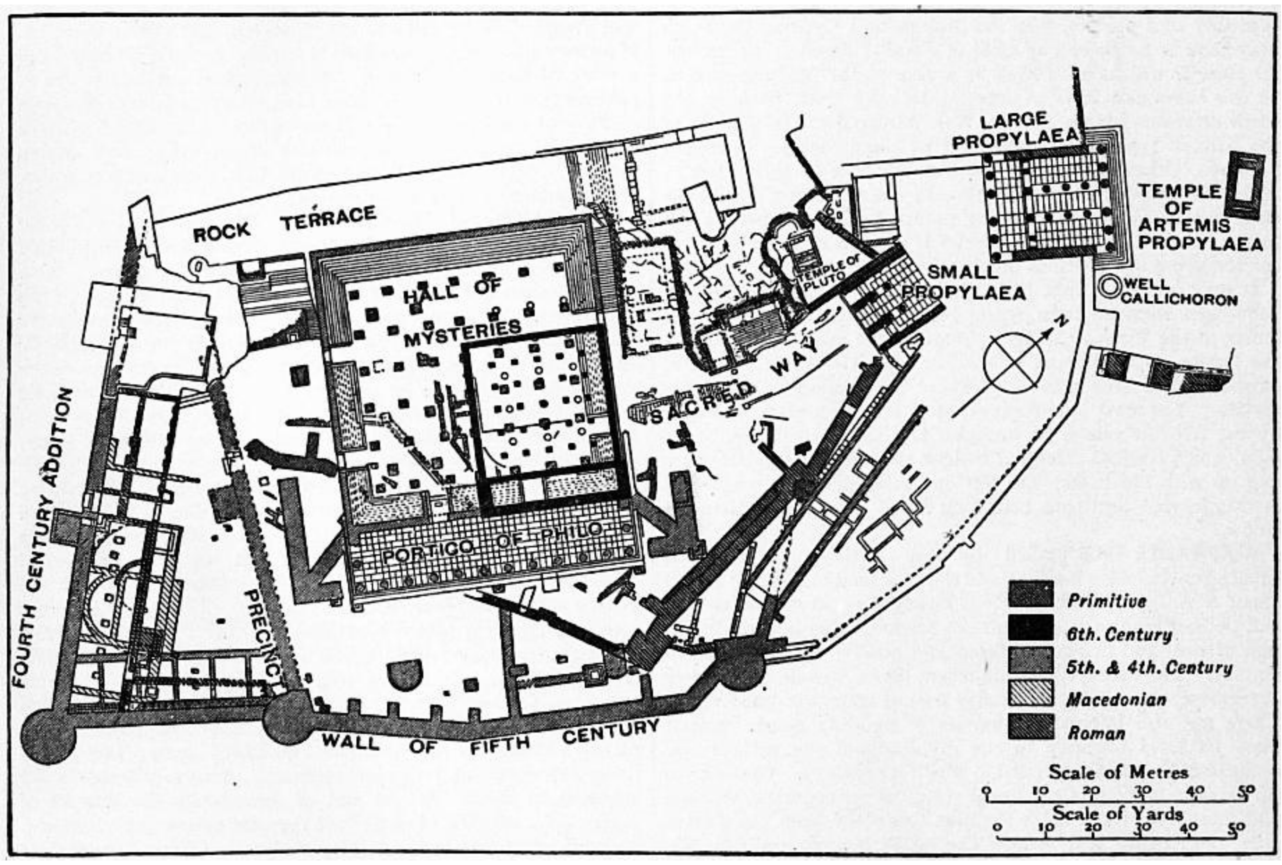
Treatment for this condition is unsatisfactory. Occasionally the dilated lymph trunks can be found, and an operation performed to implant them in some vein (lymphangeioplasty). And in some few other cases artificial lymphatics have been made by introducing sterilized silk thread in the subcutaneous tissues of the affected part, and prolonging it into the normal tissues. This operation has been most successful when performed on elephantoid arms dependent on a late stage of cancerous breast. 262 Elevation of the limb and elastic pressure should always be tried, but often amputation has to be resorted to in the end. The disease is totally different from the so-called elephantiasis graecorum or true leprosy, for which see Leprosy.

ELEPHANT'S-FOOT, the popular name for the plant *Testudinaria elephantipes*, a native of the Cape of Good Hope. It takes its name from the large tuberous stem, which grows very slowly but often reaches a considerable size, *e.g.* more than 3 yds. in circumference with a height of nearly 3 ft. above ground. It is rich in starch, whence the name Hottentot bread, and is covered on the outside with thick, hard, corky plates. It develops slender, leafy, climbing shoots which die down each season. It is a member of the monocotyledonous order Dioscoreaceae, climbing plants with slender herbaceous or shrubby shoots, to which belong the yam and the British black bryony, *Tamus communis*.

ELETS, a town of Russia, in the government of Orel, 122 m. by rail E.S.E. of Orel, on the railway which connects Riga with Tsaritsyn on the lower Volga. Pop. (1883) 36,680; (1900) 38,239. Owing to its advantageous position Elets has grown rapidly. Its merchants buy large quantities of grain, and numerous flour-mills, many of them driven by steam, prepare flour, which is forwarded to Moscow and Riga. The trade in cattle is very important. Elets has the first grain elevator erected in Russia (1887), a railway school, and important tanneries, foundries for cast iron and copper, tallow-melting works, limekilns and brickworks. The cathedral and two monasteries contain venerated historic relics.

Elets is first mentioned in 1147, when it was a fort of Ryazan. The Turkish Polovtsi or Kumans attacked it in the 12th century, and the Mongols destroyed it during their first invasion (1239) and again in 1305. The Tatars plundered it in 1415 and 1450; and it seems to have been completely abandoned in the latter half of the 15th century. Its development dates from the second half of the 17th century, when it became a centre for the trade with south Russia.

ELEUSIS, an ancient Greek city in Attica about 14 m. N.W. of Athens, occupying the eastern part of a rocky ridge close to the shore opposite the island of Salamis. Its fame is due chiefly to its Mysteries, for which see Mystery. Tradition carries back the origin of Eleusis to the highest antiquity. In the earlier period of its history it seems to have been an independent rival of Athens, and it was afterwards reckoned one of the twelve Old Attic cities. A considerable portion of its small territory was occupied by the plains of Thria, noticeable for their fertility, though the hopes of the husbandmen were not unfrequently disappointed by the blight of the south wind. To the west was the Πεδίον Ῥάριον or Rharian Plain, where Demeter is said to have sown the first seeds of corn; and on its confines was the field called Orgas, planted with trees consecrated to Demeter and Persephone. The sacred buildings were destroyed by Alaric in A.D. 396, and it is not certain whether they were restored before the extinction of all pagan rites by Theodosius. The present village on the site is of Albanian origin; it is called Lefsina or Lepsina, officially Ἐλευσίς.



The Site.—Systematic excavations, begun in 1882 by D. Philios for the Greek Archaeological Society, have laid bare the whole of the sacred precinct. It is now possible to trace its boundaries as extended at various periods, and also many successive stages in the history of the Telesterion, or Hall of Initiation. These complete excavations have shown the earlier and partial excavations to have been in some respects deceptive.

In front of the main entrance of the precinct is a large paved area, with the foundations of a temple in it, usually identified as that of Artemis Propylaea; in their present form both area and temple date from Roman times; and on each side of the Great Propylaea are the foundations of a Roman triumphal arch. Just below the steps of the Propylaea, on the left as one enters, there has been discovered, at a lower level than the Roman pavement, the curb surrounding an early well. This is almost certainly the 263
λλίχορον φρέαρ mentioned by Pausanias. The Great Propylaea is a structure of Roman imperial date, in close imitation of the Propylaea on the Athenian Acropolis. It is, however, set in a wall of 6th-century work, though repaired in later times. This wall encloses a sort of outer court, of irregular triangular shape. The Small Propylaea is not set exactly opposite to the Great Propylaea, but at an angle to it; an inscription on the architrave records that it was built by Appius Claudius Pulcher, the contemporary of Cicero. It is also set in a later wall that occupies approximately the same position as two earlier ones, which date from the 6th and 5th centuries respectively, and must have indicated the boundary of the inner precinct. From the Small Propylaea a paved road of Roman date leads to one of the doors of the Telesterion. Above the Small Propylaea, partly set beneath the overhanging rock, is the precinct of Pluto; it has a curious natural cleft approached by rock-cut steps. Several inscriptions and other antiquities were found here, including the famous head, now in Athens, usually called Eubouleus, though the evidence for its identification is far from satisfactory. A little farther on is a rock-cut platform, with a well, approached by a broad flight of steps, which probably served for spectators of the sacred procession. Beyond this, close to the side of the Telesterion, are the foundations of a temple on higher ground; it has been conjectured that this was the temple of Demeter, but there is no evidence that such a building existed in historic times, apart from the Telesterion.

The Telesterion, or Hall of Initiation, was a large covered building, about 170 ft. square. It was surrounded on all sides by steps, which must have served as seats for the mystae, while the sacred dramas and processions took place on the floor of the hall: these seats were partly built up, partly cut in the solid rock; in later times they appear to have been cased with marble. There were two doors on each side of the hall, except the north-west, where it is cut out of the solid rock, and a rock terrace at a higher level adjoins it; this terrace may have been the station of those who were not yet admitted to the full initiation. The roof of the hall was carried by rows of columns, which were more than once renewed.

The architectural history of the hall has been traced by Professor W. Dörpfeld with the help of the various foundations that have been brought to light. The earliest building on the site is a small rectangular structure, with walls of polygonal masonry, built of the rock quarried on the spot. This was succeeded by a square hall, almost of the same plan as the later Telesterion, but about a quarter of the size; its eastern corner coincides with that of the later building, and it appears to have had a portico in front like that which, in the later hall, was a later addition. Its roof was carried by columns, of which the bases can still be seen. This building has with great probability been assigned to the time of Peisistratus; it was destroyed by the Persians. Between this event and the erection of the present hall, which must be substantially the one designed by Ictinus in the time of Pericles, there must have been a restoration, of which we may see the remains in a set of round sinkings to carry columns, which occur only in the north-east part of the hall; a set of bases arranged on a different system occur in the south-west part, and it is difficult to see how these two systems could be reconciled unless there were some sort of partition between the two parts of the hall. Both sets were removed to make way for the later columns, of which the bases and some of the drums still remain. These later columns are shown, by inscriptions and other fragments built into their bases, to belong to later Roman times. At the eastern and southern corners of the hall of Ictinus are projecting masses of masonry, which may be the foundation for a portico that was to be added; but perhaps they were only buttresses, intended to resist the thrust of the roof of this huge structure, which rested at its northern and western corners against the solid rock of the hill. On the south-east side the hall is faced with a portico, extending its whole width; the marble pavement of this portico is a most conspicuous feature of Eleusis at the present day. The portico was added to the hall by the architect Philo, under Demetrius of Phalerum, about the end of the 4th century B.C. It was never completed, for the fluting of its columns still remains unfinished.

The Telesterion took up the greater part of the sacred precinct, which seems merely to have served to keep the profane away from the temple. The massive walls and towers of the time of Pericles, which resemble those of a fortress, are quite close in on the south and east; later, probably in the 4th century B.C., the precinct was extended farther to the south, and at its end was erected a building of considerable extent, including a curious apsidal chamber, for which a similar but larger curved structure was substituted in Roman times. This was probably the Bouleuterion. The precinct was full of altars, dedications and inscriptions; and many fragments of sculptures, pottery and other antiquities, from the earliest to the latest days of Greece, have been discovered. It is to be noted that the subterranean passages which some earlier explorers imagined to be connected with the celebration of the mysteries, have proved to be nothing but cisterns or watercourses.

The excavations of Eleusis, and the antiquities found in them, have been published from time to time in the Ἐφημερὶς Ἀρχαιολογική and in the Πρακτικά of the Greek Archaeological Society, especially for 1887 and 1895. See also D. Philios, *Éleusis, ses mystères, ses ruines, et son musée*. Inscriptions have also been published in the *Bulletin de correspondance hellénique*.

(E. Gr.)

ELEUTHERIUS, pope from about 175 to 189. Allusions to him are found in the letters of the martyrs of Lyons, cited by Eusebius, and in other documents of the time. The *Liber Pontificalis*, at the beginning of the 6th century, says that he had relations with a British king, Lucius, who was desirous of being converted to Christianity. This tradition—Roman, not British—is an enigma to critics, and, apparently, has no historical foundation.

(L. D.*)

ELEUTHEROPOLIS (Gr. Ἐλευθέρα πόλις, “free city”), an ancient city of Palestine, 25 m. from Jerusalem on the road to Gaza, identified by E. Robinson with the modern Beit Jibrīn. This identification is confirmed by Roman milestones in the neighbourhood. It represents the Biblical Mareshah, the ruins of which exist at Tell Sandahannah close by. As Betogabra it is mentioned by Ptolemy; the name Eleutheropolis dates from the Syrian visit of Septimius Severus (A.D. 202). Eusebius in his *Onomasticon* uses it as a central point from which the distances of other towns are measured. It was destroyed in 796, rebuilt by the crusaders in 1134 (their fortress and chapel remain, much ruined). It was finally captured by Bibars, 1244. Beit Jibrīn is in the centre of a district of great archaeological interest. Besides the crusader and other remains in the village itself, the surrounding country possesses many *tells* (mounds) covering the sites of ancient cities. The famous caves of Beit Jibrīn honeycomb the hills all round. These are immense artificial excavations of unknown date. Roman milestones and aqueducts also are found, and close by the now famous tomb of Apollophanes, with wall-paintings of animals and other ornamentation, was discovered in 1902; a description of it will be found in Thiersch and Peters, *The Marissa Tombs*, published by the Palestine Exploration Fund.

(R. A. S. M.)

ELEVATORS, Lifts or Hoists, machines for raising or lowering loads, whether of people or material, from one level to another. They are operated by steam, hydraulic or electric power, or, when small and light, by hand. Their construction varies with the magnitude of the work to be performed and the character of the motive power. In private houses, where only small weights, as coal, food, &c., have to be transferred from one floor to another, they usually consist simply of a small counter-balanced platform suspended from the roof or an upper floor by a tackle, the running part of which hangs from top to bottom and can be reached and operated at any level. In buildings where great weights and numbers of people have to be lifted, or a high speed of elevation is demanded, some form of motor is necessary. This is usually, directly or indirectly, a steam-engine or occasionally a gas-engine; sometimes a water-pressure engine is adopted, and it is becoming more and more common to employ an electric motor deriving its energy from the general distribution of the city. Large establishments, 264
hotels or business houses, commonly have their own source of energy, an electric or other power “plant,” on the premises.

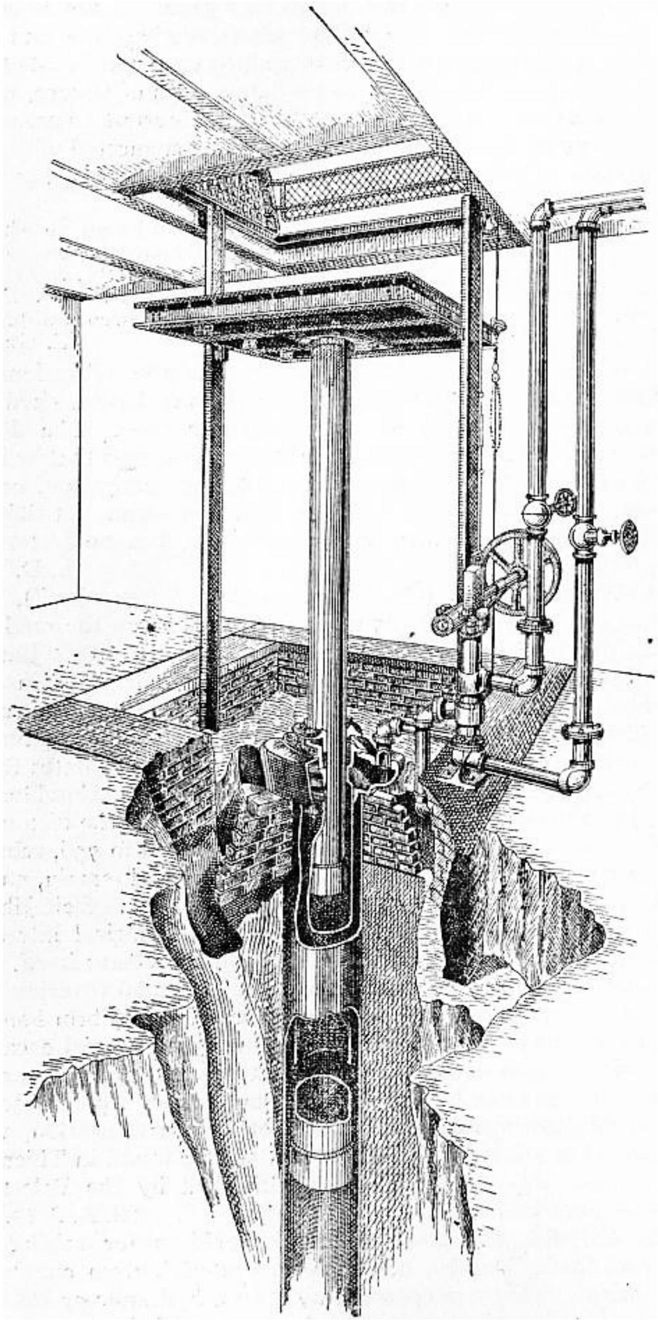


Fig. 1.—The Plunger, or Direct Lift Hydraulic Engine.

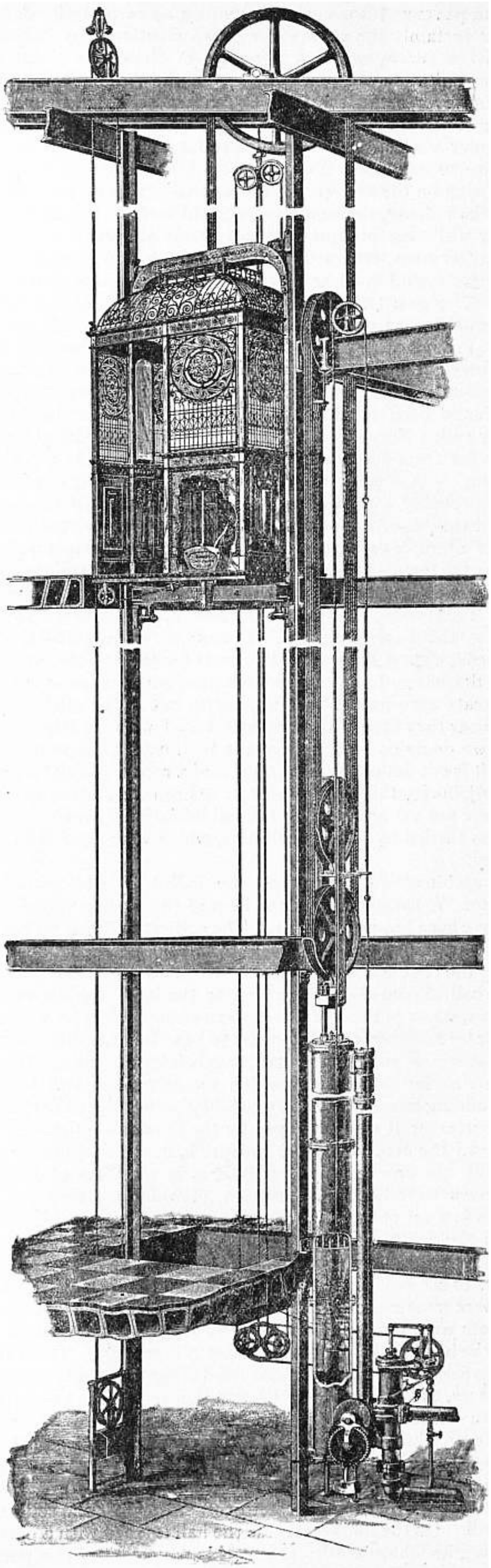


FIG. 2.—The Otis Standard Hydraulic Passenger Lift, with Pilot Valve and Lever-operating Device.

The hydraulic elevator is the simplest in construction of elevators proper, sometimes consisting merely of a long pipe set deeply in the ground under the cage and containing a correspondingly long plunger, which rises and falls as required and carries the elevator-cage on its upper end (fig. 1). The “stroke” is thus necessarily equal to the height traversed by the cage, with some surplus to keep the plunger steady within its guiding-pipe. The pipe

Construction of elevators.

or pump chamber has a length exceeding the maximum rise and fall of the plunger, and must be strong enough to sustain safely the heavy hydraulic pressures needed to raise plunger and cage with load. The power is usually supplied by a steam pump (occasionally by a hydraulic motor), which forces water into the chamber of the great pipe as the elevator rises, a waste-cock drawing off the liquid in the process of lowering the cage. A single handle within the cage generally serves to apply the pressure when raising, and to reduce it when lowering the load. The most common form of hydraulic elevator, for important work and under usual conditions of operation, as in cities, consists of a suspended cage, carried by a tackle, the running part of which is connected with a set of pulleys at each end of a frame (fig. 2). The rope is made fast at one end, and its intermediate part is carried round first one pulley at the farther end of the frame and then round another at the nearer end, and so on as often as is found advisable in the particular case. The two pulley shafts carrying these two sets of pulleys are made to traverse the frame in such a way as, by their separation, to haul in on the running part, or, by their approximation, to permit the weight of the cage to haul out the rope. By this alternate hauling and "rendering" of the rope the cage is raised and lowered. The use of a number of parallel and independent sets of pulleys and tackles assures safety in case of the breakage of any one, each being strong enough alone to hold the load. The movement of the pair of pulley shafts is effected by a water-pressure engine, actuating the plunger of a pump which is similar to that used in the preceding apparatus, but being relatively of short stroke and large diameter, is more satisfactory in design and construction as well as in operation. Electricity may be applied to elevators of this type by attaching the travelling sheaves to a nut in which works a screwed shaft driven by an electric motor. In other electric lifts the cables which support the cage are wound on a drum which is turned by a motor, the drum being connected to the motor-shaft either by a series of pinions or by a worm-gear. The drum may also be worked by a steam or gas engine. Where the traffic is not very heavy, a form of elevator that requires no attendant is convenient. In this any one wishing to use the lift has merely to press a button placed by the side of the lift-gate on the floor on which he happens to be standing, when the car will come to him; and having entered it he can cause it to travel to any floor he desires by pressing another button inside the car. The motive power in such cases may be either electric or hydraulic, but the control of the switches or valves that govern the action of the apparatus is electric. 265

The history of the elevator is chronologically extensive, but only since 1850 has rapid or important progress been effected. In that year George H. Fox & Co. built an elevator operated by the motion of a vertical screw, the nut on which carried the cage. This device was used in a number of instances, especially in hotels in the large cities, during the succeeding twenty years, and was then generally supplanted by the hydraulic lift of the kind already described as the plunger-lift. With the increased demand for power, speed, safety, convenience of manipulation, and comfort in operation, the inventive ability of the engineer developed the various systems more and more perfectly, and experience gradually showed to what service each type was best adapted and the best construction of each for its peculiar work. Whatever the class, the following are the essentials of design, construction and operation: the elevator must be safe, comfortable, speedy and convenient, must not be too expensive in either first cost or maintenance, and must be absolutely trustworthy. It must not be liable to fracture of any element of the hoisting gear that will permit either the fall of the cage or its projection by an overweighted balance upwards against the top of its shaft. It must be possible to stop it, whether in regular working or in emergency, or when accident occurs, with sufficient promptness, yet without endangering life or property, or even very seriously inconveniencing the passengers. Acceleration and retardation in starting and stopping must be smooth and easy, the stop must be capable of being made precisely where and when intended, and no danger must be incurred by the passengers from contact with running parts of the mechanism or with the walls and doors of the elevator shaft.

Essentials of design, &c.

These requirements have been fully met in the later forms of elevator commonly employed for passenger service. Usual sizes range from loads of 1000 to 5000 ℔ with speeds of from 80 to 250 ft. a minute unloaded, and 75 to 200 ft. loaded, and a height of travel of from 50 to 200 ft. In some very tall buildings, as the Singer and Metropolitan buildings in New York, elevators have been installed having a maximum speed of 600 ft. a minute, with a rise of over 500 ft. Where electric motors are employed, their speed ranges from 600 and 700 revolutions per minute in the larger to 1000 and 1200 in the smaller sizes, corresponding to from 20 down to 4 or 5 h.p. Two or more counter-weights are employed, and from four to six suspension cables ensure as nearly as possible absolute safety. The electric elevators of the Central London railway are guaranteed to raise 17,000 ℔ 65 ft. in some of its shafts, in 30 secs. from start to stop. Over 100,000 ft. of ⅞ in. and 17,000 ft. of ¾ in. steel rope are required for its 24 shafts, and each rope can carry from 16 to 22 tons without breaking. The steel used in the cables, of which there are four to six for each car and counter-weight, has a tenacity of 85 to 90 tons per sq. in. of section of wire. The maximum pull on each set of rope is assumed to be not over 9500 ℔, the remainder of the load being taken by the counterbalance. Oil "dash-pots" or buffers, into which enter plungers attached to the bottom of the cage, prevent too sudden a stop in case of accident, and safety-clutches with friction adjustments of ample power and fully tested before use give ample insurance against a fall even if all the cables should yield at once—an almost inconceivable contingency. The efficiency, *i.e.* the ratio of work performed to power expended in the same time, was in these elevators found by test to be between 70 and 75%.

Safety devices constitute perhaps the most important of the later improvements in elevator construction where passengers are carried. The simplest and, where practicable, most certain of them is the "air-cushion", a chamber into which the cage drops if detached or from any cause allowed to fall too rapidly to the bottom, compression of the air bringing it to rest without shock (fig. 3). This chamber must be perfectly air-tight, except in so far as a purposely arranged clearance around the sides, diminishing downwards and in well-established proportion, is adjusted to permit a "dash-pot" action and to prevent rebound. The air-cushion should be about one-tenth the depth of the elevator shaft; in high buildings it may be a well 20 or 30 ft. deep. The Empire building, in New York, is twenty storeys in height, the total travel of the cage is 287 ft., and the air-cushion is 50 ft. deep, extending from the floor of the third storey to the bottom of the shaft. Sliding doors of great strength, and automatic in action, at the first and second floors, are the only openings. The shaft is tapered for some distance below the third floor, and then carried straight to the bottom. An inlet valve admits air freely as the cage rises, and an adjusted safety-valve provides against excess pressure. A "car," falling freely from the twentieth storey, was checked by this arrangement without injury to a basket of eggs placed on its floor. Other safety devices consist of catches under the floor of the cage, so arranged that they are held out of engagement by the pull on the cables. But if the strain is suddenly relieved, as by breakage of a cable or accident to the engine or motor, they instantly fly into place and, engaging strong side-struts in the shaft, hold the car until it can be once more lifted by its cables. These operate well when the cables part at or near the car, but they are apt to fail if the break occurs on the opposite side of the carrying sheaves at the top of the shaft, since the friction and inertia of the mass of the cables may in that case be sufficient to hold the pawls out of gear either entirely or until the headway is so great as to cause the smashing of all resistances when they do engage.

Safety devices.

Fig. 3.
Safety Air-Cushion.

Another principle employed in safety arrangements is the action of inertia 266
of parts properly formed and attached. Any dangerous acceleration of the cage causes the inertia of these parts to produce a retardation relative to the car which throws into action a brake or a catch, and thus controls the motion within safe limits or breaks the fall. The hydraulic brake has been used in this apparatus, as have mechanical and pneumatic apparatus. This control of the speed of fall is most commonly secured by the employment of a centrifugal or other governor or regulator. The governor may be on the top of the cage and driven by a stationary rope fixed between the top and bottom of the shafts, or it may be placed at the top of the shaft and driven by a rope travelling with the car. Its action is usually to trip into service a set of spring grips or friction clutches, which, as a rule, grasp the guides of the cage and by their immense pressure and great resultant friction bring the cage to rest within a safe limit of speed, time and distance. A coefficient of friction of about 15% is assumed in their design, and this estimate is confirmed by their operation. Pressures of 10 tons or more are sometimes provided in these grips to ensure the friction required. There are many different forms of safety device of these various classes, each maker having his own. The importance of absolute safety against a fall is so great that the best builders are not satisfied with any one form or principle, but combine provisions against every known danger, and often duplicate such precautions against the most common accidents.

The "travelling staircase," which may be classed among the passenger elevators, usually consists of a staircase so constructed that while the passenger is ascending it the whole structure is also ascending at a predetermined rate, so that the progress made is the sum of the two rates of motion. The system of "treads and risers" is carried on a long endless band of chain sustained by guides holding it in its desired line, and rendering at either end over cylinders or sprockets. The junctions between the stairway and the upper or lower floors are ingeniously arranged so as to avoid danger of injury to the passengers.

Freight elevators have the same general forms as the passenger elevators, but are often vastly larger and more powerful, and are not as a rule fitted up for such heights of lift, or constructed with such elaborate provision for safety or with any special finish. Elevators raising grain, coal, earth and similar materials, such as can be taken up by scooping into a bucket, or can be run into and out of the bucket by gravity, constitute a class by themselves, and are described in the article Conveyors.

The term "grain elevator" is often used to include buildings as well as machinery, and it is not unusual in Europe to hear a flour-mill, with its system of motor machinery, mills, elevator and storage departments, spoken of as an "American elevator" (see Granaries).

ELF (O. Eng. *aelf*; cf. Ger. *Alp*, nightmare), a diminutive supernatural being of Teutonic mythology, usually of a more or less mischievous and malignant character, causing diseases and evil dreams, stealing children and substituting changelings, and thus somewhat different from the Romanic fairy, which usually has less sinister associations. The prehistoric arrow-heads and other flint implements were in England early known as “elf-bolts” or “elf-arrows,” and were looked on as the weapons of the elves, with which they injured cattle. So too a tangle in the hair was called an “elf-lock,” as being caused by the mischief of the elves.

ELGAR, SIR EDWARD (1857-), English musical composer, son of W.H. Elgar, who was for many years organist in the Roman Catholic church of St George at Worcester, was born there on the 2nd of June 1857. His father’s connexion with music at Worcester, with the Glee Club and with the Three Choirs Festivals, supplied him with varied opportunities for a musical education, and he learnt to play several instruments. In 1879 he became bandmaster at the county lunatic asylum, and held that post till 1884. He was also a member of an orchestra at Birmingham, and in 1883 an intermezzo by him was played there at a concert. In 1882 he became conductor of the Worcester Amateur Instrumental Society; and in 1885 he succeeded his father as organist at St George’s, Worcester. There he wrote a certain amount of church music. In 1889 he moved to London, but finding no encouragement retired to Malvern in 1891; in 1904 he went to live at Hereford, and in 1905 was made professor of music at Birmingham University. To the public generally he was hardly known till his oratorio *The Dream of Gerontius* was performed at Birmingham in 1900, but this was at once received as a new revelation in English music, both at home and by Richard Strauss in Germany, and the composer was made a Mus. Doc. at Cambridge. His experience in writing church music for a Roman Catholic service cannot be overlooked in regard to this and other works by Elgar, who came to be regarded as the representative of a Catholic or neo-Catholic style of religious music, for which an appreciative public was ready in England at the moment, owing to the recent developments in the more artistic and sensuous side of the religious movement. And the same interest attached to his later oratorios, *The Apostles* (1903) and *The Kingdom* (1906). But Elgar’s sudden rise into popularity, confirmed by his being knighted in 1904, drew attention to his other productions. In 1896 his *Scenes from the Saga of King Olaf* was recognized by musicians as a fine work, and in the same year his *Scenes from the Bavarian Highlands* and *Lux Christi* were performed; and apart from other important compositions, his song-cycle *Sea-Pictures* was sung at Norwich in 1899 by Clara Butt, and his orchestral *Variations on an original theme* were given at a Richter concert in the same year. In 1901 his popular march “Pomp and Circumstance” was played at a promenade concert, the stirring melody of his song “Land of Hope and Glory” being effectually utilized. It is impossible here to enumerate all Sir Edward Elgar’s works, which have excited a good deal of criticism in musical circles without impairing his general recognition as one of the few front-rank English composers of his day; but his most important later production, his first orchestral symphony, produced in 1908 with immediate success, raised his reputation as a composer to an even higher place, as a work of marked power and beauty, developing the symphonic form with the originality of a real master of his art. In 1908 he resigned his professorship at Birmingham University.

ELGIN, a city of Kane county, Illinois, U.S.A., in the N. part of the state, 36 m. N.W. of Chicago. Pop. (1880) 8787; (1890) 17,823; (1900) 22,433, of whom 5419 were foreign-born; (1910 census) 25,976. Elgin is served by the Chicago & North-Western and the Chicago, Milwaukee & St Paul railways, and by interurban electric railways to Chicago, Aurora and Belvidere. The city is the seat of the Northern Illinois hospital for the insane, of the Elgin Academy (chartered 1839; opened 1856), and of St Mary’s Academy (Roman Catholic); and has the Gail Borden public library, with 35,000 volumes in 1908. The city has six public parks, Lord’s Park containing 112, and Wing Park 121 acres. The city is in a fine dairying region and is an important market for butter. Among Elgin’s manufactures are watches and watch-cases, butter and other dairy products, cooperage (especially butter tubs), canned corn, shirts, foundry and machine-shop products, pipe-organs, and caskets and casket trimmings; in 1905 Elgin’s total factory product was valued at $9,349,274. The Elgin National Watch factory, and the Borden milk-condensing works, are famous throughout the United States and beyond. The publishing office of the Dunkers, or German Brethren, is at Elgin; and several popular weeklies with large circulations are published here. A permanent settlement was made as early as 1835, and Elgin was chartered as a city in 1854 and was rechartered in 1880.

ELGIN, a royal, municipal and police burgh, and county town of Elginshire, Scotland, situated on

the Lossie, 5 m. S. of Lossiemouth its port, on the Moray Firth, and 71¼ m. N.W. of Aberdeen, with stations on the Great North of Scotland and Highland railways. Pop. (1901) 8460. It is a place of very considerable antiquity, was created a royal burgh by Alexander I., and received its charter from Alexander II. in 1234. Edward I. stayed at the castle in 1296 and 1303, and it was to blot out the memory of his visit that the building was destroyed immediately after national independence had been reasserted. The hill on which it stood was renamed the Ladyhill, and on the scanty ruins of the castle 267
now stands a monument to the 5th duke of Gordon, consisting of a column surmounted by a statue.

The burgh has suffered periodically from fire, notably in 1452, when half of it was burnt by the earl of Huntly. Montrose plundered it twice in 1645. In 1746 Prince Charles Edward spent a few days in Thunderton House. His hostess, Mrs Anderson, an ardent Jacobite, kept the sheets in which he slept, and was buried in them on her death, twenty-five years afterwards. For fifty years after this date the place retained the character and traditions of a sleepy cathedral city, but with the approach of the 19th century it was touched by a more modern spirit. As the result much that was picturesque disappeared, but the prosperity of Elgin was increased, so that now, owing to its pleasant situation in “the Garden of Scotland,” its healthy climate, cheap living, and excellent educational facilities, it has become a flourishing community. The centre of interest is the cathedral of Moray, which was founded in 1224, when the church of the Holy Trinity was converted to this use. It was partially burned in 1270 and almost destroyed in 1390 by Alexander Stewart, the Wolf of Badenoch, natural son of Robert II., who had incurred the censure of the Church. In 1402 Alexander, lord of the Isles, set fire to the town, but spared the cathedral for a consideration, in memory of which mercy the Little Cross (so named to distinguish it from the Muckle or Market Cross, restored in 1888) was erected. After these outrages it was practically rebuilt on a scale of grandeur that made it the most magnificent example of church architecture in the north. Its design was that of a Jerusalem cross, with two flanking towers at the east end, two at the west end, and one in the centre, at the intersection of the roofs of the nave and transepts. It measured 282 ft. long from east to west by 120 ft. across the transepts, and consisted of the choir, the gable of which was pierced by two tiers of five lancet windows and the Omega rose window; the north transept, in which the Dunbars were buried, and the south transept, the doorway of which is interesting for its dog’s-tooth ornamentation; and the nave of five aisles. The grand entrance was by the richly carved west door, above which was the Alpha window. The central steeple fell in 1506, but was rebuilt, the new tower with its spire reaching a height of 198 ft. By 1538 the edifice was complete in every part. Though the Reformation left it unscathed, it suffered wanton violence from time to time. By order of the privy council the lead was stripped off the roofs in 1567 and sold to Holland to pay the troops; but the ship conveying the spoils foundered in the North Sea. In 1637 the roof-tree of the choir perished during a gale, and three years later the rich timber screen was demolished. The central tower again collapsed in 1711, after which the edifice was allowed to go to ruin. Its stones were carted away, and the churchyard, overgrown with weeds, became the dumping-ground for rubbish. It lay thus scandalously neglected until 1824, when John Shanks, a “drouthy” cobbler, was appointed keeper. By a species of inspiration this man, hitherto a ne’er-do-well, conceived the notion of restoring the place to order. Undismayed, he attacked the mass of litter and with his own hands removed 3000 barrow-loads. When he died in 1841 he had cleared away all the rubbish, disclosed the original plan, and collected a quantity of fragments. A tablet, let into the wall, contains an epitaph by Lord Cockburn, recording Shanks’s services to the venerable pile, which has since been entrusted to the custody of the commissioners of woods and forests. The chapter-house, to the north-east of the main structure, suffered least of all the buildings, and contains a ’Prentice pillar, of which a similar story is told to that of the ornate column in Roslin chapel. In the lavatory, or vestibule connecting the chapter-house with the choir, Marjory Anderson, a poor half-crazy creature, a soldier’s widow, took up her quarters in 1748. She cradled her son in the piscina and lived on charity. In the course of time the lad joined the army and went to India, where he rose to the rank of major-general and amassed a fortune of £70,000 with which he endowed the Elgin Institution (commonly known as the Anderson Institution) at the east end of High Street, for the education of youth and the support of old age. Within the precincts of the cathedral grounds stood the bishop’s palace (now in ruins), the houses of the dean and archdeacon (now North and South Colleges), and the manses of the canons. Other ecclesiastical buildings were the monasteries of Blackfriars (1230) and Greyfriars (1410) and the preceptory of Maisondieu (1240). They also were permitted to fall into decay, but the 3rd marquess of Bute undertook the restoration of the Greyfriars’ chapel. The parish church, in the Greek style, was built in 1828. Gray’s hospital, at the west end of High Street, was endowed by Dr Alexander Gray (1751-1808), and at the east end stands the Institution, already mentioned, founded by General Andrew Anderson (1746-1822). Other public buildings include the assembly rooms, the town-hall, the museum (in which the antiquities and natural history of the shire are abundantly illustrated), the district asylum, the academy, the county buildings and the court house, the market buildings, the Victoria school of science and art, and Lady Gordon-Cumming’s children’s home. In 1903 Mr G.A. Cooper presented his native town with a public park of 42 acres, containing lakes representing on a miniature scale the British Isles. Grant Lodge, an old mansion of the Grant family, occupying the south-west corner of the park, was converted into the public library. From the top of Ladyhill the view commands the links of the Lossie and the surrounding country, and a recreation ground is laid out on Lossie Green.

The industries include distilling and brewing, nursery gardening, tanning, saw and flour mills, iron-foundries and manufactures of woollens, tweeds and plaiding, and the quarrying of sandstone. Elgin combines with Banff, Cullen, Inverurie, Kintore and Peterhead to return one member to parliament, and the town is controlled by a council with provost and bailies.

Two miles and a half S. by W. of Elgin stands the church of Birnie, with the exception of the church at Mortlach in Banffshire probably the oldest place of public worship in Scotland still in use. It is not later than 1150 and, with its predecessor, was the cathedral of Moray during the rule of the first four bishops; the fourth bishop, Simon de Toeny, an Englishman, was buried in its precincts in 1184. In the church is preserved an old Celtic altar-bell of hammered iron, known as the "Ronnell bell." Such is the odour of sanctity of this venerable church that there is an old local saying that "to be thrice prayed for in the kirk of Birnie will either mend or end ye." Six miles to the S.W. of Elgin, charmingly situated in a secluded valley encircled by fir-clad heights, lie the picturesque remains of Pluscarden Priory, a Cistercian house founded by Alexander II. in 1230. The ruins, consisting of tower, choir, chapter-house, refectory and other apartments, are nearly hidden from view by their dense coating of ivy and the fine old trees, including many beautiful examples of copper beech, by which they are surrounded. Its last prior, Alexander Dunbar, died in 1560. The *Liber Pluscardensis*, a valuable authority on early Scots history, was compiled in the priory by Maurice Buchanan in 1461. The chronicle comes down to the death of James I. The 3rd marquess of Bute acquired the ruins in 1897.

ELGIN AND KINCARDINE, EARLS OF. Thomas Bruce, 7th earl of Elgin (1766-1841), British diplomatist and art collector, was born on the 20th of July 1766, and in 1771 succeeded his brother in the Scottish peerage as the 7th earl of Elgin (cr. 1633), and 11th of Kincardine (cr. 1647). He was educated at Harrow and Westminster, and, after studying for some time at the university of St Andrews, proceeded to the continent, where he studied international law at Paris, and military science in Germany. When his education was completed he entered the army, in which he rose to the rank of general. His chief attention was, however, devoted to diplomacy. In 1792 he was appointed envoy at Brussels, and in 1795 envoy extraordinary at Berlin; and from 1799 to 1802 he was envoy extraordinary at the Porte. It was during his stay at Constantinople that he formed the purpose of removing from Athens the celebrated sculptures now known as the Elgin Marbles. His doing so was censured by some as vandalism, and doubts were also expressed as to the artistic value of many of the marbles; but he vindicated himself in a pamphlet published in 1810, and entitled *Memorandum on the* 268
Subject of the Earl of Elgin's Pursuits in Greece. In 1816 the collection was purchased by the nation for £36,000, and placed in the British Museum, the outlay incurred by Lord Elgin having been more than £50,000. Lord Elgin was a Scottish representative peer for fifty years. He died at Paris on the 14th of November 1841.

James Bruce, 8th earl of Elgin (1811-1863), British statesman, eldest son of the 7th earl by his second marriage, was born in 1811, and succeeded to the peerage as 8th earl of Elgin and 12th of Kincardine in 1841. He was educated at Eton and at Christ Church, Oxford, where he had as companions and rivals his younger predecessors in the office of governor-general of India, Dalhousie and Canning. He began his official career in 1842 at the age of thirty, as governor of Jamaica. During an administration of four years he succeeded in winning the respect of all classes. He improved the condition of the negroes and conciliated the planters by working through them. In 1846 Lord Grey appointed him governor-general of Canada. Son-in-law of the popular earl of Durham, he was well received by the colonists, and he set himself deliberately to carry out the Durham policy. In this his frank and genial manners aided him powerfully. His assent to the local measure for indemnifying those who had suffered in the troubles of 1837 led the mob of Montreal to pelt his carriage for the rewarding of rebels for rebellion, as Mr Gladstone described it. But long before his eight years' term of service expired he was the most popular man in Canada. His relations with the United States, his hearty support of the self-government and defence of the colony, and his settlement of the free-trade and fishery questions, led to his being raised in 1849 to the British peerage as Baron Elgin.

Soon after his return to England in 1854, Lord Palmerston offered him a seat in the cabinet as chancellor of the duchy of Lancaster, which he declined. But when, in 1856 the seizure of the "Arrow" by Commissioner Yeh plunged England into war with China, he at once accepted the appointment of special envoy with the expedition. On reaching Point de Galle he was met by a force summoned from Bombay to Calcutta by the news of the sepoy mutiny at Meerut on the 11th of May. His first idea, that the somewhat meagre intelligence would justify most energetic action in China, was at once changed when urgent letters from Lord Canning reached him at Singapore, the next port, on the 3rd of June. H.M.S. "Shannon" was at once sent on to Calcutta with the troops destined for China, and Lord Elgin himself followed it, when gloomier letters from India reached him. The arrival of the "Shannon" gave new life to the handful of white men fighting for civilization against fearful odds, and before the reinforcements from England arrived the back of the mutiny had been broken. Nor was the position in China seriously affected by the want of the troops. Lord Elgin sent in his ultimatum to Commissioner Yeh at Canton on the same day, the 12th of December, that he learned the relief of Lucknow, and he soon after sent Yeh a prisoner to Calcutta. By July 1858, after months of Chinese deception, he was able to leave the Gulf of Pechili with the emperor's assent to the Treaty of Tientsin. Subsequently he visited Japan, and obtained less considerable concessions from its government in the Treaty of Yeddo. It is true that the negotiations were confined to the really subordinate Tycoon or Shogun, but that visit proved the beginning of British influence in the most progressive country of Asia. Unfortunately, the Chinese difficulty was not yet at an end. After tedious disputes with the tariff commissioners as to the opium duty, and a visit to the upper waters of the Yang-tzse, Lord Elgin had reached England in May 1859. But when his brother and the allied forces attempted to proceed to Peking with the ratified treaty, they were fired on from the Taku forts at the mouth of the Peiho. The Chinese had resolved to try the fortune of war once more, and Lord Russell again sent out Lord Elgin as ambassador extraordinary to demand an apology for the attack, the execution of the treaty, and an indemnity for the military and naval expenditure. Sir Robert Napier (afterwards Lord Napier of Magdala) and Sir Hope Grant, with the French, so effectually routed the Tatar troops and sacked the Summer Palace that by the 24th of October 1860 a convention was concluded which was "entirely satisfactory to Her Majesty's government." Lord Elgin had not been a month at home when Lord Palmerston selected him to be viceroy and governor-general of India. He had now attained the object of his honourable ambition, after the office had been filled in most critical times by his juniors and old college companions, the marquis of Dalhousie and Earl Canning. He succeeded a statesman who had done much to reorganize the whole administration of India, shattered as it had been by the mutiny. But, as the first viceroy directly appointed by the Crown, and as subject to the secretary of state for India, Lord Elgin at once gave up all Lord Canning had fought for, in the co-ordinate independence, or rather the stimulating responsibility, of the governor-general, which had prevailed from the days of Clive and Warren Hastings. On the other hand, he loyally carried out the wise and equitable policy of his predecessor towards our feudatories with a firmness and a dignity that in the case of Holkar and Udaipur had a good effect. He did his best to check the aggression of the Dutch in Sumatra, which was contrary to treaty, and he supported Dost Mahommed in Kabul until that aged warrior entered the then neutral and disputed territory of Herat. Determined to maintain inviolate the integrity of our own north-west frontier, Lord Elgin assembled a camp of exercise at Lahore, and marched a force to the Peshawar border to punish those branches of the Yusufzai tribe who had violated the engagements of 1858.

It was in the midst of this "little war" that he died. Soon after his arrival at Calcutta, he had projected the usual tour to Simla, to be followed by an inspection of the Punjab and its warlike ring-fence of Pathans. He even contemplated the summoning of the central legislative council at Lahore. After passing the summer of 1863 in the cool retreat of Peterhoff, Simla, Lord Elgin began a march across the hills from Simla to Sialkot by the upper valleys of the Beas, the Ravi and the Chenab, chiefly to decide the two allied questions of tea cultivation and trade routes to Kashgar and Tibet. The climbing up to the Rotung Pass (13,000 ft.) which separates the Beas valley from that of the Chenab, and the crossing of the frail twig bridge across the Chundra torrent, prostrated him by the time he had descended into the smiling English-like Kangra valley. Thence he wrote his last letter to Sir Charles Wood, still full of hope and not free from anxiety as to the Sittana expedition. At the lovely hill station of Dharmsala, "the place of piety," he died of fatty degeneration of heart on the 20th of November 1863.

For his whole career see *Letters and Journals of James, Eighth Earl of Elgin*, edited by Walrond, but corrected by his brother-in-law, Dean Stanley; for the China missions see *Narrative of the Earl of Elgin's Mission to China and Japan*, by Laurence Oliphant, his private secretary; for the brief Indian administration see the *Friend of India* for 1862-1863.

Victor Alexander Bruce, 9th earl of Elgin (1849-), British statesman, was born on the 16th of May 1849, the son of the 8th earl, and was educated at Eton and Balliol College, Oxford. In 1863 he succeeded as 9th earl of Elgin and 13th of Kincardine. A Liberal in politics, he became first commissioner of works (1886), and subsequently viceroy of India (1894-1899). His administration in India was chiefly notable for the frontier risings of 1897-1898. The Afridis broke out into a fanatical revolt and through hesitation on the part of the government were allowed to seize the Khyber Pass, necessitating the Tirah Expedition. After his return to England he was nominated chairman of the royal commission to investigate the conduct of the South African War; and on the formation of Sir Henry Campbell-Bannerman's ministry in December 1905, he became a member of the cabinet as secretary of state for the colonies. In this capacity, though he showed many statesmanlike qualities, he was somewhat overshadowed by his brilliant under-secretary in the Commons, Mr Winston Churchill, whose speeches on colonial affairs were as aggressive as Lord Elgin's were cautious; and when in April 1908, Mr Asquith became prime minister, Lord Elgin retired from the cabinet.

ELGINSHIRE, or Moray (Gaelic "among the seaboard men"), a northern county of Scotland, bounded N. by the Moray Firth, E. and S.E. by Banffshire, S. and S.W. by Inverness and W. by Nairnshire. It comprises only the eastern portion of the ancient province of Moray, which extended from the Spey to the Beauly and from the Grampians to the sea, embracing an area of about 3900 sq. m. The area of the county is 305,119 acres, or 477 sq. m.

Elginshire is naturally divided into two sections, the level and fertile coast and its hinterland—"the Laigh o' Moray," a tract 30 m. long by from 5 to 12 m. broad—and the hilly country in the south. There are, however, no high mountains. Carn Ruigh (1784 ft.), Larig Hill (1783) and Carn Kitty (1711) are the chief eminences in the south-central district until the ridge of the Cromdale Hills is reached on the Banffshire border, where the highest point is 2329 ft. above the sea. The two most important rivers, the Spey (*q.v.*) and the Findhorn, both have their sources in Inverness-shire. About 50 m. of the course of the Spey are in Elginshire, to which it may be roughly said to serve as the boundary line on the south-east and east. The Findhorn rises in the Monadliadh Mountains which form the watershed for several miles between it and the Spey. Of its total course of nearly 70 m. only the last 12 are in the county, where it separates the woods of Altyre from the Forest of Darnaway, before entering the Moray Firth in a bay on the north-eastern shore to which it has given its name. During the first 7 m. of its flow in Elginshire the stream passes through some of the finest scenery in Scotland. It is liable to sudden risings, and in the memorable Moray floods of August 1829 wrought the greatest havoc. Of other rivers the Lossie rises in the small lakes on the flanks of Carn Kitty and pursues a very winding course of 34 m. till it reaches the Moray Firth; Ballintomb Burn, Rothes Burn and Tulchan Burn are left-hand affluents of the Spey; the Dorbock and Divie, uniting their forces near Dunphail House, join the Findhorn at Relugas; and Muckle Water, a left-hand tributary of the Findhorn, comes from Nairnshire. The Spey and Findhorn are famous for salmon, but some of the smaller streams, too, afford good sport. The lochs are few and unimportant, among them being Loch Spynie, 2½ m. N., and Loch-na-Bo, 4 m. S.E. of Elgin; Loch of Blairs, 2½ m. S. of Forres; Loch Romach, 3 m. S. of Rafford; Loch Dallas, about 4 m. S.W. of Dallas, and Lochindorb in the S.W., 6 m. N.N.W. of Grantown. Loch Spynie was once a lake extending from the Firth to within 2½ m. of Elgin and covering an area of over 2000 acres. Its shores were the haunt of a great variety of birds, and its waters were full of salmon, sea-trout and pike. But early in the 19th century it was resolved to reclaim the land, and the drainage works then undertaken reduced the beautiful loch to a swamp of some 120 acres.

Lochindorb is now the largest lake, being 2 m. in length and fully ½ m. wide. In the upper end, on an island believed to be artificial, stand the ruins of Lochindorb Castle, in the 14th century the stronghold of the Wolf of Badenoch, and afterwards successively the property of the earl of Moray, the Campbells of Cawdor and the earl of Seafield. Sir Thomas Dick Lauder saw at Cawdor Castle a massive iron gate which, according to tradition, Sir Donald Campbell of Cawdor carried on his back from Lochindorb to Cawdor, a distance of 13 m. In the southern half of the county, amongst the hills, are several glens, among them the Glen of Rothes, Glen Lossie, Glen Gheallaidh, Glen Tulchan and Glen Beag. Strathspey, though more of a valley than a glen, is remarkable for its extent and beauty.

Geology.—This county may be divided geologically into two areas, the hilly region to the south being composed of the crystalline schists of the Central Highlands and the fertile plain of Moray being made up of Old Red Sandstone and Triassic strata. In the Cromdale Hills in the south-east of the county the metamorphic series comprises schistose quartzite, quartz-schists, micaceous flagstones and mica-schists, which are granulitic and holocrystalline, the dark laminae in some cases containing heavy residues such as ilmenite and zircon. The greater portion of the metamorphic area west of the Spey consists of granulitic quartz-biotite-granulites and bands of muscovite-biotite-schist belonging to the Moine series of the Geological Survey (see Scotland: *Geology*). In certain areas these are permeated by granitic material in the form of thin strings, knots and veins. Excellent sections of these rocks are exposed in the Findhorn, the Divie and the tributaries of the Spey. Near Grantown there is a group locally developed, comprising crystalline limestone with tremolite, kyanite gneiss, muscovite-biotite-schist and quartzite, the age and relations of which are still uncertain. The general strike of the crystalline schists, save where there are local deflections, is north-east and south-west, and the general dip is to the south-east. Between Lochindorb and Grantown there is a mass of granite belonging to the later intrusions of the Highlands represented by the Cairngorm granite. Within the county there are representatives of the middle and upper divisions of the Old Red Sandstone resting unconformably on the crystalline schists. The strata of the middle or Orcadian series consist of conglomerates, sandstones, shales and clays, with limestone nodules containing fish remains. This sequence is well displayed in the banks of the Spey north of Boat of Bridge and in the Tynet Burn east of Fochabers, the latter being one of the well-known localities for ichthyolites in the middle or Orcadian division. In the Tynet and Gollachie Burn sections, the fish bed is overlaid by conglomerates and red pebbly sandstones, passing upwards into a thin zone of andesite lavas, indicating contemporaneous volcanic action. West of the Tynet Burn and Spey sections there is no trace of the members of the Orcadian division till we reach the Muckle Burn and Lethen Bar in Nairnshire, save the coarse conglomerate filling the ancient hollow of the valley of Rothes which may belong to the middle series. In that direction they are overlapped by the Upper Old Red Sandstone, which in the river Lossie, in the Lochty Burn and the Findhorn rest directly on the metamorphic rocks. Even to the south of the main boundary of the upper division there are small outliers of that series resting on the crystalline schists. Hence there must be a discordance between the Middle and Upper Old Red Sandstone in this county. The strata of the upper division consist of red, grey and yellow false-bedded sandstones with conglomeratic bands, which are well seen in the Findhorn between Sluie and Cothall, where they are associated with a bed of cornstone, all dipping to the N.N.W. at gentle angles. South of Elgin they are exposed in the Lossie and at Scaat Craig, while to the north of that town they extend along the ridge from Bishopmill to Alves. By means of the fish remains, which occur at Scaat Craig, in the Bishopmill quarries, at Alves, in the Findhorn cliffs and in the Whitemyre quarry on the Muckle Burn, the Upper Old Red Sandstone in this county is arranged in two groups, the Alves and Rosebrae. In the area lying to the north of the Upper Old Red Sandstone ridge at Bishopmill and Quarrywood, the strata of Triassic age occur, where they consist of pale grey and yellow sandstones and a peculiar cherty and calcareous band, known as the cherty rock of Stotfield. The sandstones are visible in quarries on the north slope of Quarry Wood, at Findrassie, at Spynie and along the ridge and sea-shore between Burghead and Lossiemouth. They are invested with special interest on account of the remarkable series of reptilian remains obtained from them, comprising *Stagonolepis*, a crocodile allied to the modern caiman in form; *Telerpeton* and *Hyperodapedon*, species of lizards; *Dicynodonts* (*Gordonia* and *Geikia*) and a horned reptile, *Elginia mirabilis* (see Scotland: *Geology*). The palaeontological evidence points to the conclusion that these reptiliferous sandstones must belong in part to the Trias, indeed it is possible that the lower portion may be of Permian age. In the Cutties Hillock quarry west of Elgin these reptiliferous beds rest directly on the sandstones containing *Holoptychius* of Upper Old Red Sandstone age, so that the apparent conformability must be entirely deceptive. Within the area occupied by the Trias west of Stotfield, flagstones appear, charged with fish scales of Upper Old Red age, where they form a low ridge protruding through the younger strata. Both the Upper Old Red and Triassic sandstones have been largely quarried for building purposes. On the shore at Lossiemouth there is a patch of greenish white sandstones yielding fossils characteristic of the Lower Oolite.

The glacial deposits distributed over the fertile plain of Moray and in the upland valleys are of interest. The low grounds were crossed by the ice descending the Moray Firth in an easterly and south-easterly direction, which carried boulders of granite from Strath Nairn and augen gneiss from Easter Ross. In the Elgin district, boulders belonging to the horizons of the Lower and Middle Lias, the Oxford Clay and the Upper Chalk are found both in the glacial deposits and on the surface of the ground. The largest transported mass occurs at Linksfield, where a succession of limestones and shales rests on boulder clay and is covered by it, which from the fossils may be of Rhaetic or Lower Lias age.

Climate and Agriculture.—The climate of the coast is equable and mild, even exotic fruits ripening readily in the open. The uplands are colder and damp. The average temperature in January is 38° F. and in July 58.5°, while for the year the mean is 47° F. The rainfall for the year averages 26 in. Considering its latitude and the extent of its arable land the standard of farming in Elginshire is high.
The rich soil of the lowlands is well adapted for wheat, barley and oats. The acreage confined to the 270
glens and straths under barley approximates that under oats. In the uplands, oats is the principal cereal. The breeding of live-stock is profitable, and some of the finest specimens of shorthorned and polled cattle and of crosses between the two are bred. On the larger farms in the Laigh Leicester sheep are kept all the year round, but in the uplands the Blackfaced take their place. Large numbers of horses and pigs are also raised.

Other Industries.—Whisky is the chief product, and the numerous distilleries are usually busy. There are woollen mills at Elgin and elsewhere and chemical works at Forres and Burghead. Owing to the absence of coal what little mineral wealth there is (iron and lead) cannot be remuneratively worked. The sandstone quarries, yielding a building-stone of superior quality, are practically inexhaustible. The plantations mainly consist of larch and fir and, to a smaller extent, of oak. Much timber was once floated down the Spey and other rivers, but, since the increased facilities of carriage afforded by the railways, trees have been felled on a wider scale. Boat-building is carried on at Burghead, Lossiemouth and Kingston—so-called from the fact that a firm from Kingston-on-Hull laid down a yard there in 1784—while at Garmouth the fishing fleet lies up during the winter and is also repaired there. The Firth fisheries are of considerable value. The boats go out from Findhorn, Burghead, Hopeman and Lossiemouth, which are all furnished with safe harbours. Findhorn has been twice visited by calamities. The first village was overwhelmed by the drifting sands of Culbin, and the second was buried beneath the waves in 1701. Kingston harbour is tidal, exposed, and liable to interruption from a shifting bar. The deep sea fisheries comprise haddock, cod, ling and herring, and the Spey, Findhorn and Lossie yield large quantities of salmon.

The Great North of Scotland railway enters the shire in the S.E. from Craigellachie, whence a branch runs up the Spey to Boat of Garten in Inverness-shire, and in the N.E. from Port Gordon, running in both cases to Elgin, from which a branch line extends to Lossiemouth. The Highland railway traverses the western limits of the shire running almost due north to Forres, whence it turns westward to Nairn and eastward to Elgin. From the county town it runs to Aberdeen via Orbliston and Keith, with a branch to Fochabers from Orbliston.

Population and Government.—The population was 43,471 in 1891 and 44,800 in 1901, when 1865 persons spoke both Gaelic and English, and 2 spoke Gaelic only. The chief towns are Elgin (pop. in 1901, 8460), Forres (4313) and Lossiemouth (3904), to which may be added Rothes (1621), Grantown (1568) and Burghead (1531). In conjunction with Nairnshire the county returns one member to parliament. Elgin and Forres are royal burghs; the municipal and police burghs include Burghead, Elgin, Forres, Grantown, Lossiemouth, and Rothes. Elginshire is included in one sheriffdom with Inverness and Nairn, and there is a resident sheriff-substitute at Elgin. The county is under school-board jurisdiction, several of the schools earning grants for higher education. There are academies at Elgin and Fochabers and science and art and technical schools at Elgin and Grantown. The bulk of the “residue” grant is spent in subsidizing the agricultural department of Aberdeen University and the science schools and art and technical classes in the county.

History.—Moray, in the wider sense, was first peopled by Picts of the Gaelic branch of Celts, of whom relics are found in the stone circle at Viewfield and at many places in Nairnshire. Christianity, introduced under the auspices of Columba (from whose time the site of Burghead church has probably been so occupied), flourished for a period until the Columban church was expelled in 717 by King Nectan. Thereafter the district was given over to internecine strife between the northern and southern Picts, which was ended by the crushing victory of Kenneth MacAlpine in 831, as one result of which the kingdom of Pictavia was superseded by the principality of Moravia. Still, settled order had not yet been secured, for the Norsemen raided the country first under Thorstein and then under two Sigurds. It was in the time of the second Sigurd that the Firth was fixed as the northern boundary of Moray. In spite of such interruptions as the battle of Torfness (Burghead) on the 14th of August 1040, in which Thorfinn, earl of Orkney and Shetland, overthrew a strong force of Scots under King Duncan, the consolidation of the kingdom was being gradually accomplished. After Macbeth ascended the throne the Scandinavians held their hands. Though Macbeth and his *fainéant* successor, “daft” Lulach, were the only kings whom Moray gave to Scotland, the province never lacked for able, if headstrong, men, and it continued to enjoy home rule under its own marmaer, or great steward (the equivalent of *earl*, the title that replaced it), until the dawn of the 12th century, when as an entity it ceased to exist. With a view to breaking up the power of the marmaers David I. and his successors colonized the seaboard with settlers from other parts of the kingdom. Nevertheless, from time to time the clansmen and their chiefs descended from their fastnesses and plundered the Laigh, keeping the people for generations in a state of panic. Meanwhile, the Church had become a civilizing force. In 1107 Alexander had founded the see of Moray and the churches of Birnie, Kinneddar and Spynie were in turn the cathedral of the early bishops, until in 1224 under the episcopate of Andrew of Moray (de Moravia), the church of the Holy Trinity in Elgin was chosen for the cathedral. Another factor that drew men together was the struggle for independence. In his effort to stamp out Scottish nationality Edward I. came as far north as Elgin, where he stayed for four days in July 1296, and whence he issued his writ for the parliament at Berwick. Wallace, however, had no doughtier supporter than Sir Andrew Moray of Bothwell, and Bruce recognized the assistance he had received from the men of the north by erecting Moray into an earldom on the morrow of Bannockburn and bestowing it upon Thomas Randolph (see Moray, Thomas Randolph, earl of). Henceforward the history of the county resolved itself in the main into matters affecting the power of the Church and the ambitions of the Moray dynasties. The Church accepted the Reformation peacefully if not with gratitude. But there was strife between Covenanters and the adherents of Episcopacy until, prelacy itself being abolished in 1689, the bishopric of Moray came to an end after an existence of 581 years. (For the subsequent history of the earldom, which was successively held by the Randolphs, the Dunbars, the Douglases, the royal Stewarts and an illegitimate branch of the Stewarts, see Murray or Moray, earls of.) Other celebrated Moray families who played a more or less strenuous part in local politics were the Gordons, the Grants and the Duffs. Still, national affairs occasionally evoked interest in Moray. In the civil war Montrose ravaged the villages which stood for the Covenanters, but most of the great lairds shifted in their allegiance, and the mass of the people were quite indifferent to the declining fortunes of the Stewarts. Charles II. landed at Garmouth on the 3rd of July 1650 on his return from his first exile in Holland, but hurried southwards to try the yoke of Presbytery. The fight at Cromdale (May day, 1690) shattered the Jacobite cause, for the efforts in 1715 and 1745 were too spasmodic and half-hearted to affect the loyalty of the district to Hanoverian rule. A few weeks before Culloden Prince Charles Edward stayed in Elgin for some days, and a month afterwards the duke of Cumberland passed through the town at the top of his speed and administered the *coup de grâce* to the Young Pretender on Drummossie Moor.

Twice Elginshire has been the scene of catastrophes without parallel in Scotland. In 1694 the barony of Culbin—a fine estate, with a rent roll in money and kind of £6000 a year, belonging to the Kinnairds, comprising 3600 acres of land, so fertile that it was called the Granary of Moray, a handsome mansion, a church and several houses—was buried under a mass of sand in a storm of extraordinary severity. The sandy waste measures 3 m. in length and 2 in breadth, and the sand, exceedingly fine and light, is constantly shifting and, at rare intervals, exposing traces of the vanished demesne. This wilderness of dome-shaped dunes divided by a loftier ridge lies to the north-west of Forres. The other calamity was the Moray floods of the 2nd and 3rd of August 1829. The Findhorn 271
rose 50 ft. above the ordinary level, inundating an area of 20 sq. m.; the Divie rose 40 ft., and the Lossie flooded all the low ground around Elgin. The floods tore down bridges and buildings, and obliterated farms and homesteads.

Authorities.—Lachlan Shaw, *History of the Province of Moray* (Gordon’s edition, Glasgow, 1882); *A Survey of the Province of Moray* (Elgin, 1798); W. Rhind, *Sketches of the Past and Present State of Moray* (Edinburgh, 1839); E. Dunbar Dunbar, *Documents relating to the Province of Moray* (Edinburgh, 1895); C.A. Gordon, *History of the House of Gordon* (Aberdeen, 1890); C. Rampini, *History of Moray and Nairn* (Edinburgh, 1897); C. Innes, *Elgin, Past and Present* (Elgin, 1860); J. Macdonald, “Burghead” (*Proceedings of Glasgow Archaeological Soc.*), (1891); Sir T. Dick Lauder, *The Wolf of Badenoch* (Glasgow, 1886); *An Account of the Great Floods of August 1829 in the Province of Moray and Adjoining Districts* (Elgin, 1873).

ELGON, also known as Masawa, an extinct volcano in British East Africa, cut by 1° N. and 34½° E., forming a vast isolated mass over 40 m. in diameter. The outer slopes are in great measure precipitous on the north, west and south, but fall more gradually to the east. The southern cliffs are remarkable for extensive caves, which have the appearance of water-worn caves on a coast line and have for ages served as habitations for the natives. The higher parts slope gradually upwards to the rim of an old crater, lying somewhat north of the centre of the mass, and measuring some 8 m. in diameter. The highest point of the rim is about 14,100 ft. above the sea. Steep spurs separated by narrow ravines run out from the mountain, affording the most picturesque scenery. The ravines are traversed by a great number of streams, which flow north-west and west to the Nile (through Lake

Choga), south and south-east to Victoria Nyanza, and north-east to Lake Rudolf by the Turkwell, the head-stream of which rises within the crater, breaking through a deep cleft in its rim. To the north-west of the mountain a grassy plain, swampy in the rains, falls towards the chain of lakes ending in Choga; towards the north-east the country becomes more arid, while towards the south it is well wooded. The outer slopes are clothed in their upper regions with dense forest formed in part of bamboos, especially towards the south and west, in which directions the rainfall is greater than elsewhere. The lower slopes are exceptionally fertile on the west, and produce bananas in abundance. On the north-west and north the region between 6000 and 7000 ft. possesses a delightful climate, and is well watered by streams of ice-cold water. The district of Save on the north is a halting-place for Arab and Swahili caravans going north. On the west the slopes are densely inhabited by small Bantu-Negro tribes, who style their country Masawa (whence the alternative name for the mountain); but on the south and north there are tribes which seem akin to the Gallas. Of these, the best known are the El-gonyi, from whom the name Elgon has been derived. They formerly lived almost entirely in the caves, but many of them have descended to villages at the foot of the mountain. Elgon was first visited in 1883 by Joseph Thomson, who brought to light the cave-dwellings on the southern face. It was crossed from north to south, and its crater reached, in 1890 by F.J. Jackson and Ernest Gedge, while the first journey round it was made by C.W. Hobley in 1896.

(E. He.)

ELI (Hebrew for "high"? 1 Sam. chaps, i.-iv.), a member of the ancient priesthood founded in Egypt (1 Sam. ii. 27), priest of the temple of Shiloh, the sanctuary of the ark, and also "judge" over Israel. This was an unusual combination of offices, when it is considered that in the history preserved to us he appears in the weakness of extreme old age, unable to control the petulance and rapacity of his sons, Hophni and Phinehas, who disgraced the sanctuary and disgusted the people. While the central authority was thus weakened, the Philistines advanced against Israel, and gained a complete victory in the great battle of Ebenezer, where the ark was taken, and Hophni and Phinehas slain. On hearing the news Eli fell from his seat and died. In a passage not unlike the account of the birth of Benjamin (Gen. xxxv. 16 sqq.), it is added that the wife of Phinehas, overwhelmed at the loss of the ark and of her husband, died in child-birth, naming the babe Ichabod (1 Sam. iv. 19 sqq.). This name, which popular etymology explained by the words "the glory is removed (or, stronger, 'banished') from Israel" (cf. Hos. x. 5), should perhaps be altered from *I-kābōd* (as though "not glory") to Jōchebed (*Yōkebed*, a slight change in the original), the name which tradition also gave to the mother of Moses (*q.v.*). After these events the sanctuary of Shiloh appears to have been destroyed (cf. Jer. vii. 12, xxvi. 6, 9), and the descendants of Eli with the whole of their clan or "father's house" subsequently appear as settled at Nob (1 Sam. xxi. 1, xxii. 11 sqq., cp. xiv. 3), perhaps in the immediate neighbourhood of Jerusalem (Is. x. 32). In the massacre of the clan by Saul, and the subsequent substitution of the survivor Abiathar by Zadok (1 Kings ii. 27, 35), later writers saw the fulfilment of the prophecies of judgment which was said to have been uttered in the days of Eli against his corrupt house (1 Sam. ii. 27 sqq., iii. 11 sqq.).[1]

See further, Samuel, Books of; and on Eli as a descendant of a Levite clan (1 Sam. ii 27 sq.), see Levites (§ 3).

(W. R. S.; S. A. C.)

1 On the old views relating to the succession of the priests, according to which the high-priesthood was diverted from the line of Eleazar and Phinehas into that of Ithamar, see Robertson Smith, *Old Test. in Jewish Church*, 2nd ed., p. 266.

ELIAS, of Cortona (*c.* 1180-1253), disciple of St Francis of Assisi, was born near Assisi, about 1180, of the working class, but became schoolmaster at Assisi and then notary at Bologna. In 1217 he was the head of the Franciscan mission to the Holy Land, and in 1219 St Francis made him first provincial minister of Syria. When St Francis was recalled from the East in 1220 he brought Elias with him. Elias played a leading part in the early history of the Franciscan order (see Franciscans); Francis made him his vicar general in 1221; and he was the practical acting superior of the order till Francis' death in 1226, and the real superior till the general chapter of 1227. This chapter did not elect him minister general, but that of 1232 did; at the chapter of 1239 he was deposed. During these years he erected the basilica and monastery at Assisi which were entirely his creation—he collected the funds and carried the work through, being himself the builder and even the architect. Elias was a man of extraordinary ability, the friend both of Gregory IX. and of his opponent Frederick II. After his deposition Elias joined the party of the emperor and so incurred excommunication. Frederick sent him as ambassador to Constantinople. He dressed and lived as a Franciscan throughout and a small number of friars adhered to him; for these he built a church and monastery at Cortona. Unavailing efforts were made to bring about his reconciliation with the order and the Church; at last on his death-bed he made his submission to the pope and died in 1253, having received the Sacraments.

The best account of Elias is that by Ed. Lempp, *Frère Élie de Cortone* (1901), who points out the conflict of view, as to the relations between Elias and Francis, between the *Speculum perfectionis* and the *First Life*, by Thomas of Celano; Lempp and Sabatier accept the hostile picture given by the *Speculum perfectionis*. But see further Francis of Assisi, Saint, "Note on Sources," and especially the articles by Goetz, there referred to, in the *Hist. Vierteljahrsschrift.* There is a good article on Elias, but written before the new materials had been produced, in Wetzer und Welte, *Kirchenlexicon* (ed. 2).

(E. C. B.)

ELIAS, JOHN (1774-1841), Welsh Nonconformist preacher and reformer, was born on the 2nd of May 1774, in the parish of Abererch, Carnarvonshire. In his youth he came under the influence of the Calvinistic Methodist revival and became a preacher at nineteen. In 1799 he married and settled at Llanfechell in Anglesey, giving up his trade as a weaver to become a small shopkeeper. His fame as a preacher increased, and under the direction of Thomas Charles of Bala he established numerous Sunday schools, and gave and secured considerable Welsh support to the founding of the London Missionary Society, the British and Foreign Bible Society and the Religious Tract Society. On Charles's death in 1814 he became the recognized leader of the Calvinistic Methodist Church, and the story of his life is simply a record of marvellously successful preaching tours. He died on the 8th of June 1841; ten thousand people attended his funeral.

His eloquence was so remarkable that he was known as "the Welsh Demosthenes." His strength lay in his intense conviction of an intimate connexion between sin and punishment and in his power of dramatic presentation. As an ecclesiastic he was not so successful; he helped to compile his church's Confession of Faith in 1823, and laid great stress on a clause which limited the scope of the atonement to the elect. He was a stout Tory in politics and had many friends among the Anglican clergy; he opposed the movement for Roman Catholic emancipation. Several of his sermons were published in Welsh. 272

ELIAS LEVITA (1469-1549), Jewish grammarian, was born at Neustadt on the Aisch, a place in Bavaria lying between Nuremberg and Würzburg. He preferred to call himself "Ashkenazi," the German, and bore also the nickname of "Bachur," the youth or student, which latter he gave as title to his Hebrew grammar. Before the end of the 15th century he went to Italy, which thenceforth remained his home. He lived first at Padua, went in 1509, after the capture of this town by the army of the League of Cambrai, to Venice, and finally in 1513 to Rome, where he found a patron in the learned general of the Augustinian Order, the future cardinal Egidio di Viterbo, whom he helped in his study of the Kabbalah, while he himself was inspired by him to literary work. The storming of Rome by the army of the Constable de Bourbon in 1527 compelled Elias to go to Venice, where he was employed as corrector in the printing-house of Daniel Bomberg. In the years 1541 and 1542 he lived at Isny, in Southern Württemberg, where he published several of his writings in the printing-house of the learned pastor Paul Fagius. The last years of his life he spent at Venice, continuously active in spite of ill-health and the weakness of old age. His monument in the graveyard of the Jewish community at Venice boasts of him that "he illuminated the darkness of grammar and turned it into light." The importance of Levita rests both in his numerous writings and in his personal activity. In the remarkable period which saw the rise of the Reformation and gave to the study of the Hebrew Bible and to its language an importance in the history of the world, it was Levita who furthered in an extraordinary manner the study of Hebrew in Christian circles by his activity as a teacher and by his writings. To his pupils especially belong Sebastian Minoter, who translated Levita's grammatical works into Latin, also George de Selve, bishop of Lavaur, the French ambassador in Venice (1536), who was instrumental in obtaining for Levita an invitation from Francis I. to come to Paris, which invitation, however, Levita did not accept. Levita's writings on Hebrew grammar (*Bachur*, a text-book, 1518; *Harkaba*, an explanation, alphabetically arranged, of irregular word-forms; a Table of Paradigms; *Pirke Elijahu*, a description—partly metrical—of phonetics, and other chapters of the grammar, 1520; his earliest work, a Commentary on Moses Kimḥi's Hebrew Grammar, 1508) were by reason of their methodical exposition, their clear articulation, their avoidance of prolixity, especially suited as an introduction to the study of the Hebrew language. Amongst Levita's other writings is the first dictionary of the Targumim (*Meturgeman*, 1541) and the first attempt at a lexicon in which much of the treasure of late Hebrew language was explained (*Tishbi*, explanation of 712 new Hebrew vocables, as a supplement to the dictionaries of David Kimḥi and Nathan b. Yeḥiel, 1542). Scientifically most valuable, and of original importance, are the works of Levita on the *Massora*; his Concordance to the Massora (*Sefer Zikhronot* completed in the second revision 1536), of which hitherto only a small part has been published, and especially his most celebrated book *Massoreth Hamasoreth* (1538), published with English translation by Chr. D. Ginsburg, London, 1867. This was the first attempt to give a systematic account of the contents and history of the Massora. By his criticism of the Massora, and especially by proving that the punctuation of the books of the Hebrew Bible is of late origin, Levita exercised an epoch-making influence. Of his other writings may be mentioned his running commentary on David Kimḥi’s Grammar and Dictionary (in the Bomberg editions 1545, 1546), his German translation of the Psalms (1545) and the *Baba-Buch* (more properly *Buovobuch*, a German recension of the Italian novel *Historia di Buovo d’ Antona*, 1508).

Of the literature on Levita may be mentioned: Y. Levi, *Elia Levita und seine Leistungen als Grammatiker* (Breslau, 1888); W. Bacher, “E. Levita’s wissenschaftliche Leistungen” in *Z. d. D. M. G.* xliii. (1889), p. 206-272.

(W. Ba.)

ELIE, a village and watering-place of Fifeshire, Scotland, on the shore of the Firth of Forth. Pop. 687. It is 10 m. due S. of St Andrews, but 20 m. distant by the North British railway, which makes a great bend by following the coast. Though it retains some old houses, and the parish church dates from 1639, Elie is, as a whole, quite modern and is one of the most popular resorts in the county on account of its fine golf links and excellent bathing. The royal burgh of Earlsferry (pop. 317) is situated in the parish of Elie, which it adjoins on the west. Its charter, granted by Malcolm Canmore, having been burned, it was renewed by James VI. The chief structure is the town hall, which is modern but has an ancient steeple. The place derived its name from its use by the earls of Fife as a ferry to the opposite shore of Haddington, 8 m. distant. Macduff’s cave near Kincraig Point is believed traditionally to have been that in which the thane took refuge from Macbeth. Two and a half miles north is Balcarres House, belonging to the earl of Crawford, where Lady Anne Barnard (1750-1825) was born.

ÉLIE DE BEAUMONT, JEAN BAPTISTE ARMAND LOUIS LÉONCE (1798-1874), French geologist, was born at Canon, in Calvados, on the 25th of September 1798. He was educated at the Lycée Henri IV. where he took the first prize in mathematics and physics; at the École Polytechnique, where he stood first at the exit examination in 1819; and at the École des Mines (1819-1822), where he began to show a decided preference for the science with which his name is associated. In 1823 he was selected along with Dufrénoy by Brochant de Villiers, the professor of geology in the École des Mines, to accompany him on a scientific tour to England and Scotland, in order to inspect the mining and metallurgical establishments of the country, and to study the principles on which Greenough’s geological map of England (1820) had been prepared, with a view to the construction of a similar map of France. In 1835 he was appointed professor of geology at the École des Mines, in succession to Brochant de Villiers, whose assistant he had been in the duties of the chair since 1827. He held the office of engineer-in-chief of mines in France from 1833 until 1847, when he was appointed inspector-general; and in 1861 he became vice-president of the Conseil-Général des Mines and a grand officer of the Legion of Honour. His growing scientific reputation secured his election to the membership of the Academy of Berlin, of the Academy of Sciences of France and of the Royal Society of London. By a decree of the president he was made a senator of France in 1852, and on the death of Arago (1853) he was chosen perpetual secretary of the Academy of Sciences. Élie de Beaumont’s name is widely known to geologists in connexion with his theory of the origin of mountain ranges, first propounded in a paper read to the Academy of Sciences in 1829, and afterwards elaborated in his *Notice sur le système des montagnes* (3 vols., 1852). According to his view, all mountain ranges parallel to the same great circle of the earth are of strictly contemporaneous origin, and between the great circles a relation of symmetry exists in the form of a pentagonal *réseau*. An elaborate statement and criticism of the theory was given in his anniversary address to the Geological Society of London in 1853 by William Hopkins (*Quart. Journ. Geol. Soc.*). The theory has not found general acceptance, but it proved of great value to geological science, owing to the extensive additions to the knowledge of the structure of mountain ranges which its author made in endeavouring to find facts to support it. Probably, however, the best service Élie de Beaumont rendered to science was in connexion with the geological map of France, in the preparation of which he had the leading share. During this period Élie de Beaumont published many important memoirs on the geology of the country. After his superannuation at the École des Mines he continued to superintend the issue of the detailed maps almost until his death, which occurred at Canon on the 21st of September 1874. His academic lectures for 1843-1844 were published in 2 vols., 1845-1849, under the title *Leçons de géologie pratique*. 273

A list of his works was published in the *Ann. des Mines*, vol. vii. 1875. P. 259.

ELIJAH (a Hebrew name meaning "Yah[weh] is God"), in the Bible, the greatest and sternest of the Hebrew prophets, makes his appearance in the narrative of the Old Testament with an abruptness not out of keeping with his character and work (1 Kings xvii. 1).[1] The first and most important part of his career lay in the reign of Ahab, *i.e.* during the first half of the 9th century B.C. He is introduced as predicting the drought[2] God was to send upon Israel as a punishment for the apostasy into which Ahab had been led by his heathen wife Jezebel. During the first portion of this period Elijah found a refuge by the brook Cherith, "before the Jordan." This description leaves it uncertain whether the brook was to the east of Jordan in Elijah's native Gilead, or—less probably—to the west in Samaria. Here he drank of the brook and was fed by ravens, who night and morning brought him bread and flesh.[3] When this had dried up, the prophet betook himself to Zarephath, a Phoenician town near Sidon. At the gate of the town he met the widow to whom he had been sent, gathering sticks for the preparation of what she believed was to be her last meal. She received the prophet with hospitality, sharing with him her all but exhausted store, in faith of his promise in the name of the God of Israel that the supply would not fail so long as the drought lasted. During this period her son died and was miraculously restored to life in answer to the prayers of the prophet (1 Kings xvii. 8-24).

Elijah emerged from his retirement in the third year, when, the famine having reached its worst, Ahab and his minister Obadiah had themselves to search the land for provender for the royal stables. To the latter Elijah suddenly appeared, and announced his intention of showing himself to Ahab. The king met Elijah with the reproach that he was "the troubler of Israel," which the prophet boldly flung back upon him who had forsaken the commandments of the Lord and followed the Baalim.[4] The retort was accompanied by a challenge—or rather a command—to the king to assemble on Mount Carmel "all Israel" and the four hundred and fifty prophets of Baal. (The four hundred prophets of Asherah have been added later.) From the allusion to an "altar of Jehovah that was broken down" (1 Kings xviii. 30) it has been inferred that Carmel was an ancient sacred place. (On Mount Carmel and Elijah's connexion with it in history and tradition see Carmel.)

The scene on Carmel is perhaps the grandest in the life of Elijah, or indeed in the whole of the Old Testament. As a typical embodiment for all time of the conflict between superstition and true religion, it is lifted out of the range of mere individual biography into that of spiritual symbolism, and it has accordingly furnished at once a fruitful theme for the religious teacher and a lofty inspiration for the artist. The false prophets were allowed to invoke their god in whatever manner they pleased. The only interruption came in the mocking encouragement of Elijah (1 Kings xviii. 27), a rare instance of grim sarcastic humour occurring in the Bible. Its effect upon the false prophets was to increase their frenzy. The evening came,[5] and the god had made no sign. Elijah now stepped forward with the quiet confidence and dignity that became the prophet and representative of the true God. All Israel is represented symbolically in the twelve stones with which he built the altar; and the water which he poured upon the sacrifice and into the surrounding trench was apparently designed to prevent the suspicion of fraud! In striking contrast to the "vain repetitions" of the false prophets are the simple words with which Elijah makes his prayer to Yahweh. Once only, with the calm assurance of one who knew that his prayer would be answered, he invokes the God of his fathers. The answer comes at once: "The fire of the Lord (Gen. xix. 24, Lev. x. 2) fell and consumed the burnt offering, and the wood, and the stones, and the dust, and licked up the water that was in the trench." So convincing a sign was irresistible; all the people fell on their faces and acknowledged Yahweh as the true God. This was immediately followed by the destruction of the false prophets, slain by Elijah beside the brook Kishon (xviii. 40). The deed, though not without parallel in the Old Testament history, stamps the peculiarly vindictive character of Elijah's prophetic mission.[6]

On the evening of the day that had witnessed the decisive contest, Elijah proceeded once more to the top of Carmel, and there, with "his face between his knees" (possibly engaged in the prayer referred to in James v. 17 sq.), waited for the long-looked-for blessing. His servant, sent repeatedly to search the sky for signs, returned the seventh time reporting a little cloud arising out of the sea "like a man's hand." The sky was speedily full of clouds and a great rain was falling when Ahab, to escape the storm, set out in his chariot for Jezreel. As a proof of Elijah's supernatural power, it is stated that the prophet, for some unknown object, ran before the chariot to the entrance of Jezreel, a distance of at least 16 m. On being told what had taken place, Jezebel sent a messenger to Elijah with a vow that ere another day had passed his life would be even as the lives of the prophets of Baal, and the threat was enough to cause him to take to instant flight (xix. 1-3; cp. LXX. in v. 2). The first stage of the journey was to Beersheba, on the southern limits of Judah. Here he left his servant (according to old Jewish tradition, the widow's son of Zarephath, afterwards the prophet Jonah), and proceeded a day's journey into the wilderness. Resting under a solitary broom bush (a kind of *genista*), he gave vent to his disappointment in a prayer for death. By another of those many miraculous interpositions which occur in his history he was twice supplied with food and drink, in the strength of which he journeyed forty days and forty nights until he came to Horeb, where he lodged in a cave.[7] A hole "just large enough for a man's body" (Stanley), immediately below the summit of Jebel Mūsa, is still pointed out by tradition as the cave of Elijah.

If the scene on Carmel is the grandest, that on Horeb is spiritually the most profound in the story of

Elijah (xix. 9 sqq.). Not in the strong wind that brake the rocks in pieces, not in the earthquake, not in the fire, but in the still small voice that followed the Lord made himself known. A threefold commission was laid upon him: he was to return to Damascus and anoint Hazael king of Syria; he was to anoint Jehu, the son of Nimshi, as king of Israel in place of Ahab; and as his own successor in the 274
prophetic office he was to anoint Elisha (xix. 15-18).[8]

Leaving Horeb and proceeding northwards along the desert route to Damascus, Elijah met Elisha engaged at the plough probably near his native place, Abel-meholah, in the valley of the Jordan, and by the symbolical act of casting his mantle upon him, consecrated him to the prophetic office. This was the only command of the three which he fulfilled in person; the other two were carried out by his successor.[9] After the call of Elisha the narrative contains no notice of Elijah for several years, although the LXX., by placing 1 Kings xxi. before ch. xx., proceeds at once to the tragic story of Naboth's vineyard (see Jezebel). He is now the champion of freedom and purity of life, like Nathan when he confronted David for the murder of Uriah. Without any indication of whence or how he came, he again appeared, as usual with startling abruptness, in the vineyard when Ahab entered to take possession of it, and pronounced upon the king and his house that awful doom (1 Kings xxi. 17-24) which, though deferred for a time, was ultimately fulfilled to the letter (see Jehu).

With one more denunciation of the house of Ahab, Elijah's function as a messenger of wrath was fully discharged (2 Kings i.). When Ahaziah, the son of Ahab, having injured himself by falling through a lattice, sent to inquire of Baal-zebub, the god of Ekron, whether he should recover, the prophet was commanded to appear to the messengers and tell them that, for this resort to a false god, the king should die. The effect of his appearance was such that they turned back without attempting to fulfil their errand. Ahaziah despatched a captain with a band of fifty to arrest him. They came upon Elijah seated on "the mount,"—probably Carmel. The imperious terms in which he was summoned to come down were punished by fire from heaven, which descended at the bidding of Elijah and consumed the whole land. A second captain and fifty were despatched, behaved in a similar way, and met the same fate. The leader of a third troop took a humbler tone, sued for mercy, and obtained it. Elijah then went with them to the king, but only to repeat before his face the doom he had already made known to his messengers, which was almost immediately afterwards fulfilled. The spirit, even the style of this narrative, points unmistakably to its being of late origin. It shocks the moral sense with its sanguinary character more than, perhaps, any other Old Testament story.

The only mention of Elijah's name in the book of Chronicles (2 Chronicles xxi. 12-15) is where he is represented as sending a letter of rebuke and denunciation to Jehoram, son of Jehoshaphat, king of Judah. The chronological difficulties which are involved suggest that the floating traditions of this great personality were easily attached to well-known names whether strictly contemporary or not. It was before the death of Jehoshaphat that the last grand scene in Elijah's life occurred (2 Kings ii., see iii. 1). He had taken up his residence with Elisha at one of the prophetic guilds at Gilgal. His approaching end seems to have been known to the guilds at Bethel and Jericho, both of which they visited in their last journey. At the Jordan, Elijah, wrapping his prophet's mantle together, smote the water with it, and so by a last miracle passed over on dry ground. When they had crossed the master desired the disciple to ask some parting blessing. The request for a double portion (*i.e.* probably a first-born's portion, Deut. xxi. 17)[10] of the prophet's spirit Elijah characterized as a hard thing; but he promised to grant it if Elisha should see him when he was taken away. The end is told in words of simple sublimity: "And it came to pass, as they still went on and talked, that, behold, there appeared a chariot of fire, and horses of fire, which parted them both asunder; and Elijah went up by a whirlwind into heaven" (2 Kings ii. 11). It is scarcely necessary to point out, however, that through the figure the narrative evidently means to convey as fact that Elijah passed from earth, not by the gates of death, but by miraculous translation. Such a supernatural close is in perfect harmony with a career into every stage of which the supernatural enters as an essential feature. For whatever explanation may be offered of the miraculous element in Elijah's life, it must obviously be one that accounts not for a few miraculous incidents only, which might be mere excrescences, but for a series of miraculous events so closely connected and so continuous as to form the main thread of the history.

Elijah occupied an altogether peculiar place in later Jewish history and tradition. For the general belief that he should return for the restoration of Israel cf. Mal. iv. 5-6; Matt. xi. 14, xvi. 14; Luke ix. 8; John i. 21, and on the development of the thought see Bousset, *Antichrist*, s.v., and the *Jewish Encyc.* vol. v. p. 126. In Mahommedan tradition Elijah is the everlasting youthful el-Khidr or el-Khadir.

Elijah is canonized both in the Greek and in the Latin Churches, his festival being kept in both on the 20th July—the date of his ascension in the nineteenth year of Jehoshaphat, according to Cornelius a Lapide. The natural and most reliable estimate of the career of Elijah is that which is based upon a critical examination of the narratives; see, in addition to Robertson Smith, *Prophets of Israel*(2), pp. 75 sqq., Cheyne, *Hallowing of Criticism*, the articles by Addis in *Encyc. Bib.*, and J. Strachan, Hastings' *Dict. Bib.*, H. Gunkel, *Elias, Yahve u. Baal* (Tübingen, 1906), the literature to Kings, Books of, and the histories referred to in Jews. There is difference of opinion as to the historical importance of both Elijah and Elisha; for a useful summary of views, as also for fuller bibliographical information, see W.R. Harper, *Amos and Hosea* (*Internat. Crit. Comm.*), pp. xxiv.-xlix., and article Hebrew Religion.

(W. R. S.; S. A. C.)

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1 The text is uncertain. According to the LXX., he was a native of Tishbeh in Gilead; a more natural reading. Klostermann's conjecture that the original name of his home was Jabesh-Gilead is attractive but unnecessary. His appearance in the narrative, like Melchizedek, "without father, without mother" (Heb. vii.

3), gave rise to various rabbinical traditions, such as that he was Phinehas, the grandson of Aaron, returned to earth, or that he was an angel in human form.

2 Its duration is vaguely stated; from Luke iv. 25, James v. 17, we learn that it lasted three years and a half; but according to Phoenician tradition (Jos. *Ant.* viii. 13. 2) only one year.

3 The rationalistic view that the word translated "ravens" should be "Arabians" is improbable. Cheyne's suggestion that the unknown brook Cherith should be placed to the south of Judah agrees with Josephus (*Ant.* viii. 13. 2, "he departed into the southern parts") and with 1 Kings xix. 3, 8; "Jordan" may refer to another river, if it be not a gloss; see Cheyne, *Ency. Bib.*, s.v. "Cherith."

4 The sudden introduction of Elijah in xvii. 1 may be accounted for by the supposition that the commencement of the narrative had been omitted by the editor of xvi. 29 sqq. Hence we are not told the cause of Ahab's hostility towards Elijah, nor is the allusion to Jezebel's massacre of the prophets (xviii. 3, 13) explained. It would appear from Obadiah's words in ver. 9 that he himself was in fear of his life. Later tradition supposed he was the captain of 2 Kings i. 13, or that the widow of 2 Kings iv. 1 had been his wife.

5 The definition of time by the stated oblation (xviii. 29, 36) is very noteworthy (cp. 2 Kings iii. 20).

6 It is obvious that a purely rationalistic interpretation of the great sign whereby Jahweh manifested himself would be out of place. But there is an interesting parallel in the legend of the kindling of the sacred fire and the igniting of the "thick water" in the time of Nehemiah (2 Macc. i. 18-36). Elsewhere, there were sacred fires kindled by the aid of magical invocations (*e.g.* Hypaepa, Pausanias v. 27. 3).

7 Yahweh is here supposed to have his seat on the ancient mountain. "It was the God of the Exodus to whom he appealed, the ancient King of Israel in the journeyings through the wilderness." For the cave, cp. Ex. xxxiii. 22.

8 The theophany is clearly no rebuke to an impatient prophet, nor a lesson that the kingdom of heaven was to be built up by the slow and gentle operation of spiritual forces. It expresses the spirituality of Yahweh in a way that indicates a marked advance in the conception of his nature. See Skinner, *Century Bible*, "Kings," *ad loc.*

9 The geographical indications imply that in one account the journey to Damascus and the anointing of Hazael and Jehu must have intervened, and were omitted because another account ascribed these acts to Elisha (2 Kings viii. ix.). In the latter we possess a more historical account of the anointing of Jehu, and Robertson Smith observes: "When the history in 1 Kings represents Elijah as personally commissioned to inaugurate [the revolution] by anointing Jehu and Hazael as well as Elisha, we see that the author's design is to gather up the whole contest between Yahweh and Baal in an ideal picture of Elijah and his work" (*Ency. Brit.* (9) art. Kings, vol. xiv. p. 85).

10 Understood in Eccles. xlviii. 12 (Heb.) to mean that Elisha was *twice as great* as Elijah.

ELIJAH WILNA, or Elijah ben Solomon, best known as the Gaon Elijah of Wilna (1720-1797), a noted Talmudist who hovered between the new and the old schools of thought. Orthodox in practice and feeling, his critical treatment of the rabbinic literature prepared the way for the scientific investigations of the 19th century. As a teacher he was one of the first to discriminate between the various strata in rabbinic records; to him was due the revival of interest in the older Midrash (*q.v.*) and in the Palestinian Talmud (*q.v.*), interest in which had been weak for some centuries before his time. He was an ascetic, and was a keen opponent of the emotional mysticism which was known as the new Hassidism.

See S. Schechter's *Studies in Judaism* (London, 1896). His voluminous writings are classified in the *Jewish Encyclopedia*, v. 134.

(I. A.)

ELIOT, CHARLES WILLIAM (1834-   ), American educationalist, the son of Samuel Atkins Eliot (1798-1862), mayor of Boston, representative in Congress, and in 1842-1853 treasurer of Harvard, was born in Boston on the 20th of March 1834. He graduated in 1853 at Harvard College, where he was successively tutor (1854-1858) and assistant professor of chemistry (1858-1863). He studied chemistry and foreign educational methods in Europe in 1863-1865, was professor of analytical chemistry in the newly established Massachusetts Institute of Technology (1865-1869), although absent fourteen months in Europe in 1867-1868; and in 1869 was elected president of Harvard University, a choice remarkable at once for his youth and his being a layman and scientist. With Johns Hopkins University, Harvard, in his presidency, led in the work of efficient graduate schools. Its elective system, which has spread far, although not originated by President Eliot, was thoroughly established by him, and is only one of many radical changes which he championed with great success. The raising of entrance requirements, which led to a corresponding raising of the standards of secondary schools, and the introduction of an element of choice in these entrance requirements, which allowed a limited election of studies to secondary pupils, became national tendencies primarily through President Eliot’s potent influence. As chairman of a national Committee of Ten (1890) on secondary school studies, he urged the abandonment of brief disconnected “information” courses, the correlation of subjects taught, the equal rank in college requirements of subjects in which equal time, consecutiveness and concentration were demanded, and a more thorough study of English composition; and to a large degree he secured national sanction for these reforms and their working out by experts into a practicable and applicable system. He laboured to unify the entire educational system, minimize prescription, cast out monotony, and introduce freedom and enthusiasm; and he emphasized the need of special training for special work. He was first to suggest (1894) co-operation by colleges in holding common entrance examinations throughout the country, and it was largely through his efforts that standards were so approximated that this became possible. He contended that secondary schools maintained by public funds should shape their courses for the benefit of students whose education goes no further than such high schools, and not be mere training schools for the universities. His success as administrator and man of affairs and as an educational reformer made him one of the great figures of his time, in whose opinions on any topic the deepest interest was felt throughout the country. In November 1908 he resigned the presidency of Harvard, and retired from the position early in 1909, when he was succeeded by Professor Abbott Lawrence Lowell. In December 1908 he was elected president of the National Civil Service Reform League.

His writings include *The Happy Life* (1896); *Five American Contributions to Civilization, and Other Essays and Addresses* (1897); *Educational Reform, Essays and Addresses 1869-1897* (1898); *More Money for the Public Schools* (1903); *Four American Leaders* (1906), chapters on Franklin, Washington, Channing and Emerson; *University Administration* (1908); and with F.H. Storer, a *Compendious Manual of Qualitative Chemical Analysis* (Boston, 1869; many times reissued and revised). His annual reports as President of Harvard were notable contributions to the literature of education in America, and he delivered numerous public addresses, many of which have been reprinted.

See “President Eliot’s Administration,” by different hands, a summary of his work at Harvard in 1869-1894, in *The Harvard Graduates’ Magazine*, vol. 2, pp. 449-504 (Boston, Mass., 1894); and E. Kuhnemann, *Charles W. Eliot, President of Harvard* (Boston, 1909).

His son, Charles Eliot (1859-1897), graduated at Harvard in 1882, studied landscape architecture at the Bussey Institution of Harvard and in Europe, successfully urged the incorporation of the Massachusetts Trustees of Public Reservations (1891) and of the Metropolitan Park Commission (1892) of Boston, became landscape architect to the Metropolitan Park Commission in 1892, and in 1893, with F.L. Olmsted and J.C. Olmsted, formed the firm of Olmsted, Olmsted & Eliot, which was employed by the Metropolitan Commission. His life was written by his father, *Charles Eliot, Landscape Architect* (Boston, 1902).

ELIOT, GEORGE, the pen-name of the famous English writer, *née* Mary Ann (or Marian) Evans (1819-1880), afterwards Mrs J.W. Cross, born at Arbury Farm, in Warwickshire, on the 22nd of November 1819. Her father, Robert Evans, was the agent of Mr Francis Newdigate, and the first twenty-one years of the great novelist’s life were spent on the Arbury estate. She received an ordinary education at respectable schools till the age of seventeen, when her mother’s death, and the marriage of her elder sister, called her home in the character of housekeeper. This, though it must have sharpened her sense, already too acute, of responsibility, was an immense advantage to her mind, and, later, to her career, for, delivered from the tiresome routine of lessons and class-work, she was able to work without pedantic interruptions at German, Italian and music, and to follow her unusually good taste in reading. The life, inasmuch as she was a girl still in her teens, was no doubt monotonous, even unhappy. Just as Cardinal Newman felt, with such different results, the sadness and chain of evangelical influences from his boyhood till the end of his days, so Marian Evans was subdued all through her youth by a severe religious training which, while it pinched her mind and crushed her spirit, attracted her idealism by the very hardness of its perfect counsels. It is not surprising to find, therefore, that when Mr Evans moved to Coventry in 1841, and so enlarged the circle of their acquaintance, she became much interested in some new friends, Mr and Mrs Charles Bray and Mr Charles Hennell. Mr Bray had literary taste and wrote works on the *Education of the Feelings*, the *Philosophy of Necessity*, and the like. Mr Hennell had published in 1838 *An Enquiry concerning the Origin of Christianity*. Miss Evans, then twenty-two, absorbed immediately these unexpected, and, at that time, daring habits of thought. So compelling was the atmosphere that it led to a complete change in her opinions. Kind in her affection, she was relentless in argument. She refused to go to church (for some time, at least), wrote painful letters to a former governess—the pious Miss Lewis—and barely avoided an irremediable quarrel with her father, a churchman of the old school. Here was rebellion indeed. But rebels come, for the most part, from the provinces where petty tyranny, exercised by small souls, show the scheme of the universe on the meanest possible scale. George Eliot was never orthodox again; she abandoned, with fierce determination, every creed, and although she passed, later, through various phases, she remained incessantly a rationalist in matters of faith and in all other matters. It is nevertheless true that she wrote admirably about religion and religious persons. She had learnt the evangelical point of view; she knew—none better—the strength of religious motives; vulgar doubts of this fact were as distasteful to her as they were to another eminent writer, to whom she refers in one of her letters (dated 1853) as “a Mr Huxley, who was the centre of interest” at some “agreeable evening.” Her books abound in tributes to Christian virtue, and one of her own favourite characters was Dinah Morris in *Adam Bede*.

She undertook, about the beginning of 1844, the translation of Strauss’s *Leben Jesu*. This work, published in 1846, was considered scholarly, but it met, in the nature of things, with no popular success. On the death of Mr Evans in 1849, she went abroad for some time, and we hear of no more literary ventures till 1851, when she accepted the assistant-editorship of the *Westminster Review*. For a while she had lodgings at the offices of that publication in the Strand, London. She wrote several notable papers, and became acquainted with many distinguished authors of that period—among them Herbert Spencer, Carlyle, Harriet Martineau, Francis Newman and George Henry Lewes. Her friendship with the last-named led to a closer relationship which she regarded as a marriage. Among the many criticisms passed upon this step (in view of the fact, among other considerations, that Lewes had a wife living at the time), no one has denied her courage in defying the law, or questioned the quality of her tact in a singularly false position. That she felt the deepest affection for Lewes is evident; that we owe the development of her genius to his influence and constant sympathy is all but certain. Yet it is also sure that what she gained from his intimate companionship was heavily paid for in the unceasing consciousness that most people thought her guilty of a grave mistake, and found her written words, with their endorsement of traditional morality, wholly at variance with the circumstances of her private life. Doubts of her suffering in this respect will be at once dismissed after a study of her journal and letters. Stilted and unnatural as these are to a tragic degree, one can read well enough between the lines, and also in the elaborate dedication of each manuscript to “my husband” (in terms of the strongest love), that self-repression, coupled with audacity, does not make for peace. Her sensitiveness to criticism was extreme; a flippant paragraph or an illiterate review with regard to her work actually affected her for days. The whole history of her union with Lewes is a complete illustration of the force of sheer will—in that case partly her own and not inconsiderably his —over a nature essentially unfitted for a bold stand against attacks. At first she and the man whom she had described “as a sort of miniature Mirabeau in appearance,” went abroad to Weimar and 276
Berlin, but they returned to England the same year and settled, after several moves, in lodgings at East Sheen.

In 1854 she published *The Essence of Christianity*, a translation from Feuerbach, a philosopher to whom she had been introduced by Charles Bray. During 1855 she translated Spinoza’s *Ethics*, wrote articles for the *Leader*, the *Westminster Review*, and the *Saturday Review*—then a new thing. It was not until the following year that she attempted the writing of fiction, and produced *The Sad Fortunes of the Reverend Amos Barton*—the first of the *Scenes of Clerical Life*. These, published in *Blackwood’s Magazine*, were issued in two volumes in 1858. The press in general extended a languid welcome to this work, and although the author received much encouragement from private sources, notably from Charles Dickens, the critics were mostly non-committal, and it was not until the publication of *Adam Bede* in 1859 that enthusiasm was attracted to the quality of the earlier production. *Adam Bede*, in the judgment of many George Eliot’s masterpiece, met with a success (in her own words) “triumphantly beyond anything she had dreamed of.” In 1860 appeared *The Mill on the Floss*. After the sensational good fortune of *Adam Bede*, the criticism applied to the new novel seems to have been disappointing. We find Miss Evans telling her publisher that “she does not wish to see any newspaper articles.” But the book made its way, and prepared an ever-growing army of readers for *Silas Marner* (1861), *Romola* (1862-1863), and *Felix Holt* (1866).

Silas Marner shows a reversion to her early manner—the manner of *Scenes of Clerical Life*. *Romola*, which is what is called an historical novel, owes its vitality not to the portraits of Savonarola or of the heroine, or to its vigorous pictures of Florentine life in the 15th century, but to its superb presentment of the treacherous, handsome Tito Melema, who belongs not to any one period but to every generation. *Felix Holt*, a novel dealing with political questions, is strained by a painfulness too severe for any reader’s pleasure. Where other eminent authors have produced mechanical books, or books which were mere repetitions of their most popular effort, she erred only on the side of the ponderous and the distressing. *Felix Holt* is both, and it is the only one of her novels which lacks an unforgettable human note. *The Spanish Gypsy* (1868), a drama in blank verse, received more public response than most compositions of the kind executed by those connected with the drama or with poetry only; and she published in 1874 another volume of verses, *The Legend of Jubal and other Poems*.

Any depression which the author may have felt with regard to the faults found with some of the last-named books was completely cured by the praise bestowed on *Middlemarch* (1872). This profound study of certain types of English character was supreme at the time of its writing, and it remains supreme, of its school, in European literature. Thackeray is brilliant; Tolstoi is vivid to a point where life-likeness overwhelms any consideration of art; Balzac created a whole world; George Eliot did not create, but her exposition of the upper and middle class minds of her day is a masterpiece of scientific psychology. *Daniel Deronda* (1876), a production on the same lines, was less satisfactory. It exhibited the same human insight, the passionate earnestness, the insinuated special pleading for hard cases, the same intellectual strength, but the subject was unwieldy, almost forbidding, and, as a result, the novel, in spite of its distinction, has never been thoroughly liked. The death of Mr Lewes in 1878 was also the death-blow to her artistic vitality. She corrected the proofs of *Theophrastus Such* (a collection of essays), but she wrote no more. About two years later, however, she married Mr J.W. Cross, a gentleman whose friendship was especially congenial to a temperament so abnormally dependent on affectionate understanding as George Eliot’s. But she never really recovered from her shock at the loss of George Lewes, and died at 4 Cheyne Walk, Chelsea, on the 22nd of December 1880.

No right estimate of her, whether as a woman, an artist or a philosopher, can be formed without a steady recollection of her infinite capacity for mental suffering, and her need of human support. The statement that there is no sex in genius, is on the face of it, absurd. George Sand, certainly the most independent and dazzling of all women authors, neither felt, nor wrote, nor thought as a man. Saint Teresa, another great writer on a totally different plane, was pre-eminently feminine in every word and idea. George Eliot, less reckless, less romantic than the Frenchwoman, less spiritual than the Spanish saint, was more masculine in style than either; but her outlook was not, for a moment, the man’s outlook; her sincerity, with its odd reserves, was not quite the same as a man’s sincerity, nor was her humour that genial, broad, unequivocal humour which is peculiarly virile. Hers approximated, curiously enough, to the satire of Jane Austen, both for its irony and its application to little everyday affairs. Men’s humour, in its classic manifestations, is on the heroic rather than on the average scale: it is for the uncommon situations, not for the daily tea-table.

Her method of attacking a subject shows the influence of Jane Austen, especially in parts of *Middlemarch*; one can detect also the stronger influence of Mrs Gaskell, of Charlotte Brontë, and of Miss Edgeworth. It was, however, but an influence, and no more than a man writer, anxious to acquire a knowledge of the feminine point of view, might have absorbed from a study of these women novelists. One often hears that she is not artistic; that her characterization is less distinct than Jane Austen’s; that she tells more than should be known of her heroes and heroines. But it should be remembered that Jane Austen dealt with familiar domestic types, whereas George Eliot excelled in the presentation of extraordinary souls. One woman drew members of polite society with correct notions, while the other woman depicted social rebels with ideas and ideals. In every one of George Eliot’s books, the protagonists, tortured by dreams of perfection, are in revolt against the prudent compromises of the worldly. All through her stories, one hears the clash of “the heroic for earth too high,” and the desperate philosophy, disguised it is true, of Omar Khayyam. In her day, Epicureanism had not reached the life of the people, nor passed into the education of the mob. Few dared to confess that the pursuit of pleasure, whether real or imagined, was the aim of mankind. The charm of Jane Austen is the charm of the untroubled and well-to-do materialist, who sees in a rich marriage, a comfortable house, carriages and an assured income the best to strive for; and in a fickle lover of either sex or the loss of money the severest calamities which can befall the human spirit. Jane Austen despised the greater number of her characters: George Eliot suffered with each of hers. Here, perhaps, we find the reason why she is accused of being inartistic. She could not be impersonal.

Again, George Eliot was a little scornful to those of both sexes who had neither special missions nor the consciousness of this deprivation. Men are seldom in favour of missions in any field. She demanded, too strenuously from the very beginning, an aim, more or less altruistic, from every individual; and as she advanced in life this claim became the more imperative, till at last it overpowered her art, and transformed a great delineator of humanity into an eloquent observer with far too many personal prejudices. But she was altogether free from cynicism, bitterness, or the least tendency to pride of intellect. She suffered from bodily weakness the greater part of her life, and, but for an extraordinary mental health—inherited from the fine yeoman stock from which she sprang—it is impossible that she could have retained, at all times, so sane a view of human conduct, or been the least sentimental among women writers of the first rank—the one wholly without morbidity in any disguise. The accumulation of mere book knowledge, as opposed to the friction of a life spent among all sorts and conditions of men, drove George Eliot at last to write as a specialist for specialists: joy was lost in the consuming desire for strict accuracy: her genius became more and more speculative, less and less emotional. The highly trained brain suppressed the impulsive heart,—the heart described with such candour and pathos as Maggie Tulliver’s in *The Mill on the Floss*. For this reason—chiefly because philosophy is popularly associated with inactive depression, whereas human nature is held to be eternally exhilarating—her later works have not received so much praise as her earlier productions. But one has only to compare *Romola* or *Daniel Deronda* with the compositions of any author except herself to realize the greatness of her designs, and the astonishing gifts brought to their final accomplishment. 277

See also the *Life of George Eliot*, edited by J.W. Cross (3 vols., 1885-1887); *George Eliot*, by Sir Leslie Stephen, in the “English Men of Letters” series (1902); by Oscar Browning, “Great Writers” series (1890), with a bibliography by J.P. Anderson; by Mathilde Blind, “Eminent Women” series, a new edition of which also contains a bibliography (Boston, Mass., 1904).

(P. M. T. C.)

ELIOT, SIR JOHN (1592-1632), English statesman, son of Richard Eliot, a member of an old Devonshire family lately settled in Cornwall, was born at his father’s seat at Port Eliot in Cornwall in 1592. He matriculated at Exeter College, Oxford, on the 4th of December 1607, and leaving the university after a residence of three years he studied law at one of the inns of court. He also spent some months travelling in France, Spain and Italy, in company, for part of the time, with young George Villiers, afterwards duke of Buckingham. He was only twenty-two when he began his parliamentary career as member for St Germans in the “addled parliament” of 1614. In 1618 he was knighted, and next year through the patronage of Buckingham he obtained the appointment of vice-admiral of Devon, with large powers for the defence and control of the commerce of the county. It was not long before the characteristic energy with which he performed the duties in his office involved him in difficulties. After many attempts, in 1623 he succeeded by a clever but dangerous manœuvre in entrapping the famous pirate John Nutt, who had for years infested the southern coast, inflicting immense damage upon English commerce. The issue is noteworthy. The pirate, having a powerful protector at court in Sir George Calvert, the secretary of state, was pardoned; while the vice-admiral, upon charges which could not be substantiated, was flung into the Marshalsea, and detained there nearly four months.

A few weeks after his release Eliot was elected member of parliament for Newport (February 1624). On the 27th of February he delivered his first speech, in which he at once revealed his great powers as an orator, demanding boldly that the liberties and privileges of parliament, repudiated by James I. in the former parliament, should be secured. In the first parliament of Charles I., in 1625, he urged the enforcement of the laws against the Roman Catholics. Meanwhile he had continued the friend and supporter of Buckingham and greatly approved of the war with Spain. Buckingham’s incompetence, however, and the bad faith with which both he and the king continued to treat the parliament, alienated Eliot completely from the administration. Distrust of his former friend quickly grew in Eliot’s excitable mind to a certainty of his criminal ambition and treason to his country. Returned to the parliament of 1626 as member for St Germans, he found himself, in the absence of other chiefs of the opposition whom the king had secured by nominating them sheriffs, the leader of the House. He immediately demanded an inquiry into the recent disaster at Cadiz. On the 27th of March he made an open and daring attack upon Buckingham and his evil administration. He was not intimidated by the king’s threatening intervention on the 29th, and persuaded the House to defer the actual grant of the subsidies and to present a remonstrance to the king, declaring its right to examine the conduct of ministers. On the 8th of May he was one of the managers who carried Buckingham’s impeachment to the Lords, and on the 10th he delivered the charges against him, comparing him in the course of his speech to Sejanus. Next day Eliot was sent to the Tower. On the Commons declining to proceed with business as long as Eliot and Sir Dudley Digges (who had been imprisoned with him) were in confinement, they were released, and parliament was dissolved on the 15th of June. Eliot was immediately dismissed from his office of vice-admiral of Devon, and in 1627 he was again imprisoned for refusing to pay a forced loan, but liberated shortly before the assembling of the parliament of 1628, to which he was returned as member for Cornwall. He joined in the resistance now organized to arbitrary taxation, was foremost in the promotion of the Petition of Right, continued his outspoken censure of Buckingham, and after the latter’s assassination in August, led the attack in the session of 1629 on the ritualists and Arminians.

In February the great question of the right of the king to levy tonnage and poundage came up for discussion; and on the king ordering an adjournment of parliament, the speaker, Sir John Finch, was held down in the chair while Eliot’s resolutions against illegal taxation and innovations in religion were read to the House by Holles (*q.v.*). In consequence, Eliot, with eight other members, was imprisoned on the 4th of March in the Tower. He refused to answer in his examination, relying on his privilege of parliament, and on the 29th of October was removed to the Marshalsea. On the 26th of January he appeared at the bar of the king’s bench, with Holles and Valentine, to answer a charge of conspiracy to resist the king’s order, and refusing to acknowledge the jurisdiction of the court he was fined £2000 and ordered to be imprisoned during the king’s pleasure and till he had made submission. This he steadfastly refused. While some of the prisoners appear to have had certain liberty allowed to them, Eliot’s confinement in the Tower was made exceptionally severe. Charles’s anger had been from the first directed chiefly against him, not only as his own political antagonist but as the prosecutor and bitter enemy of Buckingham; “an outlawed man,” he described him, “desperate in mind and fortune.”

Eliot languished in prison for some time, during which he wrote several works, his *Negotium posterorum*, an account of the parliament in 1625; *The Monarchie of Man*, a political treatise; *De jure majestatis, a Political Treatise of Government*; and *An Apology for Socrates*, his own defence. In the spring of 1632 he fell into a decline. In October he petitioned Charles for permission to go into the country, but leave could only be obtained at the price of submission, and was finally refused. He died on the 27th of November 1632. When his son requested permission to move the body to Port Eliot, Charles, whose resentment still survived, returned the curt refusal: “Let Sir John Eliot be buried in the church of that parish where he died.” The manner of Eliot’s death, not without suspicion of foul play, and as the result of the king’s implacability and the severe treatment to which he had been subjected, had more effect, probably, than any other single incident in embittering and precipitating the dispute between king and parliament; and the tragic sacrifice of a man so gifted and patriotic, and actuated originally by no antagonistic feeling against the monarchy or the church, is the surest condemnation of the king’s policy and administration. Eliot was essentially a great orator, inspired by enthusiasm and high ideals, which he was able to communicate to his hearers by his eloquence, but, like Chatham afterwards, he had not only the gifts but the failings of the orator, was incapable of well-reasoned and balanced judgment, and, though one of the greatest personalities of the time, was inferior to Pym both as a party leader and as a statesman.

Eliot married Rhadagund, daughter of Richard Gedie of Trebursye in Cornwall, by whom he had five sons, from the youngest of whom Nicholas the present earl of St Germans is descended, and four daughters.

The *Life of Sir J. Eliot*, by J. Forster (1864), is supplemented and corrected by Gardiner's *History of England*, vols. v.-vii., and the article in the *Dict. of Nat. Biog.*, by the same author. Eliot's writings, together with his Letter-Book, have been edited by Dr Grosart.

ELIOT, JOHN (1604-1690), American colonial clergyman, known as the "Apostle to the Indians," was born probably at Widford, Hertfordshire, England, where he was baptized on the 5th of August 1604. He was the son of Bennett Eliot, a middle-class farmer. Little is known of his boyhood and early manhood except that he took his degree of B.A. at Jesus College, Cambridge, in 1622. It seems probable that he entered the ministry of the Established Church, but there is nothing definitely known of him until 1629-1630, when he became an usher or assistant at the school of the Rev. Thomas Hooker, at Little Baddow, near Chelmsford. The influence of Hooker apparently determined him to 278 become a Puritan, but his connexion with the school ceased in 1630, when Laud's persecutions drove Hooker into exile. The realization of the difficulties in the way of a non-conforming clergyman in England undoubtedly determined Eliot to emigrate to America in the autumn of 1631, where he settled first at Boston, assisting for a time at the First Church. In November 1632 he became "teacher" to the church at Roxbury, with which his connexion lasted until his death. There he married Hannah Mulford, who had been betrothed to him in England, and who became his constant helper. In the care of the Roxbury church he was associated with Thomas Welde from 1632 to 1641, with Samuel Danforth (1626-1674) from 1649 to 1674, and with Nehemiah Walter (1663-1750) from 1688 to 1690.

Inspired with the idea of converting the Indians, his first step was to perfect himself in their dialects, which he did by the assistance of a young Indian whom he received into his home. With his aid he translated the Ten Commandments and the Lord's Prayer. He first successfully preached to the Indians in their own tongue at Nonantum (Newton) in October 1646. At the third meeting several Indians declared themselves converted, and were soon followed by many others. Eliot induced the Massachusetts General Court to set aside land for their residence, the same body also voting him £10 to prosecute the work, and directing that two clergymen be annually elected by the clergy as preachers to the Indians. As soon as the success of Eliot's endeavours became known, the necessary funds flowed in upon him from private sources in both Old and New England. In July 1649 parliament incorporated the "Society for the Propagation of the Gospel in New England," which henceforth supported and directed the work inaugurated by Eliot. The first appeal for aid brought contributions of £11,000. In 1651 the Christian Indian town founded by Eliot was removed from Nonantum to Natick, where residences, a meeting-house, and a school-house were erected, and where Eliot preached, when able, once in every two weeks as long as he lived. To this community Eliot applied a plan of government by means of tens, fifties and hundreds, which he subsequently advocated as suitable for all England. Eliot's missionary labours encouraged others to follow in his footsteps. A second town under his direction was established at Ponkapog (Stoughton) in 1654, in which he had the assistance of Daniel Gookin (*c.* 1612-1687). His success was duplicated in Martha's Vineyard and Nantucket by the Mayhews, and by 1674 the unofficial census of the "praying Indians" numbered 4000. King Philip's War (1675-76) was a staggering blow to all missionary enterprise; and although few of the converted Indians proved disloyal, it was some years before adequate support could again be enlisted. Yet at Eliot's death, which occurred at Roxbury on the 21st of May 1690, the missions were at the height of their prosperity, and that the results of his labours were not permanent was due only to the racial traits of the New England tribes.

Of wider influence and more lasting value than his personal labours as a missionary was Eliot's work as a translator of the Bible and various religious works into the Massachusetts dialect of the Algonquian language. The first work completed was the *Catechism*, published in 1653 at Cambridge, Massachusetts, the first book to be printed in the Indian tongue. Several years elapsed before Eliot completed his task of translating the Bible. The New Testament was at last issued in 1661, and the Old Testament followed two years later. The New Testament was bound with it, and thus the whole Bible was completed. To it were added a Catechism and a metrical version of the Psalms. The title of this Bible, now a great rarity, is *Mamussee Wunneetupanatamwe Up-Biblum God naneeswe Nukkone Testament kah wonk Wusku Testament-Ne quoshkinnumuk nashpe Wuttinneumoh Christ noh assoowesit John Eliot*; literally translated, "The Whole Holy His-Bible God, both Old Testament and also New Testament. This turned by the-servant-of-Christ, who is called John Eliot."

This book was printed in 1663 at Cambridge, Mass., by Samuel Green and Marmaduke Johnson, and was the first Bible printed in America. In 1685 appeared a second edition, in the preparation of which Eliot was assisted by the Rev. John Cotton (1640-1699), the younger, of Plymouth, who also had a wide knowledge of the Indian tongue.

Besides his Bible, Eliot published at Cambridge in 1664 a translation of Baxter's *Call to the Unconverted*, and in 1665 an abridged translation of Bishop Bayly's *Practice of Piety*. With the assistance of his sons he completed (1664) his well-known Indian Grammar Begun, printed at Cambridge, Massachusetts, in 1666. It was reprinted in vol. ix. of the *Collections of the Massachusetts Historical Society*. *The Indian Primer*, comprising an exposition of the Lord's Prayer and a translation of the Larger Catechism, was published at Cambridge in 1669, and was reprinted under the editorial superintendence of Mr John Small of the university of Edinburgh in 1877. In 1671 Eliot printed in English a little volume entitled *Indian Dialogues*, followed in 1672 by his *Logick Primer*, both of which were intended for the instruction of the Indians in English. His last translation was Thomas Shepard's *Sincere Convert*, completed and published by Grindal Rawson in 1689. Eliot's literary activity, however, extended into other fields than that of Indian instruction. He was, with Richard Mather, one of the editors of the *Bay Psalm Book* (1640). Several tracts written wholly or in part by him in the nature of reports to the society which supported his missions were published at various times in England. In 1660 he published a curious treatise on government entitled *The Christian Commonwealth*, in which he found the ideal of government in the ancient Jewish state, and proposed the reorganization of the English government on the basis of a numerical subdivision of the inhabitants. His *Harmony of the Gospels* (1678) was a life of Jesus Christ.

Bibliography.—An account of Eliot's life and work is contained in Williston Walker's *Ten New England Leaders* (New York, 1901). There is a "Life of John Eliot," by Convers Francis, in *Sparks' American Biography*, vol. v. (New York, 1853); another by N. Adams (Boston, 1847); and a sketch in Cotton Mather's *Magnalia* (London, 1702). For a good account of his publications in the Indian language see the chapter on "The Indian Tongue and its Literature," by J.H. Trumbull, in vol. i. of the *Memorial History of Boston* (1882).

(W. Wr.)

ELIS, or Eleia, an ancient district of southern Greece, bounded on the N. by Achaea, E. by Arcadia, S. by Messenia, and W. by the Ionian Sea. The local form of the name was Valis, or Valeia, and its meaning, in all probability, "the lowland." In its physical constitution Elis is practically one with Achaea and Arcadia; its mountains are mere offshoots of the Arcadian highlands, and its principal rivers are fed by Arcadian springs. From Erymanthus in the north, Skollis (now known as Mavri and Santameri in different parts of its length) stretches toward the west, and Pholoe along the eastern frontier; in the south a prolongation of Mount Lycaeon bore in ancient times the names of Minthe and Lapithus, which have given place respectively to Alvena and to Kaiapha and Smerna. These mountains are well clothed with vegetation, and present a soft and pleasing appearance in contrast to the picturesque wildness of the parent ranges. They gradually sink towards the west and die off into what was one of the richest alluvial tracts in the Peloponnesus. Except where it is broken by the rocky promontories of Chelonatas (now Chlemutzi) and Ichthys (now Katakolo), the coast lies low, with stretches of sand in the north and lagoons and marshes towards the south. During the summer months communication with the sea being established by means of canals, these lagoons yield a rich harvest of fish to the inhabitants, who at the same time, however, are almost driven from the coast by the swarms of gnats. The district for administrative purposes forms part of the nome of Elis and Achaea (see Greece).

Elis was divided into three districts—Hollow or Lowland Elis (ἡ κοίλη Ἦλις), Pisatis, or the territory of Pisa, and Triphylia, or the country of the three tribes. (1) *Hollow Elis*, the largest and most northern of the three, was watered by the Peneus and its tributary the Ladon, whose united stream forms the modern Gastouni. It included not only the champaign country originally designated by its name, but also the mountainous region of Acrorea, occupied by the offshoots of Erymanthus. Besides the capital city of Elis, it contained Cyllene, an Arcadian settlement on the sea-coast, whose inhabitants worshipped Hermes under the phallic symbol; Pylus, at the junction of the Peneus and the Ladon, which, like so many other places of the same name, claimed to be the city of Nestor, and the fortified frontier town of Lasion, the ruins of which are still visible at Kuti, near the village of Kumani. The district was famous in antiquity for its cattle and horses; and its byssus, supposed to have been introduced by the Phoenicians, was inferior only to that of Palestine. (2) *Pisatis* extended south from Hollow Elis to the right bank of the Alpheus, and was divided into eight departments called after as many towns. Of these Salmone, Heraclea, Cicysion, Dyspontium and Harpina are known—the last being the reputed burial-place of Marmax, the suitor of Hippodamia. From the time of the early investigators it has been disputed whether Pisa, which gave its name to the district, has ever been a city, or was only a fountain or a hill. By far the most important spot in Pisatis was the scene of the great Olympic games, on the northern bank of the Alpheus (see Olympia). (3) *Triphylia* stretches south from the Alpheus to the Neda, which forms the boundary towards Messenia. Of the nine towns mentioned by Polybius, only two attained to any considerable influence—Lepreum and Macistus, which gave the names of Lepreatis and Macistia to the southern and northern halves of Triphylia. The former was the seat of a strongly independent population, and continued to take every opportunity of resisting the supremacy of the Eleans. In the time of Pausanias it was in a very decadent condition, and possessed only a poor brick-built temple of Demeter; but considerable remains of its outer walls are still in existence near the village of Strovitzi, on a part of the Minthe range.

The original inhabitants of Elis were called Caucones and Paroreatae. They are mentioned for the first time in Greek history under the title of Epeians, as setting out for the Trojan War, and they are described by Homer as living in a state of constant hostility with their neighbours the Pylians. At the close of the 11th century B.C. the Dorians invaded the Peloponnesus, and Elis fell to the share of Oxylus and the Aetolians. These people, amalgamating with the Epeians, formed a powerful kingdom in the north of Elis. After this many changes took place in the political distribution of the country, till at length it came to acknowledge only three tribes, each independent of the others. These tribes were the Epeians, Minyae and Eleans. Before the end of the 8th century B.C., however, the Eleans had vanquished both their rivals, and established their supremacy over the whole country. Among the other advantages which they thus gained was the right of celebrating the Olympic games, which had formerly been the prerogative of the Pisatans. The attempts which this people made to recover their lost privilege, during a period of nearly two hundred years, ended at length in the total destruction of their city by the Eleans. From the time of this event (572 B.C.) till the Peloponnesian War, the peace of Elis remained undisturbed. In that great contest Elis sided at first with Sparta; but that power, jealous of the increasing prosperity of its ally, availed itself of the first pretext to pick a quarrel. At the battle of Mantinea (418 B.C.) the Eleans fought against the Spartans, who, as soon as the war came to a close, took vengeance upon them by depriving them of Triphylia and the towns of the Acrorea. The Eleans made no attempt to re-establish their authority over these places, till the star of Thebes rose in the ascendant after the battle of Leuctra (371 B.C.). It is not unlikely that they would have effected their purpose had not the Arcadian confederacy come to the assistance of the Triphylians. In 366 B.C. hostilities broke out between them, and though the Eleans were at first successful, they were soon overpowered, and their capital very nearly fell into the hands of the enemy. Unable to make head against their opponents, they applied for assistance to the Spartans, who invaded Arcadia, and forced the Arcadians to recall their troops from Elis. The general result of this war was the restoration of their territory to the Eleans, who were also again invested with the right of holding the Olympic games. During the Macedonian supremacy in Greece they sided with the victors, but refused to fight against their countrymen. After the death of Alexander they renounced the Macedonian alliance. At a subsequent period they joined the Aetolian League, but persistently refused to identify themselves with the Achaeans. When the whole of Greece fell under the Roman yoke, the sanctity of Olympia secured for the Eleans a certain amount of indulgence. The games still continued to attract to the country large numbers of strangers, until they were finally put down by Theodosius in 394, two years previous to the utter destruction of the country by the Gothic invasion under Alaric. In later times Elis fell successively into the hands of the Franks and the Venetians, under whose rule it recovered to some extent its ancient prosperity. By the latter people the province of Belvedere on the Peneus was called, in consequence of its fertility, “the milch cow of the Morea.”

ELIS, the chief city of the ancient Greek district of Elis, was situated on the river Peneus, just where it passes from the mountainous district of Acrorea into the champaign below. According to native tradition, it was originally founded by Oxylus, the leader of the Aetolians, whose statue stood in the market-place. In 471 B.C. it received a great extension by the incorporation (synoecism) of various small hamlets, whose inhabitants took up their abode in the city. Up to this date it only occupied the ridge of the hill now called Kalaskopi, to the south of the Peneus, but afterwards it spread out in several suburbs, and even to the other side of the stream. As all the athletes who intended to take part in the Olympic games were obliged to undergo a month’s training in the city, its gymnasiums were among its principal institutions. They were three in number—the “Xystos,” with its avenues of plane-trees, its plethrion or wrestling-place, its altars to Heracles, to Eros and Anteros, to Demeter and Kore (Cora), and its cenotaph of Achilles; the “Tetragonon,” appropriated to boxing exercises; and the “Maltho,” in the interior of which was a hall or council chamber called Lalichmion after its founder. The market-place was of the old-fashioned type, with porticoes at intervals and paths leading between them. It was called the Hippodrome because it was commonly used for exercising horses. Among the other objects of interest were the temple of Artemis Philomirax; the Hellanodicaeon, or office of the Hellanodicae; the Corcyrean Hall, a building in the Dorian style with two façades, built of spoils from Corcyra; a temple of Apollo Acesius; a temple of Silenus; an ancient structure supported on oaken pillars and reputed to be the burial-place of Oxylus; the building where the sixteen women of Elis were wont to weave a robe for the statue of Hera at Olympia; the temple of Aphrodite, with a statue of the goddess by Pheidias as Urania with a tortoise beneath her foot, and by Scopas as Pandemos, riding on a goat; and the shrine of Dionysus, whose festival, the Thyia, was yearly celebrated in the neighbourhood. On the acropolis was a temple of Athena, with a gold and ivory statue by Pheidias. The history of the town is closely identified with that of the country. In 399 B.C. it was occupied by Agis, king of Sparta. The acropolis was fortified in 312 by Telesphorus, the admiral of Antigonus, but it was shortly afterwards dismantled by Philemon, another of his generals. A view of the site is given by Stanhope. It is now called Palaeopolis. No traces of any buildings can be identified, the only remains visible dating from Roman times.

See Pausanias vi. 23-26; J. Spencer Stanhope, *Olympia and Elis* (1824), folio; W.M. Leake, *Morea* (1830); E. Curtius, *Peloponnesus* (1851-1852); Schiller, *Stämme und Staaten Griechenlands*; C. Bursian, *Geographie von Griechenland* (1868-1872); P. Gardner, “The Coins of Elis,” in *Num. Chr.* (1879).

(E. Gr.)

ELIS, PHILOSOPHICAL SCHOOL OF. This school was founded by Phaedo, a pupil of Socrates. It existed for a very short time and was then transferred by Menedemus to Eretria, where it became known as the Eretrian school. Its chief members, beside Phaedo, were Anchipylus, Moschus and Pleistanus (see Phaedo and Menedemus).

ELISAVETGRAD, a fortress and town of Russia, in the government of Kherson, 296 m. by rail N.E. of Odessa on the Balta-Kremenchug railway, and on the Ingul river, in 48° 31′ N. and 32° 10′ E. The population increased from 23,725 in 1860 to 66,182 in 1900. The town is regularly built, with wide streets, some of them lined with trees, and is a wealthy town, which has become an industrial centre for the region especially on account of its steam flour-mills, in which it is second only to Odessa, its distilleries, mechanical workshops, tobacco and tallow factories and brickworks. It is an important centre for trade in cereals and flour for export, and in sheep, cattle, wool, leather and timber. Five fairs are held annually. It has a military school, a first-class meteorological station and a botanical garden. The town was founded in 1754 and named after the empress Elizabeth. The fortifications are now decayed. 280

ELISAVETPOL, a government of Russia, Transcaucasia, having the governments of Tiflis and Daghestan on the N., Baku on the E., and Erivan and Tiflis on the W. and Persia on the S. Area, 16,721 sq. m. It includes: (*a*) the southern slope of the main Caucasus range in the north-east, where Bazardyuzi (14,770 ft.) and other peaks rise above the snow-line; (*b*) the arid and unproductive steppes beside the Kura, reaching 1000 ft. of altitude in the west and sinking to 100-200 ft. in the east, where irrigation is necessary; and (*c*) the northern slopes of the Transcaucasian escarpment and portions of the Armenian plateau, which is intersected towards its western boundary, near Lake Gok-cha, by chains of mountains consisting of trachytes and various crystalline rocks, and reaching 12,845 ft. in Mount Kapujikh. Elsewhere the country has the character of a plateau, 7000 to 8000 ft. high, deeply trenched by tributaries of the Aras. All varieties of climate are found from that of the snowclad peaks, Alpine meadows, and stony deserts of the high levels, to that of the hill slopes, clothed with gardens and vineyards, and of the arid Caspian steppes. Thus, at Shusha, on the plateau, at an altitude of 3680 ft., the average temperatures are: year 48°, January 26°, July 66°; annual rainfall, 26.4; while at Elisavetpol, in the valley of the Kura, they are: year 55°, January 32°.2, July 77° and rainfall only 10.3 in. Nearly one-fifth of the surface is under forests.

The population which was 885,379 in 1897 (only 392,124 women; 84,130 urban), and was estimated at 953,300 in 1906, consists chiefly of Tatars (56%) and Armenians (33%). The remainder are Kurds (4.7%), Russians and a few Germans, Jews, Kurins, Udins and Tates. Peasants form the great bulk of the population. Some of the Tatars and the Kurds are nomadic. Wheat, maize, barley, oats and rye are grown, also rice. Cultivation of cotton has begun, but the rearing of silkworms is of old standing, especially at Nukha (1650 tons of cocoons on the average are obtained every year). Nearly 8000 acres are under vines, the yield of wine averaging 82½ million gallons annually. Gardening reaches a high standard of perfection. Liquorice root is obtained to the extent of about 35,000 tons annually. The rearing of live-stock is largely carried on on the steppes. Copper, magnetic iron ore, cobalt and a small quantity of naphtha are extracted, and nearly 10,000 persons are employed in manufacturing industry—copper works and silk-mills. Carpet-weaving is widely spread. Owing to the Transcaucasian railway, which crosses the government, trade, both in the interior and with Persia, is very brisk. The government is divided into eight districts, Elisavetpol, Aresh, Jebrail, Jevanshir, Kazakh, Nukha, Shusha and Zangezur. The only towns, besides the capital, are Nukha (24,811 inhabitants in 1897) and Shusha (25,656).

ELISAVETPOL (formerly *Ganja*, alternative names being Kenjeh and Kanga), a town of Russia, capital of the government of the same name, 118 m. by rail S.E. of Tiflis and 3½ m. from the railway, at an altitude of 1446 ft. Pop. (1873) 15,439; (1897) 33,090. It is a very old town, which changed hands between Persians, Khazars and Arabs even in the 7th century, and later fell into the possession of Mongols, Georgians, Persians and Turks successively, until the Russians took it in 1804, when the change of name was made. It is a badly built place, with narrow streets and low-roofed, windowless houses, and is situated in a very unhealthy locality, but has been much improved, a new European quarter having been built on the site of the old fortress (erected by the Turks in 1712-1724). The inhabitants are chiefly Tatars and Armenians, famed for their excellent gardening, and also for silkworm breeding. It has a beautiful mosque, built by Shah Abbas of Persia in 1620; and a renowned "Green Mosque" amidst the ruins of old Ganja, 4 m. distant. The Persian poet, Shah Nizam (Nizam-ed-Din), was born here in 1141, and is said to have been buried (1203) close to the town. The Persians were defeated by the Russians under Paskevich outside this town in 1826.

ELISHA (a Hebrew name meaning "God is deliverance"), in the Bible, the disciple and successor of Elijah, was the son of Shaphat of Abel-meholah in the valley of the Jordan. He was symbolically elected to the prophetic office by Elijah some time during the reign of Ahab (1 Kings xix. 19-21), and he survived until the reign of Joash. His career thus appears to have extended over a period of nearly sixty years. The relation between Elijah and Elisha was of a particularly close kind, but the difference between them is much more striking than the resemblance. Elijah is the prophet of the wilderness, wandering, rugged and austere; Elisha is the prophet of civilized life, of the city and the court, with the dress, manners and appearance of ordinary "grave citizens." Elijah is the messenger of vengeance —sudden, fierce and overwhelming; Elisha is the messenger of mercy and restoration. Elijah's miracles, with few exceptions, are works of wrath and destruction; Elisha's miracles, with but one notable exception, are works of beneficence and healing. Elijah is the "prophet as fire" (Ecclus, xlviii. 1), an abnormal agent working for exceptional ends; Elisha is the "holy man of God which passeth by us continually" (2 Kings iv. 9), mixing in the common life of the people.

It is impossible to draw up a detailed chronology of his life. In most of the events narrated no further indication of time is given than by the words "the king of Israel," the name not being specified. There are some instances in which the order of time is obviously the reverse of the order of narrative, and there are other grounds for concluding that the narrative as we now have it is confused and incomplete. This may serve not only to explain the chronological difficulties, but also to throw some light on the altogether exceptional character of the miraculous element in Elisha's history. On the literary questions, see further Kings.

Not only are Elisha's miracles very numerous, even more so than those of Elijah, but they stand in a peculiar relation to the man and his work. With all the other prophets the primary function is spiritual teaching; miracles, even though numerous and many of them symbolical like Elisha's, are only accessory. With Elisha, on the other hand, miracles seem the principal function, and the teaching is altogether subsidiary. An explanation of the superabundance of miracles in Elisha's life is suggested by the fact that several of them were merely repetitions or doubles of those of his predecessor. Such were: his first miracle, when, returning across the Jordan, he made a dry path for himself in the same manner as Elijah (2 Kings ii. 14); the increase of the widow's pot of oil (iv. 1-7); and the restoration of the son of the woman of Shunem to life (iv. 18-37). The theory that stories from the earlier life have been imported by mistake into the later, even if tenable, applies only to three of the miracles, and leaves unexplained a much larger number which are not only not repetitions of those of Elijah, but have an entirely opposite character. The healing of the water of Jericho by putting salt in it (ii. 19-22), the provision of water for the army of Jehoshaphat in the arid desert (iii. 6-20), the neutralizing by meal of the poison in the pottage of the famine-stricken sons of the prophets at Jericho (iv. 38-41), the healing of Naaman the Syrian (v. 1-19), and the recovery of the iron axehead that had sunk in the water (vi. 1-7), are all instances of the beneficence which was the general characteristic of Elisha's wonder-working activity in contrast to that of Elijah. Another miracle of the same class, the feeding of a hundred men with twenty loaves so that something was left over (iv. 42-44), deserves mention as the most striking though not the only instance of a resemblance between the work of Elisha and that of Jesus (Matt. xiv. 13-21). The one distinct exception to the general beneficence of Elisha's activity—the 281
destruction of the forty-two children who mocked him as he was going up to Bethel (2 Kings ii. 23-25) —presents an ethical difficulty which is scarcely removed by the suggestion that the narrative has lost some particulars which would have shown the real enormity of the children's offence. We may prefer to imagine that among the homely stories told of him was one which had for its main object the inculcation of respect for one's elders.[1] The leprosy brought upon Gehazi (v. 20-27), though a miracle of judgment, scarcely belongs to the same class as the other; and it will be observed that Gehazi's subsequent relations with the court (viii. 1-6) ignore the disease, a fatal hindrance to intercourse. Further, the healing of Naaman (alluded to in Luke iv. 27) presupposes peaceful relations between Israel and the Syrians, with which, however, contrast ch. vi. The wonder-working power of Elisha is represented as continuing even after his death. As the feeding of the hundred men and the cure of leprosy connect his work with that of Jesus, so the story that a dead man who was cast into his sepulchre was brought to life by the mere contact with his bones (2 Kings xiii. 21, cf. Ecclus. xlviii. 12-

14) is the most striking instance of an analogy between his miracles and those recorded of medieval saints. Stanley (*Jewish Church*, 4th ed., ii. 276) in reference to this has remarked that in the life of Elisha alone "in the sacred history the gulf between biblical and ecclesiastical miracles almost disappears."

The place which Elisha filled in contemporary history was one of great influence and importance, and several narratives testify to his great reputation in Israel. On one occasion, when he delivered the army that had been brought out against Moab from a threatened dearth of water (2 Kings iii.),[2] he plainly intimates that, but for his regard to Jehoshaphat, the king of Judah, who was in alliance with Israel, he would not have interfered. Whether he was with the army or was supposed to be living in the desert is left obscure. An interesting touch is the influence of music upon the prophetic mind (*v.* 15). His next signal interference was during the incursions of the Syrians, when he disclosed the plans of the invaders to the "king of Israel" with such effect that they were again and again baffled. When the "king of Syria" was informed that "Elisha, the prophet that is in Israel, telleth the king of Israel the words that thou speakest in thy bed-chamber," he at once sent an army to take him captive in Dothan. At Elisha's prayer his terrified servant beheld an army of horses and chariots of fire surrounding the prophet. At a second prayer the invaders were struck blind, and in this state they were led by Elisha to Samaria, where their sight was restored. Their lives were spared at the command of the prophet, and they returned home so impressed that their incursions thenceforward ceased (vi. 8-23). This is immediately followed by the siege of Samaria by Benhadad which caused a famine of the severest kind. The calamity was imputed by the "king of Israel" to the influence of Elisha, and he ordered the prophet to be immediately put to death. Forewarned of the danger, Elisha ordered the messenger who had been sent to slay him to be detained at the door, and, when, immediately afterwards, the king himself came ("messenger" in vi. 33 should rather be *king*), predicted a great plenty within twenty-four hours. This was fulfilled by the flight of the Syrian army under the circumstances stated in ch. vii. After the episode with regard to the woman of Shunem (viii. 1-6), which is out of its chronological order, Elisha is represented as at Damascus (viii. 7-15). The reverence with which the foreign monarch Benhadad addressed Elisha deserves to be noted as showing the extent of the prophet's influence. In sending to know the issue of his illness, the king caused himself to be styled "*thy son* Benhadad." Equally remarkable is the very ambiguous nature of Elisha's reply (viii. 10).[3] The most important interference of Elisha in the history of his country constituted the fulfilment of the third of the commands laid upon Elijah. The work of anointing Jehu to be king over Israel was performed by deputy (ix. 1-3). During the forty-five years which the chronological scheme allows for the reigns of Jehu and Jehoahaz the narratives contain no notice of Elisha, but from the circumstances of his death (xiii. 14-21) it is clear that he had continued to enjoy the esteem of the dynasty which he had helped to found. Joash, the grandson of Jehu, waited on him on his death-bed, and addressed him in the words which he himself had used to Elijah: "My father, my father, the chariot of Israel and the horsemen thereof" (cf. ii. 12). By the result of a symbolic discharge of arrows he informed the king of his coming success against Syria, and immediately thereafter he died. The explicit statement that he was buried completes the contrast between him and his greater predecessor.

On the narratives, see Kings. In general those where "the prophet appears as on friendly terms with the king, and possessed of influence at court (*e.g.* 2 Kings iv. 13, vi. 9, vi. 21, compared with xiii. 14), plainly belong to the time of Jehu's dynasty, though they are related before the fall of the house of Omri. We can distinguish portions of an historical narrative which speaks of Elisha in connexion with events of public interest, without making him the central figure, and a series of anecdotes of properly biographical character.... In the latter we may distinguish one circle connected with Gilgal, Jericho and the Jordan valley to which Abel-Meholah belongs (iv. 1-7? 38-44, v.? vi. 1-7). Here Elisha appears as the head of the prophetic gilds, having his fixed residence at Gilgal.[4] Another circle, which presupposes the accession of the house of Jehu, places him at Dothan or Carmel, and represents him as a personage of almost superhuman dignity. Here there is an obvious parallelism with the history of Elijah, especially with his ascension (cf. 2 Kings vi. 17 with ii. 11; xiii. 14 with ii. 12); and it is to this group of narratives that the ascension of Elijah forms the introduction" (Robertson Smith, *Ency. Brit.*, 9th ed., art. Kings, vol. xiv. p. 186). This twofold representation finds a parallel in the narratives of Samuel, whose history and the conditions reflected therein are analogous to the life and times of Elisha.

Elisha is canonized in the Orthodox Eastern Church, his festival being on the 14th of June, under which date his life is entered in the *Acta sanctorum*.

See especially, W.R. Smith, *Prophets of Israel* (Index, *s.v.*), and the literature to Elijah; Kings, Books of; Prophet.

(W. R. S.; S. A. C.)

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1 Similarly Elijah enforces respect for the prophetic office in i. 9 sqq. Prof. Kennett points out to the present writer that the epithet "bald-head" may refer to the sign of mourning for Elisha's lost master (cf. Ez. vii. 18, Deut. xiv. 1); "Go up" is perhaps to be taken literally (in reference to Elijah's translation).

2 The method of obtaining water (*v.* 16 sq.) is that which still gives its name to the Wādi el-Aḥsā ("valley of water pits") at the southern end of the Dead Sea (*Old Test. Jew. Church*, 2nd ed., 147). On the other hand, see Burney, *Heb. Text of Kings*, p. 270.

3 R. V. marg. is an alteration to remove from Elisha the suggestion of an untruth.

4 The Gilgal of Elisha is near the Jordan—comp. vi. 1 with iv. 38, שבים לפניו,—and cannot be other than the

great sanctuary 2 m. from Jericho, the local holiness of which is still attested in the *Onomastica*. It is true that in 2 Kings ii. 1 Bethel seems to lie between Gilgal and Jericho; but v. 25 shows that Gilgal was not originally represented as Elisha's residence in this narrative, which belongs to the Carmel-Dothan series. On the other hand, for the identification with the Gilgal (Jiljilia) S.W. of Shiloh, see G.A. Smith, *Ency. Bib.* (s.v. Gilgal); Burney, *op. cit.*, p. 264; Skinner, *Century Bible*: *Kings*, p. 278.

ELISHA BEN ABUYAH (*c.* A.D. 100), a unique figure among the Palestinian Jews of the first Christian century. He was born before the destruction of the Temple (which occurred in A.D. 70) and survived into the 2nd century. It is not easy to decide as to his exact attitude towards Judaism. That he refused to accept the current rabbinical views is certain, though the Talmud cites his legal decisions. Most authorities believe that he was a Gnostic; but while it is certain that he was not a Christian, it is possible that he was simply a Sadducee, and thus an opponent not of Judaism but of Pharisaism. His disciple, the famous Pharisee Meir, remained his steadfast friend, and his efforts to reclaim his former master are among the most pathetic incidents in the Talmud. In later ages Elisha (*aḥer* "the other," as he was named) was regarded as the type of a heretic whose pride of intellect betrayed him into infidelity to law and morals. Without much appropriateness Elisha has been sometimes described as the "Faust of the Talmud."

(I. A.)

ELIXIR (from the Arabic *al-iksir*, probably an adaptation of the Gr. ξήριον, a powder used for drying wounds, from ξηρός, dry), in alchemy, the medium which would effect the transmutation of base metals into gold; it probably included all such substances—vapours, liquids, &c.—and had a wider meaning than "philosopher's stone." The same term, more fully *elixir vitae*, elixir of life, was given to 282
the substance which would indefinitely prolong life; it was considered to be closely related to, or even identical with, the substance for transmuting metals. In pharmacy the word was formerly given to a strong extract or tincture, but it is only used now for an aromatic sweet preparation, containing one or more drugs, and in such expressions as "elixir of vitriol," a mixture of sulphuric acid, cinnamon, ginger and alcohol.

ELIZABETH (1533-1603), queen of England and Ireland, born on Sunday the 7th of September 1533, and, like all the Tudors except Henry VII., at Greenwich Palace, was the only surviving child of Henry VIII. by his second queen, Anne Boleyn. With such a mother and with Cranmer as her godfather she represented from her birth the principle of revolt from Rome, but the opponents of that movement attached little importance to her advent into the world. Charles V.'s ambassador, Chapuys, hardly deigned to mention the fact that the king's *amie* had given birth to a daughter, and both her parents were bitterly disappointed with her sex. She was, however, given precedence over Mary, her elder sister by sixteen years, and Mary never forgave the infant's offence. Even this dubious advantage only lasted three years until her mother was beheaded, and by a much more serious freak on Henry's part "divorced." Elizabeth has been censured for having made no effort in later years to clear her mother's memory; but no vindication of Anne's character could have rehabilitated Elizabeth's legitimacy. Her mother was not "divorced" for her alleged adultery, because that crime was no ground for divorce by Roman or English canon law. The marriage was declared invalid *ab initio* either on the ground of Anne's precontract with Lord Percy or more probably on the ground of the affinity established between Henry and Anne by Henry's previous relations with Mary Boleyn.

Elizabeth thus lost all hereditary title to the throne, and her early years of childhood can hardly have been happier than Mary's. Nor was her legitimacy ever legally established; but after Jane Seymour's death, when Henry seemed likely to have no further issue, she was by act of parliament placed next in order of the succession after Edward and Mary and their issue; and this statutory arrangement was confirmed by the will which Henry VIII. was empowered by statute to make. Queen Catherine Parr introduced some humanity into Henry's household, and Edward and Elizabeth were well and happily educated together, principally at old Hatfield House, which is now the marquess of Salisbury's stables. They were there when Henry's death called Edward VI. away to greater dignities, and Elizabeth was left in the care of Catherine Parr, who married in indecent haste Thomas, Lord Seymour, brother of the protector Somerset. This unprincipled adventurer, even before Catherine's death in September 1548, paid indelicate attentions to Elizabeth. Any attempt to marry her without the council's leave would have been treason on his part and would have deprived Elizabeth of her contingent right to the succession. Accordingly, when Seymour’s other misbehaviour led to his arrest, his relations with Elizabeth were made the subject of a very trying investigation, which gave Elizabeth her first lessons in the feminine arts of self-defence. She proved equal to the occasion, partly because she was in all probability innocent of anything worse than a qualified acquiescence in Seymour’s improprieties and a girlish admiration for his handsome face. He or his tragic fate may have touched a deeper chord, but it was carefully concealed; and although in later years Elizabeth seems to have cherished his memory, and certainly showed no love for his brother’s children, at the time she only showed resentment at the indignities inflicted on herself.

For the rest of Edward’s reign Elizabeth’s life was less tempestuous. She hardly rivalled Lady Jane Grey as the ideal Puritan maiden, but she swam with the stream, and was regarded as a foil to her stubborn Catholic sister. She thus avoided the enmity and the still more dangerous favour of Northumberland; and some unknown history lies behind the duke’s preference of the Lady Jane to Elizabeth as his son’s wife and his own puppet for the throne. She thus escaped shipwreck in his crazy vessel, and rode by Mary’s side in triumph into London on the failure of the plot. For a time she was safe enough; she would not renounce her Protestantism until Catholicism had been made the law of the land, but she followed Gardiner’s advice to her father when he said it was better that he should make the law his will than try to make his will the law. As a presumptive ruler of England she was, like Cecil, and for that matter the future archbishop Parker also, too shrewd to commit herself to passive or active resistance to the law; and they merely anticipated Hobbes in holding that the individual committed no sin in subordinating his conscience to the will of the state, for the responsibility for the law was not his but the state’s. Their position was well enough understood in those days; it was known that they were heretics at heart, and that when their turn came they would once more overthrow Catholicism and expect a similar submission from the Catholics.

It was not so much Elizabeth’s religion as her nearness to the throne and the circumstances of her birth that endangered her life in Mary’s reign. While Mary was popular Elizabeth was safe; but as soon as the Spanish marriage project had turned away English hearts Elizabeth inevitably became the centre of plots and the hope of the plotters. Had not Lady Jane still been alive to take off the edge of Mary’s indignation and suspicion Elizabeth might have paid forfeit for Wyat’s rebellion with her life instead of imprisonment. She may have had interviews with French agents who helped to foment the insurrection; but she was strong and wary enough to avoid Henry II.’s, as she had avoided Northumberland’s, toils; for even in case of success she would have been the French king’s puppet, placed on the throne, if at all, merely to keep it warm for Henry’s prospective daughter-in-law, Mary Stuart. This did not make Mary Tudor any more friendly, and, although the story that Elizabeth favoured Courtenay and that Mary was jealous is a ridiculous fiction, the Spaniards cried loud and long for Elizabeth’s execution. She was sent to the Tower in March 1554, but few Englishmen were fanatic enough to want a Tudor beheaded. The great nobles, the Howards, and Gardiner would not hear of such a proposal; and all the efforts of the court throughout Mary’s reign failed to induce parliament to listen to the suggestion that Elizabeth should be deprived of her legal right to the succession. After two months in the Tower she was transferred to Sir Henry Bedingfield’s charge at Woodstock, and at Christmas, when the realm had been reconciled to Rome and Mary was expecting issue, Elizabeth was once more received at court. In the autumn of 1555 she went down to Hatfield, where she spent most of the rest of Mary’s reign, enjoying the lessons of Ascham and Baldassare Castiglione, and planting trees which still survive.

She had only to bide her time while Mary made straight her successor’s path by uprooting whatever affection the English people had for the Catholic faith, Roman jurisdiction and Spanish control. The Protestant martyrs and Calais between them removed all the alternatives to an insular national English policy in church and in state; and no sovereign was better qualified to lead such a cause than the queen who ascended the throne amid universal, and the Spaniards thought indecent, rejoicings at Mary’s death on the 17th of November 1558. “Mere English” she boasted of being, and after Englishmen’s recent experience there was no surer title to popular favour. No sovereign since Harold had been so purely English in blood; her nearest foreign ancestor was Catherine of France, the widow of Henry V., and no English king or queen was more superbly insular in character or in policy. She was the unmistakable child of the age so far as Englishmen shared in its characteristics, for with her English aims she combined some Italian methods and ideas. “An Englishman Italianate,” ran the current jingle, “is a devil incarnate,” and Elizabeth was well versed in Italian scholarship and statecraft. Italians, especially Bernardino Ochino, had given her religious instruction, and the Italians who rejected Catholicism usually adopted far more advanced forms of heresy than Lutheranism, Zwinglianism, or even Calvinism. Elizabeth herself patronized Giacomo Acontio, who thought dogma a “stratagema Satanae,” and her last favourite, Essex was accused of being the ringleader of “a 283
damnable crew of atheists.” A Spanish ambassador early in the reign thought that Elizabeth’s own religion was equally negative, though she told him she agreed with nearly everything in the Augsburg Confession. She was probably not at liberty to say what she really thought, but she made up by saying a great many things which she did not mean. It is clear enough that, although, like her father, she was fond of ritual, she was absolutely devoid of the religious temperament, and that her ecclesiastical preferences were dictated by political considerations. She was sincere enough in her dislike of Roman jurisdiction and of Calvinism; a daughter of Anne Boleyn could have little affection for a system which made her a bastard, and all monarchs agreed at heart with James I.’s aphorism about “no bishop, no king.” It was convenient, too, to profess Lutheran sympathies, for Lutheranism was now an established, monarchical and comparatively respectable religion, very different from the Calvinism

against which monarchs directed the Counter-reformation from political motives. Lutheran dogma, however, had few adherents in England, though its political theory coincided with that of Anglicanism in the 16th century. The compromise that resulted from these conflicting forces suited Elizabeth very well; she had little dislike of Catholics who repudiated the papacy, but she was forced to rely mainly on Protestants, and had little respect for any form of ecclesiastical self-government. She valued uniformity in religion, not as a safeguard against heresy, but as a guarantee of the unity of the state. She respected the bishops only as supporters of her throne; and, although the well-known letter beginning "Proud Prelate" is an 18th-century forgery, it is hardly a travesty of Elizabeth's attitude.

The outlines of her foreign policy are sketched elsewhere (see English History), and her courtships were diplomatic. Contemporary gossip, which was probably justified, said that she was debarred from matrimony by a physical defect; and her cry when she heard that Mary queen of Scots had given birth to a son is the most womanly thing recorded of Elizabeth. Her features were as handsome as Mary's, but she had little fascination, and in spite of her many suitors no man lost his head over Elizabeth as men did over Mary. She was far too masculine in mind and temperament, and her extravagant addiction to the outward trappings of femininity was probably due to the absence or atrophy of deeper feminine instincts. In the same way the impossibility of marriage made her all the freer with her flirtations, and she carried some of them to lengths that scandalized a public unconscious of Elizabeth's security. She had every reason to keep them in the dark, and to convince other courts that she could and would marry if the provocation were sufficient. She could not marry Philip II., but she held out hopes to more than one of his Austrian cousins whenever France or Mary Stuart seemed to threaten; and later she encouraged two French princes when Philip had lost patience with Elizabeth and made Mary Stuart his protégée. Her other suitors were less important, except Leicester, who appealed to the least intellectual side of Elizabeth and was always a cause of distraction in her policy and her ministers.

Elizabeth was terribly handicapped by having no heirs of her body and no obvious English successor. She could not afford to recognize Mary's claim, for that would have been to alienate the Protestants, double the number of Catholics, and, in her own phrase, to spread a winding-sheet before her eyes; for all would have turned to the rising sun. Mary was dangerous enough as it was, and no one would willingly make his rival his heir. Elizabeth could hardly be expected to go out of her way and ask parliament to repeal its own acts for Mary's sake; probably it would have refused. Nor was it personal enmity on Elizabeth's part that brought Mary to the block. Parliament had long been ferociously demanding Mary's execution, not because she was guilty but because she was dangerous to the public peace. She alone could have given the Spanish Armada any real chance of success; and as the prospect of invasion loomed larger on the horizon, fiercer grew the popular determination to remove the only possible centre of a domestic rising, without which the external attack was bound to be a failure. Elizabeth resisted the demand, not from compassion or qualms of conscience, but because she dreaded the responsibility for Mary's death. She wished Paulet would manage the business on his own account, and when at last her signature was extorted she made a scapegoat of her secretary Davison who had the warrant executed.

The other great difficulty, apart from the succession, with which Elizabeth had to deal arose from the exuberant aggressiveness of England, which she could not, and perhaps did not want to, repress. Religion was not really the cause of her external dangers, for the time had passed for crusades, and no foreign power seriously contemplated an armed invasion of England for religion's sake. But no state could long tolerate the affronts which English seamen offered Spain. The common view that the British Empire has been won by purely defensive action is not tenable, and from the beginning of her reign Englishmen had taken the offensive, partly from religious but also from other motives. They were determined to break up the Spanish monopoly in the new world, and in the pursuit of this endeavour they were led to challenge Spain in the old. For nearly thirty years Philip put up with the capture of his treasure-ships, the raiding of his colonies and the open assistance rendered to his rebels. Only when he had reached the conclusion that his power would never be secure in the Netherlands or the New World until England was conquered, did he despatch the Spanish Armada. Elizabeth delayed the breach as long as she could, probably because she knew that war meant taxation, and that taxation was the most prolific parent of revolt.

With the defeat of the Spanish Armada Elizabeth's work was done, and during the last fifteen years of her reign she got more out of touch with her people. That period was one of gradual transition to the conditions of Stuart times; during it practically every claim was put forward that was made under the first two Stuarts either on behalf of parliament or the prerogative, and Elizabeth's attitude towards the Puritans was hardly distinguishable from James I.'s. But her past was in her favour, and so were her sex and her Tudor tact, which checked the growth of discontent and made Essex's rebellion a ridiculous fiasco. He was the last and the most wilful but perhaps the best of her favourites, and his tragic fate deepened the gloom of her closing years. The loneliness of a queen who had no husband or children and no relatives to mention must at all times have been oppressive; it grew desolating in old age after the deaths of Leicester, Walsingham, Burghley and Essex, and Elizabeth died, the last of her race, on the 24th of March 1603.

Bishop Creighton's *Queen Elizabeth* (1896) is the best biography; there are others by E.S. Beesly (*Twelve English Statesmen*, 1892); Lucy Aikin, *Memoirs of the Court of Queen Elizabeth* (1818); and T. Wright, *Queen Elizabeth and her Times* (1838). See also A. Jessopp's article in the *Dict. Nat. Biog.*

(A. F. P.)

ELIZABETH [PETROVNA] (1709-1762), Empress of Russia, the daughter of Peter the Great and Martha Skovronskaya, born at Kolomenskoye, near Moscow, on the 18th of December 1709. Even as a child her parts were good, if not brilliant, but unfortunately her education was both imperfect and desultory. Her father had no leisure to devote to her training, and her mother was too illiterate to superintend her studies. She had a French governess, however, and at a later day picked up some Italian, German and Swedish, and could converse in these languages with more fluency than accuracy. From her earliest years she delighted every one by her extraordinary beauty and vivacity. It was Peter's intention to marry his second daughter to the young French king Louis XV., but the pride of the Bourbons revolted against any such alliance. Other connubial speculations foundered on the personal dislike of the princess for the various suitors proposed to her, so that on the death of her mother (May 1727) and the departure to Holstein of her beloved sister Anne, her only remaining near relation, the princess found herself at the age of eighteen practically her own mistress. So long as Menshikov remained in power, she was treated with liberality and distinction by the government of Peter II., but the Dolgorukis, who supplanted Menshikov and hated the memory of Peter the Great, practically banished Peter's daughter from court. Elizabeth had inherited her father's sensual 284
temperament and, being free from all control, abandoned herself to her appetites without reserve. While still in her teens, she made a lover of Alexius Shubin, a sergeant in the Semenovsky Guards, and after his banishment to Siberia, minus his tongue, by order of the empress Anne, consoled herself with a handsome young Cossack, Alexius Razumovski, who, there is good reason to believe, subsequently became her husband. During the reign of her cousin Anne (1730-1740), Elizabeth effaced herself as much as possible; but under the regency of Anne Leopoldovna the course of events compelled the indolent but by no means incapable beauty to overthrow the existing government. The idea seems to have been first suggested to her by the French ambassador, La Chétardie, who was plotting to destroy the Austrian influence then dominant at the Russian court. It is a mistake to suppose, however, that La Chétardie took a leading part in the revolution which placed the daughter of Peter the Great on the Russian throne. As a matter of fact, beyond lending the tsesarevna 2000 ducats, instead of the 15,000 she demanded of him, he took no part whatever in the actual *coup d'état* which was as great a surprise to him as to every one else. The merit and glory of that singular affair belong to Elizabeth alone. The fear of being imprisoned in a convent for the rest of her life was the determining cause of her irresistible outburst of energy. At midnight on the 6th of December 1741, with a few personal friends, including her physician, Armand Lestocq, her chamberlain, Michael Ilarionvich Vorontsov, her future husband, Alexius Razumovski, and Alexander and Peter Shuvalov, two of the gentlemen of her household, she drove to the barracks of the Preobrazhensky Guards, enlisted their sympathies by a stirring speech, and led them to the Winter Palace, where the regent was reposing in absolute security. Having on the way thither had all the ministers arrested, she seized the regent and her children in their beds, and summoned all the notables, civil and ecclesiastical, to her presence. So swiftly and noiselessly indeed had the whole revolution proceeded that as late as eight o'clock the next morning very few people in the city were aware of it. Thus, at the age of three-and-thirty, this naturally indolent and self-indulgent woman, with little knowledge and no experience of affairs, suddenly found herself at the head of a great empire at one of the most critical periods of its existence. Fortunately for herself, and for Russia, Elizabeth Petrovna, with all her shortcomings, had inherited some of her father's genius for government. Her usually keen judgment and her diplomatic tact again and again recall Peter the Great. What in her sometimes seemed irresolution and procrastination, was, most often, a wise suspense of judgment under exceptionally difficult circumstances; and to this may be added that she was ever ready to sacrifice the prejudices of the woman to the duty of the sovereign.

After abolishing the cabinet council system in favour during the rule of the two Annes, and reconstituting the senate as it had been under Peter the Great,—with the chiefs of the departments of state, all of them now Russians again, as *ex-officio* members under the presidency of the sovereign,—the first care of the new empress was to compose her quarrel with Sweden. On the 23rd of January 1743, direct negotiations between the two powers were opened at Åbo, and on the 7th of August 1743 Sweden ceded to Russia all the southern part of Finland east of the river Kymmene, which thus became the boundary between the two states, including the fortresses of Villmanstrand and Fredrikshamn. This triumphant issue was mainly due to the diplomatic ability of the new vice chancellor, Alexius Bestuzhev-Ryumin (*q.v.*), whom Elizabeth, much as she disliked him personally, had wisely placed at the head of foreign affairs immediately after her accession. He represented the anti-Franco-Prussian portion of her council, and his object was to bring about an Anglo-Austro-Russian alliance which, at that time, was undoubtedly Russia's proper system. Hence the reiterated attempts of Frederick the Great and Louis XV. to get rid of Bestuzhev, which made the Russian court during the earlier years of Elizabeth's reign the centre of a tangle of intrigue impossible to unravel by those who do not possess the clue to it (see Bestuzhev-Ryumin, Alexius). Ultimately, however, the minister, strong in the support of Elizabeth, prevailed, and his faultless diplomacy, backed by the despatch of an auxiliary Russian corps of 30,000 men to the Rhine, greatly accelerated the peace negotiations which led to the treaty of Aix-la-Chapelle (October 18, 1748). By sheer tenacity of purpose, Bestuzhev had extricated his country from the Swedish imbroglio; reconciled his imperial mistress with the courts of Vienna and London, her natural allies; enabled Russia to assert herself effectually in Poland, Turkey and Sweden, and isolated the restless king of Prussia by environing him with hostile alliances. But all this would have been impossible but for the steady support of Elizabeth, who trusted him implicitly, despite the insinuations of the chancellor’s innumerable enemies, most of whom were her personal friends.

The great event of Elizabeth’s later years was the Seven Years’ War. Elizabeth rightly regarded the treaty of Westminster (January 16, 1756, whereby Great Britain and Prussia agreed to unite their forces to oppose the entry into, or the passage through, Germany of the troops of every foreign power) as utterly subversive of the previous conventions between Great Britain and Russia. A by no means unwarrantable fear of the king of Prussia, who was “to be reduced within proper limits,” so that “he might be no longer a danger to the empire,” induced Elizabeth to accede to the treaty of Versailles, in other words the Franco-Austrian league against Prussia, and on the 17th of May 1757 the Russian army, 85,000 strong, advanced against Königsberg. Neither the serious illness of the empress, which began with a fainting-fit at Tsarskoe Selo (September 19, 1757), nor the fall of Bestuzhev (February 21, 1758), nor the cabals and intrigues of the various foreign powers at St Petersburg, interfered with the progress of the war, and the crushing defeat of Kunersdorf (August 12, 1759) at last brought Frederick to the verge of ruin. From that day forth he despaired of success, though he was saved for the moment by the jealousies of the Russian and Austrian commanders, which ruined the military plans of the allies. On the other hand, it is not too much to say that, from the end of 1759 to the end of 1761, the unshakable firmness of the Russian empress was the one constraining political force which held together the heterogeneous, incessantly jarring elements of the anti-Prussian combination. From the Russian point of view, Elizabeth’s greatness as a statesman consists in her steady appreciation of Russian interests, and her determination to promote them at all hazards. She insisted throughout that the king of Prussia must be rendered harmless to his neighbours for the future, and that the only way to bring this about was to reduce him to the rank of an elector. Frederick himself was quite alive to his danger. “I am at the end of my resources,” he wrote at the beginning of 1760, “the continuance of this war means for me utter ruin. Things may drag on perhaps till July, but then a catastrophe *must* come.” On the 21st of May 1760 a fresh convention was signed between Russia and Austria, a secret clause of which, never communicated to the court of Versailles, guaranteed East Prussia to Russia, as an indemnity for war expenses. The failure of the campaign of 1760, so far as Russia and France were concerned, induced the court of Versailles, on the evening of the 22nd of January 1761, to present to the court of St Petersburg a despatch to the effect that the king of France by reason of the condition of his dominions absolutely desired peace. On the following day the Austrian ambassador, Esterhazy, presented a despatch of a similar tenor from his court. The Russian empress’s reply was delivered to the two ambassadors on the 12th of February. It was inspired by the most uncompromising hostility towards the king of Prussia. Elizabeth would not consent to any pacific overtures until the original object of the league had been accomplished. Simultaneously, Elizabeth caused to be conveyed to Louis XV. a confidential letter in which she proposed the signature of a new treaty of alliance of a more comprehensive and explicit nature than the preceding treaties between the two powers, without the knowledge of Austria. Elizabeth’s object in this mysterious negotiation seems to have been to 285
reconcile France and Great Britain, in return for which signal service France was to throw all her forces into the German war. This project, which lacked neither ability nor audacity, foundered upon Louis XV.’s invincible jealousy of the growth of Russian influence in eastern Europe and his fear of offending the Porte. It was finally arranged by the allies that their envoys at Paris should fix the date for the assembling of a peace congress, and that, in the meantime, the war against Prussia should be vigorously prosecuted. The campaign of 1761 was almost as abortive as the campaign of 1760. Frederick acted on the defensive with consummate skill, and the capture of the Prussian fortress of Kolberg on Christmas day O.S. 1761, by Rumyantsev, was the sole Russian success. Frederick, however, was now at the last gasp. On the 6th of January 1762, he wrote to Finkenstein, “We ought now to think of preserving for my nephew, by way of negotiation, whatever fragments of my territory we can save from the avidity of my enemies,” which means, if words mean anything, that he was resolved to seek a soldier’s death on the first opportunity. A fortnight later he wrote to Prince Ferdinand of Brunswick, “The sky begins to clear. Courage, my dear fellow. I have received the news of a great event.” The great event which snatched him from destruction was the death of the Russian empress (January 5, 1762).

See Robert Nisbet Bain, *The Daughter of Peter the Great* (London, 1899); Sergyei Solovev, *History of Russia* (Rus.), vols. xx.-xxii. (St Petersburg, 1857-1877); *Politische Correspondenz Friedrichs des Grossen*, vols. i.-xxi. (Berlin, 1879, &c.); Colonel Masslowski, *Der siebenjährige Krieg nach russischer Darstellung* (Berlin, 1888-1893); Kazinsierz Waliszewski, *La Dernière des Romanov* (Paris, 1902).

(R. N. B.)

ELIZABETH [AMÉLIE EUGÉNIE] (1837-1898), consort of Francis Joseph, emperor of Austria and king of Hungary, was the daughter of Duke Maximilian Joseph of Bavaria and Louisa Wilhelmina, daughter of Maximilian I. of Bavaria, and was born on the 24th of December 1837 at the castle of Possenhofen on Lake Starnberg. She inherited the quick intelligence and artistic taste displayed in general by members of the Wittelsbach royal house, and her education was the reverse of conventional. She accompanied her eccentric father on his hunting expeditions, becoming an expert rider and climber, visiting the peasants in their huts and sharing in rustic pleasures. The emperor of Austria, Francis Joseph, met the Bavarian ducal family at Ischl in August 1853, and immediately fell in love with Elizabeth, then a girl of sixteen, and reported to be the most beautiful princess in Europe. The marriage took place in Vienna on the 24th of April 1854. In the early days of her married life she frequently came into collision with Viennese prejudice. Her attempts to modify court etiquette, and her extreme fondness for horsemanship and frequent visits to the imperial riding school, scandalized Austrian society, while her predilection for Hungary and for everything Hungarian offended German sentiment. There is no doubt that her influence helped the establishment of the *Ausgleich* with Hungary, but outside Hungarian affairs the empress took small part in politics. She first visited Hungary in 1857, and ten years later was crowned queen. Her popularity with the Hungarians remained unchanged throughout her life; and the castle of Gödöllö, presented as a coronation gift, was one of her favourite residences. Elizabeth was one of the most charitable of royal ladies, and her popularity with her Austrian subjects was more than restored by her assiduous care for the wounded in the campaign of 1866. Besides her public benefactions she constantly exercised personal and private charity. Her eldest daughter died in infancy; Gisela (b. 1856) married the Prince Leopold of Bavaria; and her youngest daughter Marie Valerie (b. 1868) married the Archduke Franz Salvator. The tragic death of her only son, the crown prince Rudolph, in 1889, was a shock from which she never really recovered. She was also deeply affected by the suicide of her cousin Louis II. of Bavaria, and again by the fate of her sister Sophia, duchess of Alençon, who perished in the fire of the Paris charity bazaar in 1897. The empress had shown signs of lung disease in 1861, when she spent some months in Madeira; but she was able to resume her outdoor sports, and for some years before 1882, when she had to give up riding, was a frequent visitor on English and Irish hunting fields. In her later years her dislike of publicity increased. Much of her time was spent in travel or at the Achilleion, the palace she had built in the Greek style in Corfu. She was walking from her hotel at Geneva to the steamer when she was stabbed by the anarchist Luigi Luccheni, on the 10th of September 1898, and died of the wound within a few hours. This aimless and dastardly crime completed the list of misfortunes of the Austrian house, and aroused intense indignation throughout Europe.

See A. de Burgh, *Elizabeth, Empress of Austria, a Memoir* (London, 1898); E. Friedmann and J. Paves, *Kaiserin Elisabeth* (Berlin, 1898); and the anonymous *Martyrdom of an Empress* (1899), containing a quantity of court gossip.

ELIZABETH (1596-1662), consort of Frederick V., elector palatine and titular king of Bohemia, was the eldest daughter of James I. of Great Britain and of Anne of Denmark, and was born at Falkland Castle in Fifeshire in August 1596. She was entrusted to the care of the earl of Linlithgow, and after the departure of the royal family to England, to the countess of Kildare, subsequently residing with Lord and Lady Harington at Combe Abbey in Warwickshire. In November 1605 the Gunpowder Plot conspirators formed a plan to seize her person and proclaim her queen after the explosion, in consequence of which she was removed by Lord Harington to Coventry. In 1608 she appeared at court, where her beauty soon attracted admiration and became the theme of the poets, her suitors including the dauphin, Maurice, prince of Orange, Gustavus Adolphus, Philip III. of Spain, and Frederick V., the elector palatine. A union with the last-named was finally arranged, in spite of the queen’s opposition, in order to strengthen the alliance with the Protestant powers in Germany, and the marriage took place on the 14th of February 1613 midst great rejoicing and festivities. The prince and princess entered Heidelberg on the 17th of June, and Elizabeth, by means of her English annuity, enjoyed five years of pleasure and of extravagant gaiety to which the small German court was totally unaccustomed. On the 26th of August 1618, Frederick, as a leading Protestant prince, was chosen king by the Bohemians, who deposed the emperor Ferdinand, then archduke of Styria. There is no evidence to show that his acceptance was instigated by the princess or that she had any influence in her husband’s political career. She accompanied Frederick to Prague in October 1619, and was crowned on the 7th of November. Here her unrestrainable high spirits and levity gave great offence to the citizens. On the approach of misfortune, however, she showed great courage and fortitude. She left Prague on the 8th of November 1620, after the fatal battle of the White Hill, for Küstrin, travelling thence to Berlin and Wolfenbüttel, finally with Frederick taking refuge at the Hague with Prince Maurice of Orange. The help sought from James came only in the shape of useless embassies and negotiations; the two Palatinates were soon occupied by the Spaniards and the duke of Bavaria; and the romantic attachment and services of Duke Christian of Brunswick, of the 1st earl of Craven, and of other chivalrous young champions who were inspired by the beauty and grace of the “Queen of Hearts,” as Elizabeth was now called, availed nothing. Her residence was at Rhenen near Arnheim, where she received many English visitors and endeavoured to maintain her spirits and fortitude, with straitened means and in spite of frequent disappointments. The victories of Gustavus Adolphus secured no permanent advantage, and his death at Lützen was followed by that of the elector at Mainz on the 29th of November 1632. Subsequent attempts of the princess to reinstate her son in his dominions were unsuccessful, and it was not till the peace of Westphalia in 1648 that he regained a portion of them, the Rhenish Palatinate. Meanwhile, Elizabeth’s position in Holland grew more and more unsatisfactory. The payment of her English annuity of £12,000 ceased after the outbreak of the troubles with the parliament; the death of Charles I. in 1649 put an end to all hopes from that quarter; and the pension allowed her by the house of Orange ceased in 1650. Her children, in consequence of disputes, abandoned her, and her eldest son Charles Louis refused her a home in his restored electorate. Nor did Charles II. at his restoration show any desire to receive her in England. Parliament voted her £20,000 in 1660 for the payment of her debts, but Elizabeth did not receive the money, and on the 19th of May 1661 she left the Hague for England, in spite of the king's attempts to hinder her journey, receiving no official welcome on her arrival in London and being lodged at Lord Craven's house in Drury Lane. Charles, however, subsequently granted her a pension and treated her with kindness. On the 8th of February 1662 she removed to Leicester House in Leicester Fields, and died shortly afterwards on the 13th of the same month, being buried in Westminster Abbey. Her beauty, grace and vivacity exercised a great charm over her contemporaries, the enthusiasm for her, however, being probably not merely personal but one inspired also by her misfortunes and by the fact that these misfortunes were incurred in defence of the Protestant cause; later, as the ancestress of the Protestant Hanoverian dynasty, she obtained a conspicuous place in English history. She had thirteen children—Frederick Henry, drowned at sea in 1629; Charles Louis, elector palatine, whose daughter married Philip, duke of Orleans, and became the ancestress of the elder and Roman Catholic branch of the royal family of England; Elizabeth, abbess and friend of Descartes; Prince Rupert and Prince Maurice, who died unmarried; Louisa, abbess; Edward, who married Anne de Gonzaga, "princesse palatine," and had children; Henrietta Maria, who married Count Sigismund Ragotzki but died childless; Philip and Charlotte, who died childless; Sophia, who married Ernest Augustus, elector of Hanover, and was mother of George I. of England; and two others who died young.

Bibliography.—See the article in *Dict. of Nat. Biography* and authorities there collected; *Five Stuart Princesses*, ed. by R.S. Rait (1902); *Briefe der Elizabeth Stuart ... an ... den Kurfürsten Carl Ludwig von der Pfalz*, by A. Wendland (Bibliothek des literarischen Vereins, 228, Stuttgart, 1902); "Elizabeth Stuart," by J.O. Opel, in Sybel's *Historische Zeitschrift*, xxiii. 289; *Thomason Tracts* (Brit. Mus.), E., 138 (14), 122 (12), 118 (40), 119 (18). Important material regarding the princess exists in the MSS. of the earl of Craven, at Combe Abbey.

ELIZABETH [PAULINE ELIZABETH OTTILIE LOUISE] (1843-), consort of King Charles I. (*q.v.*) of Rumania, widely known by her literary name of "Carmen Sylva," was born on the 29th of December 1843. She was the daughter of Prince Hermann of Neuwied. She first met the future king of Rumania at Berlin in 1861, and was married to him on the 15th of November 1869. Her only child, a daughter, died in 1874. In the Russo-Turkish War of 1877-1878 she devoted herself to the care of the wounded, and founded the Order of Elizabeth (a gold cross on a blue ribbon) to reward distinguished service in such work. She fostered the higher education of women in Rumania, and established societies for various charitable objects. Early distinguished by her excellence as a pianist, organist and singer, she also showed considerable ability in painting and illuminating; but a lively poetic imagination led her to the path of literature, and more especially to poetry, folk-lore and ballads. In addition to numerous original works she put into literary form many of the legends current among the Rumanian peasantry.

"Carmen Sylva" wrote with facility in German, Rumanian, French and English. A few of her voluminous writings, which include poems, plays, novels, short stories, essays, collections of aphorisms, &c., may be singled out for special mention. Her earliest publications were *Sappho* and *Hammerstein*, two poems which appeared at Leipzig in 1880. In 1888 she received the Prix Botta, a prize awarded triennially by the French Academy, for her volume of prose aphorisms *Les Pensées d'une reine* (Paris, 1882), a German version of which is entitled *Vom Amboss* (Bonn, 1890). *Cuvinte Sufletesci*, religious meditations in Rumanian (Bucharest, 1888), was also translated into German (Bonn, 1890), under the name of *Seelen-Gespräche*. Several of the works of "Carmen Sylva" were written in collaboration with Mite Kremnitz, one of her maids of honour, who was born at Greifswald in 1857, and married Dr Kremnitz of Bucharest; these were published between 1881 and 1888, in some cases under the pseudonyms *Dito et Idem*, and includes the novel *Aus zwei Welten* (Leipzig, 1884), *Anna Boleyn* (Bonn, 1886), a tragedy, *In der Irre* (Bonn, 1888), a collection of short stories, &c. *Edleen Vaughan, or Paths of Peril*, a novel (London, 1894), and *Sweet Hours*, poems (London, 1904), were written in English. Among the translations made by "Carmen Sylva" are German versions of Pierre Loti's romance *Pêcheur d'Islande*, and of Paul de St Victor's dramatic criticisms *Les Deux Masques* (Paris, 1881-1884); and in particular *The Bard of the Dimbovitza*, a fine English version by "Carmen Sylva" and Alma Strettell of Helène Vacarescu's collection of Rumanian folk-songs, &c., entitled *Lieder aus dem Dimbovitzathal* (Bonn, 1889). *The Bard of the Dimbovitza* was first published in 1891, and was soon reissued and expanded. Translations from the original works of "Carmen Sylva" have appeared in all the principal languages of Europe and in Armenian.

See Rumania: *History*; also M. Kremnitz, *Carmen Sylva—eine Biographie* (Leipzig, 1903); and, for a full bibliography, G. Bengescu, *Carmen Sylva—bibliographie et extraits de ses œuvres* (Paris, 1904).

ELIZABETH (1635-1650), English princess, second daughter of Charles I., was born on the 28th of December 1635 at St James's Palace. On the outbreak of the Civil War and the departure of the king from London, while the two elder princes accompanied their father, the princess and the infant duke of Gloucester were left under the care of the parliament. In October 1642 Elizabeth sent a letter to the House of Lords begging that her old attendants might not be removed. In July 1644 the royal children were sent to Sir John Danvers at Chelsea, and in 1645 to the earl and countess of Northumberland. After the final defeat of the king they were joined in 1646 by James, and during 1647 paid several visits to the king at Caversham, near Reading, and Hampton Court, but were again separated by Charles's imprisonment at Carisbrooke Castle. On the 21st of April 1648 James was persuaded to escape by Elizabeth, who declared that were she a boy she would not long remain in confinement. The last sad meeting between Charles and his two children, at which the princess was overcome with grief, and of which she wrote a short and touching account, took place on the 29th of January 1649, the day before his execution. In June she was entrusted to the care of the earl and countess of Leicester at Penshurst, but in 1650, upon the landing of Charles II. in Scotland, the parliament ordered the royal children to be taken for security to Carisbrooke Castle. The princess fell ill from a wetting almost immediately upon her arrival, and died of fever on the 8th of September. She was buried in St Thomas's church at Newport, Isle of Wight, where the initials "E.S." alone marked her grave till 1856, when a monument was erected to her memory by Queen Victoria. The princess's sorrowful career and early death have attracted general interest and sympathy. She was said to have acquired considerable proficiency in Greek, Hebrew and Latin, as well as in Italian and French, and several books were dedicated to her, including the translation of the *Electra* of Sophocles by Christopher Wase in 1649. Her mild nature and gentleness towards her father's enemies gained her the name of "Temperance."

See *Lives of the Princesses of England*, by M.A.E. Green (1855), vol. vi.; *Notes and Queries*, 7th ser., ix. 444, x. 15.

ELIZABETH [Élisabeth Philippine Marie Hélène of France] (1764-1794), commonly called Madame Elizabeth, daughter of Louis the Dauphin and Marie Josephine of Saxony, and sister of Louis XVI., was born at Versailles on the 3rd of May 1764. Left an orphan at the age of three, she was brought up by Madame de Mackau, and had a residence at Montreuil, where she gave many proofs of her benevolent character. She refused all offers of marriage so that she might remain by the side of her brother, whom she loved passionately. At the outset of the Revolution she foresaw the gravity of events, and refused to leave the king, whom she accompanied in his flight on the 20th of June 1792, and with whom she was arrested at Varennes. She was present at the Legislative Assembly when Louis was suspended, and was imprisoned in the Temple with the royal family. By the execution of the king and the removal of Marie Antoinette to the Conciergerie, Madame Elizabeth was deprived of her companions in the Temple prison, and on the 9th of May 1794 she was herself transferred to the Conciergerie, and haled before the revolutionary tribunal. Accused of assisting the king's flight, of supplying *émigrés* with funds, and of encouraging the resistance of the royal troops on the 10th of August 1792, she was condemned to death, and executed on the 10th of May 1794. Like her brother, she had all the domestic virtues, and, as was to be expected of a sister of Louis XVI., she was in favour of absolutist principles. Hers was one of the most touching tragedies of the Revolution; she perished because she was the sister of the king. 287

The *Mémoires de Madame Élisabeth* (Paris, 1858), by F. de Barghon and Fort-Rion, are of doubtful authenticity; and the collection of letters and documents published in 1865 by F. Feuillet de Conches must be used with caution (see the bibliographical note to the article Marie Antoinette). See le Comte A.F.C. Ferrand, *Éloge historique de Madame Élisabeth* (1814, containing 94 letters; 2nd ed., 1861, containing additional letters, but correspondence mutilated); Du Fresne de Beaucourt, *Étude sur Madame Élisabeth* (Paris, 1864); A. de Beauchesne, *Vie de Madame Élisabeth* (1869); La comtesse d'Armaillé, *Madame Élisabeth* (Paris, 1886); Madame d'Arvor, *Madame Élisabeth* (Paris, 1898); and Hon. Mrs Maxwell-Scott, *Madame Elizabeth of France* (1908).

ELIZABETH, SAINT (1207-1231), daughter of Andrew II., king of Hungary (d. 1235), by his first wife, Gertrude of Andechs-Meran (d. 1213), was born in Pressburg in 1207. At four years of age she was betrothed to Louis IV., landgrave of Thuringia, and conducted to the Wartburg, near Eisenach, to be educated under the direction of his parents. In spite of her decidedly worldly surroundings at the Thuringian court, she evinced from the first an aversion from even the most innocent pleasures, and stimulated by the example of her mother's sister, St Hedwig, wife of Henry VI., duke of Silesia-Breslau, devoted her whole time to religion and to works of charity. She was married at the age of fourteen, and acquired such influence over her husband that he adopted her point of view and zealously assisted her in all her charitable endeavours. According to the legend, much celebrated in German art, Louis at first desired to curtail her excessive charities, and forbade her unbounded gifts to the poor. One day, returning from hunting, he met his wife descending from the Wartburg with a heavy bundle filled with bread. He sternly bade her open it; she did so, and he saw nothing but a mass of red roses. The miracle completed his conversion. On the death of Louis "the Saint" in 1227, Elizabeth was deprived of the regency by his brother, Henry Raspe IV. (d. 1247), on the pretext that she was wasting the estates by her alms; and with her three infant children she was driven from her home without being allowed to carry with her even the barest necessaries of life. She lived for some time in great hardship, but ultimately her maternal uncle, Egbert, bishop of Bamberg, offered her an asylum in a house adjoining his palace. Through the intercession of some of the principal barons, the regency was again offered her, and her son Hermann was declared heir to the landgraviate; but renouncing all power, and making use of her wealth only for charitable purposes, she preferred to live in seclusion at Marburg under the direction of her confessor, the bigoted persecutor Conrad of Marburg. There she spent the remainder of her days in penances of unusual severity, and in ministrations to the sick, especially those afflicted with the most loathsome diseases. She died at Marburg on the 19th of November 1231, and four years afterwards was canonized by Gregory IX. on account of the frequent miracles reported to have been performed at her tomb.

The exhibition in the Royal Academy of P.H. Calderon's picture, "St Elizabeth of Hungary's Great Act of Renunciation," now in the Tate Gallery in London, roused considerable protest among Catholics. The saint is represented as kneeling nude before the altar, in the presence of her confessor and a couple of nuns. The passage this is intended to illustrate is in Lib. iv. § 1 of Dietrich of Apolda's *Vita*, which relates how, on a certain Good Friday, she went into a chapel and, in the presence of some Franciscan brothers, laid her hands on the bare altar, renounced her own will, her parents, children, relations, and all pomps of this kind (*hujus modi*) in imitation of Christ; and stripped herself utterly naked (*omnino se exuit et nudavit*) in order to follow Him naked, in the steps of poverty. A literal interpretation of this passage is not impossible; for ecstatic mystics of all ages have indulged in a like κενώσις, and Conrad, who revelled in inflicting religious tortures, was quite capable of imposing this crowning humiliation upon his gentle victim. It is far more probable, however, that the passage is not to be taken literally.

Lives of St Elizabeth were written by Theodoricus (Dietrich) of Apolda (b. 1228), Caesarius of Heisterbach (d. *c.* 1240), Conrad of Marburg and others (see Potthast, *Bibl. Hist. Med. Aev.* p. 1284). A metrical life in German exists by Johann Rothe (d. *c.* 1440), chaplain to the Landgravine Anne of Thuringia (Potthast, p. 985). *L'Histoire de Sainte Élisabeth de Hongrie*, by Montalembert, was published at Paris in 1836. Her life has also supplied the materials for a dramatic poem by Charles Kingsley, entitled the "Saint's Tragedy." The edition of this in vol. xvi. of the *Life and Works of Charles Kingsley* (London, 1902) has valuable notes, with many extracts from the original sources.

ELIZABETH, a city and the county-seat of Union county, New Jersey, U.S.A., on Elizabeth river, Newark Bay, and Arthur Kill, 10 m. S.W. of Jersey City. Pop. (1890) 37,764; (1900) 52,130, of whom 14,770 were foreign-born and 1139 were negroes; (1910 census) 73,409. It is served by the Pennsylvania, the Lehigh Valley and the Central of New Jersey railways. The site is level and the streets are broad and shaded. There are many residences of New York business men, and several historic buildings, including Liberty Hall, the mansion of William Livingston, first governor of the state; Boxwood Hall (now used as a home for aged women), the former home of Elias Boudinot; the old brick mansion of Jonathan Belcher (1681-1757), governor of the province from 1747 to 1757; the First Presbyterian Church; and the house occupied at different times by General Winfield Scott. The city has several parks, the Union county court house (1905), a public library and several charitable institutions. Elizabethport, that part of the city on Staten Island Sound, about 2 m. S.E. of the centre of Elizabeth, has a port open to vessels of 300 tons; it is an outlet of the Pennsylvania coal fields and is thus one of the most important coal shipping depots in the United States. Here, too, are a plant (covering more than 800 acres) of the Standard Oil Company and a large establishment for the manufacture of the "Singer" sewing machine—according to the U.S. census the largest manufactory of sewing machines in the world—employing more than 6000 workmen in 1905; among the other manufactures of Elizabeth are foundry and machine shop products (value in 1905, $3,887,139), wire, oil (value in 1905, $2,387,656), refined and smelted copper, the output of railway repair shops, edge tools and lager beer. The value of the manufactured products was $10,489,364 in 1890; $22,861,375 (factory product) in 1900; and $29,300,801 (factory product) in 1905.

Elizabeth was settled in 1665 by a company from Long Island for whom the land had been purchased from the Indians and a grant had been obtained from Richard Nicolls as agent for the duke of York. But about the same time the duke conveyed the entire province to John, Lord Berkeley, and Sir George Carteret, and these two conflicting grants gave rise to a long-continued controversy (see New Jersey). The town was named in honour of Elizabeth, wife of Sir George Carteret, and was first known as Elizabethtown. From 1665 to 1686 it was the seat of government of the province, and the legislature sat here occasionally until 1790. In the home of the Rev. Jonathan Dickinson (1688-1747), its first president, the first sessions of the College of New Jersey (now Princeton University) were held in 1747, but immediately afterwards the college removed to Newark. In December 1776 and twice in June 1780 the British entered Elizabeth and made it a base of operations, but on each occasion they were soon driven out. Elizabeth became a "free town and borough" in 1739; the borough charter was confirmed by the legislature in 1789 and repealed in 1790, and Elizabeth was chartered as a city in 1855. 288

See E.F. Hatfield, *History of Elizabeth, New Jersey* (New York, 1868).

ELIZABETHAN STYLE, in architecture, the term given to the early Renaissance style in England, which flourished chiefly during the reign of Queen Elizabeth; it followed the Tudor style, and was succeeded in the beginning of the 16th century by the purer Italian style introduced by Inigo Jones. It responds to the Cinque-Cento period in Italy, the François I. style in France, and the Plateresque or Silversmith's style in Spain. During the reigns of Henry VIII. and Edward VI. many Italian artists came over, who carried out various decorative features at Hampton Court; Layer Marney, Suffolk (1522-1525); Sutton Place, Surrey (1529); Nonsuch Palace and elsewhere. Later in the century Flemish craftsmen succeeded the Italians, and the Royal Exchange in London (1566-1570) is one of the first important buildings designed by Henri de Paschen, an architect from Antwerp. Longford Castle, Wollaton, Hatfield, Blickling, Audley End, and Charterhouse (London) all show the style introduced by Flemish workmen.

ELIZABETH CITY, a town, port of entry and the county-seat of Pasquotank county, North Carolina, U.S.A., on the Pasquotank river, at the head of navigation, 46 m. S. by E. of Norfolk, Virginia. Pop. (1890) 3251; (1900) 6348 (3164 negroes); (1910) 8412. It is served by the Norfolk & Southern, and the Suffolk & Carolina railways, and is on the Dismal Swamp and Albemarle & Chesapeake canals. Elizabeth City is a winter meeting-place for hunters. It is the seat of a state normal school for negroes and of the Atlantic Collegiate Institute, is a trucking centre, has shipyards, and has a large wholesale trade in clothing, groceries and general merchandise; from it are shipped considerable quantities of fish, cotton and lumber. The town is the port of entry of the Albemarle customs district, but its foreign trade is unimportant. Among its manufactures are cotton goods, iron, lumber, nets and twine, bricks, and carriages and wagons. The oyster fisheries in the vicinity are of considerable importance. Elizabeth City was settled in 1793, and was first incorporated in the same year.

ELK, or Moose, the largest of all the deer tribe, distinguished from other members of the *Cervidae* by the form of the antlers of the males. These arise as cylindrical beams projecting on each side at right angles to the middle line of the skull, which after a short distance divide in a fork-like manner. The lower prong of this fork may be either simple, or divided into two or three tines, with some flattening. In the East Siberian elk (*Alces machlis bedfordiae*) the posterior division of the main fork divides into three tines, with no distinct flattening. In the common elk (*A. machlis* or *A. alces*), on the other hand, this branch usually expands into a broad palmation, with one large tine at the base, and a number of smaller snags on the free border; there is, however, a phase of the Scandinavian elk in which the antlers are simpler, and recall those of the East Siberian race. The palmation appears to be more marked in the North American race (*A. m. americanus*) than in the typical Scandinavian elk. The largest of all is the Alaskan race (*A. m. gigas*), which is said to stand 8 ft. in height, with a span of 6 ft. across the antlers. The great length of the legs gives a decidedly ungainly appearance to the elk. The muzzle is long and fleshy, with only a very small triangular naked patch below the nostrils; and the males have a peculiar sac, known as the bell, hanging from the neck. From the shortness of their necks, elks are unable to graze, and their chief food consists of young shoots and leaves of willow and birch. In North America during the winter one male and several females form a "moose-yard" in the forest, which they keep open by trampling the snow. Although generally timid, the males become very bold during the breeding season, when the females utter a loud call; and at such times they fight both with their antlers and their hoofs. The usual pace is a shambling trot, but when pressed elks break into a gallop. The female gives birth to one or two young at a time, which are not spotted. In America the elk is known as the moose, and the former name is transferred to the wapiti deer.

(R. L.*)

ELKHART, a city of Elkhart county, Indiana, U.S.A., at the confluence of the Elkhart and St Joseph rivers, about 100 m. E. of Chicago. Pop. (1890) 11,360; (1900) 15,184, of whom 1353 were foreign-born; (1910 census) 19,282. Elkhart is at the junction of the western division with the main line of the Lake Shore & Michigan Southern railway, and is served by the Cleveland, Cincinnati, Chicago & St Louis, and the Northern Indiana railways (the latter electric). It is attractively situated and has fine business and public buildings, including a Carnegie library and the Clark hospital, with which a nurses’ training school is connected. It has also several parks, including the beautiful Island Park and McNaughton Park, the latter the annual meeting-place of the St Joseph Valley Chautauqua. A valuable water-power is utilized for manufacturing purposes. There are extensive railway-car shops and iron and brass foundries, and the manufactures include band instruments, furniture, telephone supplies, electric transformers, bridges, paper, flour, starch, rubber goods, acetylene gas machines, printing presses, drugs and carriages. The total value of the factory product was $4,345,466 in 1905, an increase of 10.5% since 1900. At Elkhart is the main publishing house of the Mennonite Church in America, two weekly periodicals being issued, one in English, *The Herald of Truth*, and one in German, the *Mennonitische Rundschau*. The first settlement was made here about 1834; and Elkhart was chartered as a city in 1875.

ELKINGTON, GEORGE RICHARDS (1801-1865), founder of the electroplating industry in England, was born in Birmingham on the 17th of October 1801, the son of a spectacle manufacturer. Apprenticed to his uncles, silver platers in Birmingham, he became, on their death, sole proprietor of the business, but subsequently took his cousin, Henry Elkington, into partnership. The science of electrometallurgy was then in its infancy, but the Elkingtons were quick to recognize its possibilities. They had already taken out certain patents for the application of electricity to metals when, in 1840, John Wright, a Birmingham surgeon, discovered the valuable properties of a solution of cyanide of silver in cyanide of potassium for electroplating purposes. The Elkingtons purchased and patented Wright’s process, subsequently acquiring the rights of other processes and improvements. Large new works for electroplating and electrogilding were opened in Birmingham in 1841, and in the following year Josiah Mason became a partner in the firm. George Richards Elkington died on the 22nd of September 1865, and Henry Elkington on the 26th of October 1852.

ELLA, or Ælla, the name of three Anglo-Saxon kings.

Ella (d. *c.* 514), king of the South Saxons and founder of the kingdom of Sussex, was a Saxon ealdorman, who landed near Arundel in Sussex with his three sons in 477. Defeating the Britons, who were driven into the forest of Andredsweald, Ella and his followers established themselves along the south coast, although their progress was slow and difficult. However, in 491, strengthened by the arrival of fresh bands of immigrants, they captured the Roman city of Anderida and “slew all that were therein.” Ella, who is reckoned as the first Bretwalda, then became king of the South Saxons, and, when he died about 514, he was succeeded by his son Cissa.

Ella (d. 588), king of the Deirans, was the son of an ealdorman named Iffa, and became the first king of Deira when, in 559, the Deirans separated themselves from the neighbouring kingdom of Bernicia. The English slaves, who aroused the interest of Pope Gregory I. at Rome, were subjects of Ella, and on this occasion the pope, punning the name of their king, suggested that “Alleluia” should be sung in his land. When Ella died in 588 Deira was conquered by Bernicia. One of his sons was Edwin, afterwards king of the Northumbrians.

Ella (d. 867), king of the Northumbrians, became king about 862 on the deposition of Osbert, although he was not of royal birth. Afterwards he became reconciled with Osbert, and together they attacked the Danes, who had invaded Northumbria, and drove them into York. Rallying, however, the Danes defeated the Northumbrians, and in the encounter both Ella and Osbert were slain. In certain legends Ella is represented as having brought about the Danish invasion of Northumbria by cruel and 289
unjust actions.

See *The Anglo-Saxon Chronicle*, edited by C. Plummer (Oxford, 1892-1899); Bede, *Historiae ecclesiasticae*, edited by C. Plummer (Oxford, 1896); Henry of Huntingdon, *Historia Anglorum*, edited by T. Arnold, Rolls Series (London, 1879); Asser, *De rebus gestis Aelfredi*, edited by W.H. Stevenson (Oxford, 1904); J.R. Green, *The Making of England* (London, 1897), and the *Dictionary of National Biography*, vol. i. (London, 1895).

ELLAND, an urban district in the Elland parliamentary division of Yorkshire, England, on the Calder, 2½ m. S. of Halifax by the Lancashire & Yorkshire railway. Pop. (1901) 10,412. The church of St Mary is Decorated and Perpendicular. Cotton-mills, woollen-factories, ironworks, flagstone quarries at Elland Edge, and fire-clay works employ the industrial population. Elland Hall, though almost rebuilt, retains the recollection of a remarkable family feud between the Ellands and the Beaumonts of Crosland Hall, the site of which may be traced in the vicinity. A nephew of Sir John Elland, in 1342, met death at the hands of a relative of the Beaumonts upon whom Sir John took vengeance, as also upon the heads of the allied houses of Lockwood and Quarmby. The children of these families were educated in the hope of avenging their parents, and after many years succeeded in doing so, cutting off Sir John Elland and his heir.

ELLENBOROUGH, EDWARD LAW, 1st Baron (1750-1818), English judge, was born on the 16th of November 1750, at Great Salkeld, in Cumberland, of which place his father, Edmund Law (1703-1787), afterwards bishop of Carlisle, was at the time rector. Educated at the Charterhouse and at Peterhouse, Cambridge, he passed as third wrangler, and was soon afterwards elected to a fellowship at Trinity. In spite of his father’s strong wish that he should take orders, he chose the legal profession, and on quitting the university was entered at Lincoln’s Inn. After spending five years as a special pleader under the bar, he was called to the bar in 1780. He chose the northern circuit, and in a very short time obtained a lucrative practice and a high reputation. In 1787 he was appointed principal counsel for Warren Hastings in the celebrated impeachment trial before the House of Lords, and the ability with which he conducted the defence was universally recognized. He had begun his political career as a Whig, but, like many others, he saw in the French Revolution a reason for changing sides, and became a supporter of Pitt. On the formation of the Addington ministry in 1801, he was appointed attorney-general and shortly afterwards was returned to the House of Commons as member for Newtown in the Isle of Wight. In 1802 he succeeded Lord Kenyon as chief justice of the king’s bench. On being raised to the bench he was created a peer, taking his title from the village of Ellenborough in Cumberland, where his maternal ancestors had long held a small patrimony. In 1806, on the formation of Lord Grenville’s ministry “of all the talents,” Lord Ellenborough declined the offer of the great seal, but accepted a seat in the cabinet. His doing so while he retained the chief justiceship was much criticized at the time, and, though not without precedent, was open to such obvious objections on constitutional grounds that the experiment has not since been repeated. As a judge he had grave faults, though his decisions displayed profound legal knowledge, and in mercantile law especially were reckoned of high authority. He was harsh and overbearing to counsel, and in the political trials which were so frequent in his time showed an unmistakable bias against the accused. In the trial of William Hone (*q.v.*) for blasphemy in 1817, Ellenborough directed the jury to find a verdict of guilty, and their acquittal of the prisoner is generally said to have hastened his death. He resigned his judicial office in November 1818, and died on the 13th of December following.

Ellenborough was succeeded as 2nd baron by his eldest son, Edward, afterwards earl of Ellenborough; another son was Charles Ewan Law (1792-1850), recorder of London and member of parliament for Cambridge University from 1835 until his death in August 1850.

Three of Ellenborough’s brothers attained some degree of fame. These were John Law (1745-1810), bishop of Elphin; Thomas Law (1759-1834), who settled in the United States in 1793, and married, as his second wife, Anne, a granddaughter of Martha Washington; and George Henry Law (1761-1845), bishop of Chester and of Bath and Wells. The connexion of the Law family with the English Church was kept up by George Henry’s sons, three of whom took orders. Two of these were Henry Law (1797-1884), dean of Gloucester, and James Thomas Law (1790-1876), chancellor of the diocese of Lichfield.

ELLENBOROUGH, EDWARD LAW, *Earl of* (1790-1871), the eldest son of the 1st Lord Ellenborough, was born on the 8th of September 1790. He was educated at Eton and St John’s College, Cambridge. He represented the subsequently disfranchised borough of St Michael’s, Cornwall, in the House of Commons, until the death of his father in 1818 gave him a seat in the House of Lords. He was twice married; his only child died young; his second wife was divorced by act of parliament in 1830.

In the Wellington administration of 1828 Ellenborough was made lord privy seal; he took a considerable share in the business of the foreign office, as an unofficial assistant to Wellington, who was a great admirer of his talents. He aimed at succeeding Lord Dudley at the foreign office, but was forced to content himself with the presidency of the board of control, which he retained until the fall of the ministry in 1830. Ellenborough was an active administrator, and took a lively interest in questions of Indian policy. The revision of the company’s charter was approaching, and he held that the government of India should be transferred directly to the crown. He was impressed with the growing importance of a knowledge of central Asia, in the event of a Russian advance towards the Indian frontier, and despatched Burnes on an exploring mission to that district. Ellenborough subsequently returned to the board of control in Peel’s first and second administrations. He had only held office for a month on the third occasion when he was appointed by the court of directors to succeed Lord Auckland as governor-general of India. His Indian administration of two and a half years, or half the usual term of service, was from first to last a subject of hostile criticism. His own letters sent monthly to the queen, and his correspondence with the duke of Wellington, published in 1874, afford material for an intelligent and impartial judgment of his meteoric career. The events chiefly in dispute are his policy towards Afghanistan and the army and captives there, his conquest of Sind, and his campaign in Gwalior.

Ellenborough went to India in order “to restore peace to Asia,” but the whole term of his office was occupied in war. On his arrival there the news that greeted him was that of the massacre of Kabul, and the sieges of Ghazni and Jalalabad, while the sepoys of Madras were on the verge of open mutiny. In his proclamation of the 15th of March 1842, as in his memorandum for the queen dated the 18th, he stated with characteristic clearness and eloquence the duty of first inflicting some signal and decisive blow on the Afghans, and then leaving them to govern themselves under the sovereign of their own choice. Unhappily, when he left his council for upper India, and learned the trifling failure of General England, he instructed Pollock and Nott, who were advancing triumphantly with their avenging columns to rescue the British captives, to fall back. The army proved true to the governor-general’s earlier proclamation rather than to his later fears; the hostages were rescued, the scene of Sir Alexander Burnes’s murder in the heart of Kabul was burned down. Dost Mahommed was quietly dismissed from a prison in Calcutta to the throne in the Bala Hissar, and Ellenborough presided over the painting of the elephants for an unprecedented military spectacle at Ferozepur, on the south bank of the Sutlej. But this was not the only piece of theatrical display which capped with ridicule the horrors and the follies of these four years in Afghanistan. When Sultan Mahmud, in 1024, sacked the Hindu temple of Somnath on the north-west coast of India, he carried off, with the treasures, the richly studded sandal-wood gates of the fane, and set them up in his capital of Ghazni. The 290
Mahommedan puppet of the English, Shah Shuja, had been asked, when ruler of Afghanistan, to restore them to India; and what he had failed to do the Christian ruler of opposing Mahommedans and Hindus resolved to effect in the most solemn and public manner. In vain had Major (afterwards Sir Henry) Rawlinson proved that they were only reproductions of the original gates, to which the Ghazni moulvies clung merely as a source of offerings from the faithful who visited the old conqueror’s tomb. In vain did the Hindu sepoys show the most chilling indifference to the belauded restoration. Ellenborough could not resist the temptation to copy Napoleon’s magniloquent proclamation under the pyramids. The fraudulent folding doors were conveyed on a triumphal car to the fort of Agra, where they were found to be made not of sandalwood but of deal. That Somnath proclamation (immortalized in a speech by Macaulay) was the first step towards its author’s recall.

Hardly had Ellenborough issued his medal with the legend “Pax Asiae Restituta” when he was at war with the amirs of Sind. The tributary amirs had on the whole been faithful, for Major (afterwards Sir James) Outram controlled them. But he had reported the opposition of a few, and Ellenborough ordered an inquiry. His instructions were admirable, in equity as well as energy, and if Outram had been left to carry them out all would have been well. But the duty was entrusted to Sir Charles Napier, with full political as well as military powers. And to add to the evil, Mir Ali Morad intrigued with both sides so effectually that he betrayed the amirs on the one hand, while he deluded Sir Charles Napier to their destruction on the other. Ellenborough was led on till events were beyond his control, and his own just and merciful instructions were forgotten. Sir Charles Napier made more than one confession like this: “We have no right to seize Sind, yet we shall do so, and a very advantageous, useful and humane piece of rascality it will be.” The battles of Meeanee and Hyderabad followed; and the Indus became a British river from Karachi to Multan.

Sind had hardly been disposed of when troubles arose on both sides of the governor-general, who was then at Agra. On the north the disordered kingdom of the Sikhs was threatening the frontier. In Gwalior to the south, the feudatory Mahratta state, there were a large mutinous army, a Ranee only twelve years of age, an adopted chief of eight, and factions in the council of ministers. These conditions brought Gwalior to the verge of civil war. Ellenborough reviewed the danger in the minute of the 1st of November 1845, and told Sir Hugh Gough to advance. Further treachery and military licence rendered the battles of Maharajpur and Punniar, fought on the same day, inevitable though they were, a surprise to the combatants. The treaty that followed was as merciful as it was wise. The pacification of Gwalior also had its effect beyond the Sutlej, where anarchy was restrained for yet another year, and the work of civilization was left to Ellenborough’s two successors. But by this time the patience of the directors was exhausted. They had no control over Ellenborough’s policy; his despatches to them were haughty and disrespectful; and in June 1844 they exercised their power of recalling him.

On his return to England Ellenborough was created an earl and received the thanks of parliament; but his administration speedily became the theme of hostile debates, though it was successfully vindicated by Peel and Wellington. When Peel’s cabinet was reconstituted in 1846 Ellenborough became first lord of the admiralty. In 1858 he took office under Lord Derby as president of the board of control, for the fourth time. It was then his congenial task to draft the new scheme for the government of India which the mutiny had rendered necessary. But his old fault of impetuosity again proved his stumbling-block. He wrote a caustic despatch censuring Lord Canning for the Oudh proclamation, and allowed it to be published in *The Times* without consulting his colleagues, who disavowed his action in this respect. General disapprobation was excited; votes of censure were announced in both Houses; and, to save the cabinet, Ellenborough resigned.

But for this act of rashness he might have enjoyed the task of carrying into effect the home constitution for the government of India which he sketched in his evidence before the select committee of the House of Commons on Indian territories on the 8th of June 1852. Paying off his old score against the East India Company, he then advocated the abolition of the court of directors as a governing body, the opening of the civil service to the army, the transference of the government to the crown, and the appointment of a council to advise the minister who should take the place of the president of the board of control. These suggestions of 1852 were carried out by his successor Lord Stanley, afterwards earl of Derby, in 1858, so closely even in details, that Lord Ellenborough must be pronounced the author, for good or evil, of the present home constitution of the government of India. Though acknowledged to be one of the foremost orators in the House of Lords, and taking a frequent part in debate, Ellenborough never held office again. He died at his seat, Southam House, near Cheltenham, on the 22nd of December 1871, when the barony reverted to his nephew Charles Edmund Law (1820-1890), the earldom becoming extinct.

See *History of the Indian Administration* (Bentley, 1874), edited by Lord Colchester; *Minutes of Evidence taken before the Select Committee on Indian Territories* (June 1852); volume i. of the *Calcutta Review*; the *Friend of India*, during the years 1842-1845; and John Hope, *The House of Scindea: A Sketch* (Longmans, 1863). The numerous books by and against Sir Charles Napier, on the conquest of Sind, should be consulted.

ELLERY, WILLIAM (1727-1820), American politician, a signer of the Declaration of Independence, was born in Newport, Rhode Island, on the 22nd of December 1727. He graduated from Harvard in 1747, engaged in trade, studied law, and was admitted to the bar in 1770. He was a member of the Rhode Island committee of safety in 1775-1776, and was a delegate in Congress in 1776-1781 and again in 1783-1785. Just after his first election to Congress, he was placed on the important marine committee, and he was made a member of the board of admiralty when it was established in 1779. In April 1786 he was elected commissioner of the continental loan office for the state of Rhode Island and from 1790 until his death at Newport, on the 15th of February 1820, he was collector of the customs for the district of Newport.

See Edward T. Channing, "Life of William Ellery," in vol. 6 of Jared Sparks's *American Biography* (Boston and London, 1836).

ELLESMERE, FRANCIS EGERTON, 1st Earl of (1800-1857), born in London on the 1st of January 1800, was the second son of the 1st duke of Sutherland. He was known by his patronymic as Lord Francis Leveson Gower until 1833, when he assumed the surname of Egerton alone, having succeeded on the death of his father to the estates which the latter inherited from the duke of Bridgewater. Educated at Eton and at Christ Church, Oxford, he entered parliament soon after attaining his majority as member for the pocket borough of Bletchingly in Surrey. He afterwards sat for Sutherlandshire and for South Lancashire, which he represented when he was elevated to the peerage as earl of Ellesmere and Viscount Brackley in 1846. In politics he was a moderate Conservative of independent views, as was shown by his supporting the proposal for establishing the university of London, by his making and carrying a motion for the endowment of the Roman Catholic clergy in Ireland, and by his advocating free trade long before Sir Robert Peel yielded on the question. Appointed a lord of the treasury in 1827, he held the post of chief secretary for Ireland from 1828 till July 1830, when he became secretary-at-war for a short time. His claims to remembrance are founded chiefly on his services to literature and the fine arts. Before he was twenty he printed for private circulation a volume of poems, which he followed up after a short interval by the publication of a translation of Goethe's Faust, one of the earliest that appeared in England, with some translations of German lyrics and a few original poems. In 1839 he visited the Mediterranean and the Holy Land. His impressions of travel were recorded in his very agreeably written *Mediterranean Sketches* (1843), and in the notes to a poem entitled *The Pilgrimage*. He published several other works in prose and verse, all displaying a fine literary taste. His literary reputation secured for him the position of rector of Aberdeen University in 1841. Lord Ellesmere was a munificent and yet discriminating patron of artists. To the splendid collection of pictures which he inherited from his great-uncle, the 3rd duke of Bridgewater, he made numerous additions, and he built a noble gallery to which the public were allowed free access. Lord Ellesmere served as president of the Royal Geographical Society and as president of the Royal Asiatic Society, and he was a trustee of the National Gallery. He died on the

18th of February 1857. He was succeeded by his son (1823-1862) as 2nd earl, and his grandson (b. 1847) as 3rd earl.

ELLESMERE, a market town in the Oswestry parliamentary division of Shropshire, England, on the main line of the Cambrian railway, 182 m. N.W. from London. Pop. of urban district (1901) 1945. It is prettily situated on the west shore of the mere or small lake from which it takes its name, while in the neighbourhood are other sheets of water, as Blake Mere, Cole Mere, White Mere, Newton Mere and Crose Mere. The church of St Mary is of various styles from Norman onward, but was partly rebuilt in 1848. The site of the castle is occupied by pleasure gardens, commanding an extensive view from high ground. The town hall contains a library and a natural history collection. The college is a large boys' school. The town is an important agricultural centre. Ellesmere canal, a famous work of Thomas Telford, connects the Severn with the Mersey, crossing the Vale of Llangollen by an immense aqueduct, 336 yds. long and 127 ft. high.

The manor of Ellesmere (*Ellesmeles*) belonged before the Conquest to Earl Edwin of Mercia, and was granted by William the Conqueror to Roger, earl of Shrewsbury, whose son, Robert de Belesme, forfeited it in 1112 for treason against Henry I. In 1177 Henry II. gave it with his sister in marriage to David, son of Owen, prince of North Wales, after whose death it was retained by King John, who in 1206 granted it to his daughter Joan on her marriage with Llewellyn, prince of North Wales; it was finally surrendered to Henry III. by David, son of Llewellyn, about 1240. Ellesmere owed its early importance to its position on the Welsh borders and to its castle, which was in ruins, however, in 1349. While Ellesmere was in the hands of Joan, lady of Wales, she granted to the borough all the free customs of Breteuil. The town was governed by a bailiff appointed by a jury at one of the court leets of the lord of the manor, until a local board was formed in 1859. In 1221 Henry III. granted Llewellyn, prince of Wales, a market on Thursdays in Ellesmere. The inquisition taken in 1383 after the death of Roger le Straunge (Lord Strange), lord of Ellesmere, shows that he also held two fairs there on the feasts of St Martin and the Nativity of the Virgin Mary. By 1597 the market had been discontinued on account of the plague by which many of the inhabitants had died, and the queen granted that Sir Edward Kynaston, Kt., and thirteen others might hold a market every Thursday and a fair on the 3rd of November. Since 1792 both have been discontinued. The commerce of Ellesmere has always been chiefly agricultural.

ELLICE (LAGOON) ISLANDS, an archipelago of the Pacific Ocean, lying between 5° and 11° S. and about 178° E., nearly midway between Fiji and Gilbert. It is under British protection, being annexed in 1892. It comprises a large number of low coralline islands and atolls, which are disposed in nine clusters extending over a distance of about 400 m. in the direction from N.W. to S.E. Their total area is 14 sq. m. and the population is about 2400. The chief groups, all yielding coco-nuts, pandanus fruit and yams, are Funafuti or Ellice, Nukulailai or Mitchell, Nurakita or Sophia, Nukufetau or De Peyster, Nui or Egg, Nanomana or Hudson, and Niutao or Lynx. Nearly all the natives are Christians, Protestant missions having been long established in several of the islands. Those of Nui speak the language of the Gilbert islanders, and have a tradition that they came some generations ago from that group. All the others are of Samoan speech, and their tradition that they came thirty generations back from Samoa is supported by recent research. They have an ancient spear which they believe was brought from Samoa, and they actually name the valley from which their ancestors started. A missionary visiting the Samoan valley found there a tradition of a party who put to sea never to return, and he also found the wood of which the staff was made growing plentifully in the district. Borings and soundings taken at Funafuti in 1897 indicate almost beyond doubt that the whole of this Polynesian region is an area of comparatively recent subsidence.

See *Geographical Journal*, passim; and *Atoll of Funafuti: Borings into a Coral Reef* (Report of Coral Reef Committee of Royal Society, London, 1904).

ELLICHPUR, or Illichpur, a town of India in the Amraoti district of Berar. Pop. (1901) 26,082. It is first mentioned authentically in the 13th century as "one of the famous cities of the Deccan." Though tributary to the Mahommedans after 1294, it remained under Hindu administration till 1318, when it came directly under the Mahommedans. It was afterwards capital of the province of Berar at intervals until the Mogul occupation, when the seat of the provincial governor was moved to Balapur. The town retains many relics of the nawabs of Berar. It has ginning factories and a considerable trade in cotton and forest produce. It is connected by good roads with Amraoti and Chikalda. It was formerly the headquarters of the district of Ellichpur, which had an area of 2605 sq. m. and a population in 1901 of 297,403. This district, however, was merged in that of Amraoti in 1905. The civil station of Paratwada, 2 m. from the town of Ellichpur, contains the principal public buildings.

ELLIOTSON, JOHN (1791-1868), English physician, was born at Southwark, London, on the 29th of October 1791. He studied medicine first at Edinburgh and then at Cambridge, in both which places he took the degree of M.D., and subsequently in London at St Thomas’s and Guy’s hospitals. In 1831 he was elected professor of the principles and practice of physic in London University, and in 1834 he became physician to University College hospital. He was a student of phrenology and mesmerism, and his interest in the latter eventually brought him into collision with the medical committee of the hospital, a circumstance which led him, in December 1838, to resign the offices held by him there and at the university. But he continued the practice of mesmerism, holding séances in his home and editing a magazine, *The Zoist*, devoted to the subject, and in 1849 he founded a mesmeric hospital. He died in London on the 29th of July 1868. Elliotson was one of the first teachers in London to appreciate the value of clinical lecturing, and one of the earliest among British physicians to advocate the employment of the stethoscope. He wrote a translation of Blumenbach’s *Institutiones Physiologicae* (1817); *Cases of the Hydrocyanic or Prussic Acid* (1820); *Lectures on Diseases of the Heart* (1830); *Principles and Practice of Medicine* (1839); *Human Physiology* (1840); and *Surgical Operations in the Mesmeric State without Pain* (1843). He was the author of numerous papers in the *Transactions* of the Medico-Chirurgical Society, of which he was at one time president; and he was also a fellow both of the Royal College of Physicians and Royal Society, and founder and president of the Phrenological Society. W.M. Thackeray’s *Pendennis* was dedicated to him.

ELLIOTT, EBENEZER (1781-1849), English poet, the “corn-law rhymer,” was born at Masborough, near Rotherham, Yorkshire, on the 17th of March 1781. His father, who was an extreme Calvinist and a strong radical, was engaged in the iron trade. Young Ebenezer, although one of a large family, had a solitary and rather morbid childhood. He was sent to various schools, but was generally regarded as a dunce, and when he was sixteen years of age he entered his father’s foundry, working for seven years with no wages beyond a little pocket money. In a fragment of autobiography printed in the *Athenaeum* (12th of January 1850) he says that he was entirely self-taught, and attributes his poetic development to long country walks undertaken in search of wild flowers, and to a collection of books, including the works of Young, Barrow, Shenstone and Milton, bequeathed to his father by a poor clergyman. At seventeen he wrote his *Vernal Walk* in imitation of Thomson. His earlier volumes of poems, dealing
with romantic themes, received little but unfriendly comment. The faults of *Night*, the earliest of 292
these, are pointed out in a long and friendly letter (30th of January 1819) from Robert Southey to the author.

Elliott’s wife brought him some money, which was invested in his father’s share of the iron foundry. But the affairs of the firm were then in a desperate condition, and money difficulties hastened his father’s death. Elliott lost all his money, and when he was forty years old began business again in Sheffield on a small borrowed capital. He attributed his father’s pecuniary losses and his own to the operation of the corn laws. He took an active part in the Chartist agitation, but withdrew his support when the agitation for the repeal of the corn laws was removed from the Chartist programme. The fervour of his political convictions effected a change in the style and tenor of his verse. The *Corn-Law Rhymes* (3rd ed., 1831), inspired by a fierce hatred of injustice, are vigorous, simple and full of vivid description. In 1833-1835 he published *The Splendid Village*; *Corn-Law Rhymes, and other Poems* (3 vols.), which included “The Village Patriarch” (1829), “The Ranter,” an unsuccessful drama, “Keronah,” and other pieces. He contributed verses from time to time to *Tait’s Magazine* and to the *Sheffield and Rotherham Independent*. In the meantime he had been successful in business, but he remained the sturdy champion of the poor. In 1837 he again lost a great deal of money. This misfortune was also ascribed to the corn laws. He retired in 1841 with a small fortune and settled at Great Houghton, near Barnsley, where he died on the 1st of December 1849. In 1850 appeared two volumes of *More Prose and Verse by the Corn-Law Rhymer*. Elliott lives by his determined opposition to the “bread-tax,” as he called it, and his poems on the subject are saved from the common fate of political poetry by their transparent sincerity and passionate earnestness.

An article by Thomas Carlyle in the *Edinburgh Review* (July 1832) is the best criticism on Elliott. Carlyle was attracted by Elliott’s homely sincerity and genuine power, though he had small opinion of his political philosophy, and lamented his lack of humour and of the sense of proportion. He thought his poetry too imitative, detecting not only the truthful severity of Crabbe, but a “slight bravura dash of the fair tuneful Hemans." His descriptions of his native county reveal close observation and a vivid perception of natural beauty.

See an obituary notice in the *Gentleman's Magazine* (Feb. 1850). Two biographies were published in 1850, one by his son-in-law, John Watkins, and another by "January Searle" (G.S. Phillips). A new edition of his works by his son, Edwin Elliott, appeared in 1876.

ELLIPSE (adapted from Gr. ἔλλειψις, a deficiency, ἐλλείπειν, to fall behind), in mathematics, a conic section, having the form of a closed oval. It admits of several definitions framed according to the aspect from which the curve is considered. *In solido*, *i.e.* as a section of a cone or cylinder, it may be defined, after Menaechmus, as the perpendicular section of an "acute-angled" cone; or, after Apollonius of Perga, as the section of any cone by a plane at a less inclination to the base than a generator; or as an oblique section of a right cylinder. Definitions *in plano* are generally more useful; of these the most important are: (1) the ellipse is the conic section which has its eccentricity less than unity: this involves the notion of one directrix and one focus; (2) the ellipse is the locus of a point the sum of whose distances from two fixed points is constant: this involves the notion of two foci. Other geometrical definitions are: it is the oblique projection of a circle; the polar reciprocal of a circle for a point within it; and the conic which intersects the line at infinity in two imaginary points. Analytically it is defined by an equation of the second degree of which the highest terms represent two imaginary lines. The curve has important mechanical relations, in particular it is the orbit of a particle moving under the influence of a central force which varies inversely as the square of the distance of the particle; this is the gravitational law of force, and the curve consequently represents the orbits of the planets if only an individual planet and the sun be considered; the other planets, however, disturb this orbit (see Mechanics).

The relation of the ellipse to the other conic sections is treated in the articles Conic Section and Geometry; in this article a summary of the properties of the curve will be given.

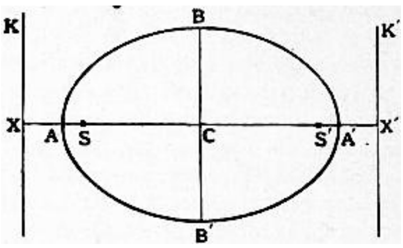

Fig. 1.

To investigate the form of the curve use may be made of the definition: the ellipse is the locus of a point which moves so that the ratio of its distance from a fixed point (the *focus*) to its distance from a straight line (the *directrix*) is constant and is less than unity. This ratio is termed the *eccentricity*, and will be denoted by *e*. Let KX (fig. 1) be the directrix, S the focus, and X the foot of the perpendicular from S to KX. If SX be divided at A so that SA/AX = e, then A is a point on the curve. SX may be also divided externally at A′, so that SA′/A′X = e, since e is less than unity; the points A and A′ are the *vertices*, and the line AA′ the *major axis* of the curve. It is obvious that the curve is symmetrical about AA′. If AA′ be bisected at C, and the line BCB′ be drawn perpendicular to AA′, then it is readily seen that the curve is symmetrical about this line also; since if we take S′ on AA′ so that S′A′ = SA, and a line K′X′ parallel to KX such that AX = A′X′, then the same curve will be described if we regard K′X′ and S′ as the given directrix and focus, the eccentricity remaining the same. If B and B′ be points on the curve, BB′ is the *minor axis* and C the *centre* of the curve.

Metrical relations between the axes, eccentricity, distance between the foci, and between these quantities and the co-ordinates of points on the curve (referred to the axes and the centre), and focal distances are readily obtained by the methods of geometrical conics or analytically. The semi-major axis is generally denoted by a, and the semi-minor axis by b, and we have the relation $b^2 = a^2 (1 - e^2)$. Also $a^2 = CS \cdot CX$, *i.e.* the square on the semi-major axis equals the rectangle contained by the distances of the focus and directrix from the centre; and 2a = SP + S′P, where P is any point on the curve, *i.e.* the sum of the focal distances of any point on the curve equals the major axis. The most important relation between the co-ordinates of a point on an ellipse is: if N be the foot of the perpendicular from a point P, then the square on PN bears a constant ratio to the product of the segments AN, NA′ of the major axis, this ratio being the square of the ratio of the minor to the major axis; symbolically $PN^2 = AN \cdot NA' (CB/CA)^2$. From this or otherwise it is readily deduced that the ordinates of an ellipse and of the circle described on the major axis are in the ratio of the minor to the major axis. This circle is termed the *auxiliary circle*.

Of the properties of a tangent it may be noticed that the tangent at any point is equally inclined to the focal distances of that point; that the feet of the perpendiculars from the foci on any tangent always lie on the auxiliary circle, and the product of these perpendiculars is constant, and equal to the product of the distances of a focus from the two vertices. From any point without the curve two, and only two, tangents can be drawn; if OP, OP′ be two tangents from O, and S, S′ the foci, then the angles OSP, OSP′ are equal and also SOP, S′OP′. If the tangents be at right angles, then the locus of the point is a circle having the same centre as the ellipse; this is named the *director circle*.

The middle points of a system of parallel chords is a straight line, and the tangent at the point where this line meets the curve is parallel to the chords. The straight line and the line through the centre parallel to the chords are named *conjugate diameters*; each bisects the chords parallel to the other. An important metrical property of conjugate diameters is the sum of their squares equals the sum of the squares of the major and minor axis.

In analytical geometry, the equation $ax^2 + 2hxy + by^2 + 2gx + 2fy + c = 0$ represents an ellipse when $ab > h^2$; if the centre of the curve be the origin, the equation is $a^1x^2 + 2h^1xy + b^1y^2 = C^1$, and if in addition a pair of conjugate diameters are the axes, the equation is further simplified to $Ax^2 + By^2 = C$. The simplest form is $x^2/a^2 + y^2/b^2 = 1$, in which the centre is the origin and the major and minor axes the axes of co-ordinates. It is obvious that the co-ordinates of any point on an ellipse may be expressed in terms of a single parameter, the abscissa being $a \cos \varphi$, and the ordinate $b \sin \varphi$, since on eliminating φ between $x = a \cos \varphi$ and $y = b \sin \varphi$ we obtain the equation to the ellipse. The angle φ is termed the *eccentric angle*, and is geometrically represented as the angle between the axis of x (the major axis of the ellipse) and the radius of a point on the auxiliary circle which has the same abscissa as the point on the ellipse.

The equation to the tangent at θ is $x \cos \theta/a + y \sin \theta/b = 1$, and to the normal $ax/\cos \theta - by/\sin \theta = a^2 - b^2$.

The area of the ellipse is πab, where a, b are the semi-axes; this result may be deduced by regarding the ellipse as the orthogonal projection of a circle, or by means of the calculus. The perimeter can only be expressed as a series, the analytical evaluation leading to an integral termed *elliptic* (see Function, ii. *Complex*). There are several approximation formulae:—$S = \pi(a + b)$ makes the perimeter about 1/200th too small; $s = \pi\sqrt{(a^2 + b^2)}$ about 1/200th too great; $2s = \pi(a + b) + \pi\sqrt{(a^2 + b^2)}$ is within 1/30,000 of the truth.

An ellipse can generally be described to satisfy any five conditions. If five points be given, Pascal's theorem affords a solution; if five tangents, Brianchon's theorem is employed. The principle of 293 involution solves such constructions as: given four tangents and one point, three tangents and two points, &c. If a tangent and its point of contact be given, it is only necessary to remember that a double point on the curve is given. A focus or directrix is equal to two conditions; hence such problems as: given a focus and three points; a focus, two points and one tangent; and a focus, one point and two tangents are soluble (very conveniently by employing the principle of reciprocation). Of practical importance are the following constructions:—(1) Given the axes; (2) given the major axis and the foci; (3) given the focus, eccentricity and directrix; (4) to construct an ellipse (approximately) by means of circular arcs.

(1) If the axes be given, we may avail ourselves of several constructions, (*a*) Let AA′, BB′ be the axes intersecting at right angles in a point C. Take a strip of paper or rule and mark off from a point P, distances Pa and Pb equal respectively to CA and CB. If now the strip be moved so that the point a is always on the minor axis, and the point b on the major axis, the point P describes the ellipse. This is known as the *trammel* construction.

(*b*) Let AA′, BB′ be the axes as before; describe on each as diameter a circle. Draw any number of radii of the two circles, and from the points of intersection with the major circle draw lines parallel to the minor axis, and from the points of intersection with the minor circle draw lines parallel to the major axis. The intersections of the lines drawn from corresponding points are points on the ellipse.

(2) If the major axis and foci be given, there is a convenient mechanical construction based on the property that the sum of the focal distances of any point is constant and equal to the major axis. Let AA′ be the axis and S, S′ the foci. Take a piece of thread of length AA′, and fix it at its extremities by means of pins at the foci. The thread is now stretched taut by a pencil, and the pencil moved; the curve traced out is the desired ellipse.

(3) If the directrix, focus and eccentricity be given, we may employ the general method for constructing a conic. Let S (fig. 2) be the focus, KX the directrix, X being the foot of the perpendicular from S to the directrix. Divide SX internally at A and externally at A′, so that the ratios SA/AX and SA′/A′X are each equal to the eccentricity. Then A, A′ are the vertices of the curve. Take any point R on the directrix, and draw the lines RAM, RSN; draw SL so that the angle LSN = angle NSA′. Let P be the intersection of the line SL with the line RAM, then it can be readily shown that P is a point on the ellipse. For, draw through P a line parallel to AA′, intersecting the directrix in Q and the line RSN in T. Then since XS and QT are parallel and are intersected by the lines RK, RM, RN, we have SA/AX = TP/PQ = SP/PQ, since the angle PST = angle PTS. By varying the position of R other points can be found, and, since the curve is symmetrical about both the major and minor axes, it is obvious that any point may be reflected in both the axes, thus giving 3 additional points.

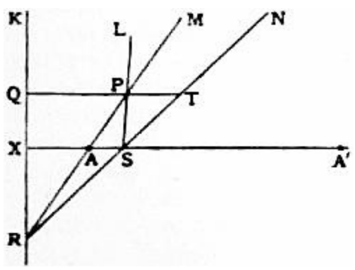

Fig. 2.

(4) If the axes be given, the curve can be approximately constructed by circular arcs in the following manner:—Let AA′, BB′ be the axes; determine D the intersection of lines through B and A parallel to the major and minor axes respectively. Bisect AD at E and join EB. Then the intersection of EB and DB′ determines a point P on the (true) curve. Bisect the chord PB at G, and draw through G a line perpendicular to PB, intersecting BB′ in O. An arc with centre O and radius OB forms part of a curve. Let this arc on the reverse side to P intersect a line through O parallel to the major axis in a point H. Then HA^1 will cut the circular arc in J. Let JO intersect the major axis in O_1. Then with centre O_1 and radius $OJ = OA^1$, describe an arc. By reflecting the two arcs thus described over the centre the ellipse is approximately described.

ELLIPSOID, a quadric surface whose sections are ellipses. Analytically, it has for its equation $x^2/a^2 + y^2/b^2 + z^2/c^2 = 1$, a, b, c being its axes; the name is also given to the solid contained by this surface (see Geometry: *Analytical*). The solids and surfaces of revolution of the ellipse are sometimes termed ellipsoids, but it is advisable to use the name spheroid (*q.v.*).

The ellipsoid appears in the mathematical investigation of physical properties of media in which the particular property varies in three directions within the media; such properties are the elasticity, giving rise to the strain ellipsoid, thermal expansion, ellipsoid of expansion, thermal conduction, refractive index (see Crystallography), &c. In mechanics, the ellipsoid of gyration or inertia is such that the perpendicular from the centre to a tangent plane is equal to the radius of gyration of the given body about the perpendicular as axis; the "momental ellipsoid," also termed the "inverse ellipsoid of inertia" or Poinsot's ellipsoid, has the perpendicular inversely proportional to the radius of gyration; the "equimomental ellipsoid" is such that its moments of inertia about all axes are the same as those of a given body. (See Mechanics.)

ELLIPTICITY, in astronomy, deviation from a circular or spherical form; applied to the elliptic orbits of heavenly bodies, or the spheroidal form of such bodies. (See also Compression.)

ELLIS (originally Sharpe), **ALEXANDER JOHN** (1814-1890), English philologist, mathematician, musician and writer on phonetics, was born at Hoxton on the 14th of June 1814. He was educated at Shrewsbury, Eton, and Trinity College, Cambridge, and took his degree in high mathematical honours. He was connected with many learned societies as member or president, and was governor of University College, London. He was the first in England to reduce the study of phonetics to a science. His most important work, to which the greater part of his life was devoted, is *On Early English Pronunciation, with special reference to Shakespeare and Chaucer* (1869-1889), in five parts, which he intended to supplement by a sixth, containing an abstract of the whole, an account of the views and criticisms of other inquirers in the same field, and a complete index, but ill-health prevented him from carrying out his intention. He had long been associated with Isaac Pitman in his attempts to reform English spelling, and published *A Plea for Phonotypy and Phonography* (1845) and *A Plea for Phonetic Spelling* (1848); and contributed the articles on "Phonetics" and "Speech-sounds" to the 9th edition of the *Ency. Brit.* He translated (with considerable additions) Helmholtz's *Sensations of Tone as a physiological Basis for the Theory of Music* (2nd ed., 1885); and was the author of several smaller works on music, chiefly in connexion with his favourite subject phonetics. He died in London on the 28th of October 1890.

ELLIS, GEORGE (1753-1815), English author, was born in London in 1753. Educated at Westminster school and at Trinity College, Cambridge, he began his literary career by some satirical verses on Bath society published in 1777, and *Poetical Tales*, by "Sir Gregory Gander," in 1778. He contributed to the *Rolliad* and the *Probationary Odes* political satires directed against Pitt's administration. He was employed in diplomatic business at the Hague in 1784; and in 1797 he accompanied Lord Malmesbury to Lille as secretary to the embassy. On his return he was introduced to Pitt, and the episode of the *Rolliad*, which had not been forgotten, was explained. He found continued scope for his powers as a political caricaturist in the columns of the *Anti-Jacobin*, a weekly paper which he founded in connexion with George Canning and William Gifford. For some years before the *Anti-Jacobin* was started Ellis had been working in the congenial field of Early English literature, in which he was one of the first to arouse interest. The first edition of his *Specimens of the Early English Poets* appeared in 1790; and this was followed by *Specimens of Early English Metrical Romances* (1805). He also edited Gregory Lewis Way's translation of select *Fabliaux* in 1796. Ellis was an intimate friend of Sir Walter Scott, who styled him "the first converser I ever saw," and dedicated to him the fifth canto of *Marmion*. Some of the correspondence between them is to be found in Lockhart's *Life*. He died on the 10th of April 1815. The monument erected to his memory in the parish church of Gunning Hill, Berks, bears a fine inscription by Canning.

ELLIS, SIR HENRY (1777-1869), English antiquary, was born in London on the 29th of November 1777. He was educated at Merchant Taylors' school, and at St John's College, Oxford, of which he was elected a fellow. After having held for a few months a sub-librarianship in the Bodleian, he was in 1800 appointed to a similar post in the British Museum. In 1827 he became chief librarian, and held that post until 1856, when he resigned on account of advancing age. In 1832 William IV. made him a knight of Hanover, and in the following year he received an English knighthood. He died on the 15th of January 1869. Sir Henry Ellis's life was one of very considerable literary activity. His first work of importance was the preparation of a new edition of Brand's *Popular Antiquities*, which appeared in 1813. In 1816 he was selected by the commissioners of public records to write the introduction to Domesday Book, a task which he discharged with much learning, though several of his views have not stood the test of later criticism. His *Original Letters Illustrative of English History* (first series, 1824; second series, 1827; third series, 1846) are compiled chiefly from manuscripts in the British Museum and the State Paper Office, and have been of considerable service to historical writers. To the Library of Entertaining Knowledge he contributed four volumes on the Elgin and Townley Marbles. Sir Henry was for many years a director and joint-secretary of the Society of Antiquaries. 294

ELLIS, ROBINSON (1834-), English classical scholar, was born at Barming, near Maidstone, on the 5th of September 1834. He was educated at Elizabeth College, Guernsey, Rugby, and Balliol College, Oxford. In 1858 he became fellow of Trinity College, Oxford, and in 1870 professor of Latin at University College, London. In 1876 he returned to Oxford, where from 1883 to 1893 he held the university readership in Latin. In 1893 he succeeded Henry Nettleship as professor. His chief work has been on Catullus, whom he began to study in 1859. His first *Commentary on Catullus* (1876) aroused great interest, and called forth a flood of criticism. In 1889 appeared a second and enlarged edition, which placed its author in the first rank of authorities on Catullus. Professor Ellis quotes largely from the early Italian commentators, maintaining that the land where the Renaissance originated had done more for scholarship than is commonly recognized. He has supplemented his critical work by a translation (1871, dedicated to Tennyson) of the poems in the metres of the originals. Another author to whom Professor Ellis has devoted many years' study is Manilius, the astrological poet. In 1891 he published *Noctes Manilianae*, a series of dissertations on the *Astronomica*, with emendations. He has also treated Avianus, Velleius Paterculus and the Christian poet Orientius, whom he edited for the Vienna *Corpus Scriptorum Ecclesiasticorum*. He edited the *Ibis* of Ovid, the *Aetna* of the younger Lucilius, and contributed to the *Anecdota Oxoniensia* various unedited Bodleian and other manuscripts. In 1907 he published *Appendix Vergiliana* (an edition of the minor poems); in 1908 *The Annalist Licinianus*.

ELLIS, WILLIAM (1794-1872), English Nonconformist missionary, was born in London on the 29th of August 1794. His boyhood and youth were spent at Wisbeach, where he worked as a market-gardener. In 1814 he offered himself to the London Missionary Society, and was accepted. During a year's training he acquired some knowledge of theology and of various practical arts, such as printing and bookbinding. He sailed for the South Sea Islands in January 1816, and remained in Polynesia, occupying various stations in succession, until 1824, when he was compelled to return home on account of the state of his wife's health. Though the period of his residence in the islands was thus comparatively short, his labours were very fruitful, contributing perhaps as much as those of any other missionary to bring about the extraordinary improvement in the religious, moral and social condition of the Pacific Archipelago that took place during the 19th century. Besides promoting the spiritual object of his mission, he introduced many other aids to the improvement of the condition of the people. His gardening experience enabled him successfully to acclimatize many species of tropical fruits and plants, and he set up and worked the first printing press in the South Seas. Returning home by way of the United States, where he advocated his work, Ellis was for some years employed as a travelling agent of the London Missionary Society, and in 1832 was appointed foreign secretary to the society, an office which he held for seven years. In 1837 he married his second wife, Sarah Stickney, a writer and teacher of some note in her generation. In 1841 he went to live at Hoddesdon, Herts, and ministered to a small Congregational church there. On behalf of the London Missionary Society he paid three visits to Madagascar (1853-1857), inquiring into the prospects for resuming the work that had been suspended by Queen Ranavolona's hostility. A further visit was paid in 1863. Ellis wrote accounts of all his travels, and Southey's praise (in the *Quarterly Review*) of his *Polynesian*

Researches (2 vols., 1829) finds many echoes. He was a fearless, upright and tactful man, and a keen observer of nature. He died on the 25th of June 1872.

ELLISTON, ROBERT WILLIAM (1774-1831), English actor, was born in London on the 7th of April 1774, the son of a watchmaker. He was educated at St Paul's school, but ran away from home and made his first appearance on the stage as Tressel in *Richard III.* at Bath in 1791. Here he was later seen as Romeo, and in other leading parts, both comic and tragic, and he repeated his successes in London from 1796. He acted at Drury Lane from 1804 to 1809, and again from 1812; and from 1819 he was the lessee of the house, presenting Kean, Mme Vestris and Macready. Ill-health and misfortune culminated in his bankruptcy in 1826, when he made his last appearance at Drury Lane as Falstaff. But as lessee of the Surrey theatre he acted almost up to his death, which was hastened by intemperance. Leigh Hunt compared him favourably with Garrick; Byron thought him inimitable in high comedy; Macready praised his versatility. Elliston was the author of *The Venetian Outlaw* (1805), and, with Francis Godolphin Waldron, of *No Prelude* (1803), in both of which plays he appeared.

ELLORA, a village of India in the native state of Hyderabad, near the city of Daulatabad, famous for its rock temples, which are among the finest in India. They are first mentioned by Ma′sudi, the Arabic geographer of the 10th century, but merely as a celebrated place of pilgrimage. The caves differ from those of Ajanta in consequence of their being excavated in the sloping sides of a hill and not in a nearly perpendicular cliff. They extend along the face of the hill for a mile and a quarter, and are divided into three distinct series, the Buddhist, the Brahmanical and the Jain, and are arranged almost chronologically. The most splendid of the whole series is the Kailas, a perfect Dravidian temple, complete in all its parts, characterized by Fergusson as one of the most wonderful and interesting monuments of architectural art in India. It is not a mere interior chamber cut in the rock, but is a model of a complete temple such as might have been erected on the plain. In other words, the rock has been cut away externally as well as internally. First the great sunken court measuring 276 ft. by 154 ft. was hewn out of the solid trap-rock of the hillside, leaving the rock mass of the temple wholly detached in a cloistered court like a colossal boulder, save that a rock bridge once connected the upper storey of the temple with the upper row of galleried chambers surrounding three sides of the court. Colossal elephants and obelisks stand on either side of the open mandapam, or pavilion, containing the sacred bull; and beyond rises the monolithic Dravidian temple to Siva, 90 ft. in height, hollowed into vestibule, chamber and image-cells, all lavishly carved. Time and earthquakes have weathered and broken away bits of the great monument, and Moslem zealots strove to destroy the carved figures, but these defects are hardly noticed. The temple was built by Krishna I., Rashtrakuta, king of Malkhed in 760-783.

ELLORE, a town of British India, in the Kistna district of Madras, on the East Coast railway, 303 m. from Madras. Pop. (1901) 33,521. The two canal systems of the Godavari and the Kistna deltas meet here. There are manufactures of cotton and saltpetre, and an important Church of England high school. Ellore was formerly a military station, and the capital of the Northern Circars. At Pedda Vegi to the north of it are extensive ruins, which are believed to be remains of the Buddhist kingdom of Vengi. From these the Mahommedans, after their conquest of the district in 1470, obtained material for building a fort at Ellore.

ELLSWORTH, OLIVER (1745-1807), American statesman and jurist, was born at Windsor, Connecticut, on the 29th of April 1745. He studied at Yale and Princeton, graduating from the latter in 1766, studied theology for a year, then law, and began to practise at Hartford in 1771. He was state's attorney for Hartford county from 1777 to 1785, and achieved extraordinary success at the bar, amassing what was for his day a large fortune. From 1773 to 1775 he represented the town of Windsor in the general assembly of Connecticut, and in the latter year became a member of the important commission known as the "Pay Table," which supervised the colony's expenditures for military purposes during the War of Independence. In 1779 he again sat in the assembly, this time representing Hartford. From 1777 to 1783 he was a member of the Continental Congress, and in this body he served on three important committees, the marine committee, the board of treasury, and the committee of appeals, the predecessors respectively of the navy and treasury departments and the Supreme Court under the Federal Constitution. From 1780 to 1785 he was a member of the governor's council of Connecticut, which, with the lower house before 1784 and alone from 1784 to 1807, constituted a supreme court of errors; and from 1785 to 1789 he was a judge of the state superior court. In 1787, with Roger Sherman and William Samuel Johnson (1727-1819), he was one of Connecticut's delegates to the constitutional convention at Philadelphia, in which his services were numerous and important. In particular, when disagreement seemed inevitable on the question of representation, he, with Roger Sherman, proposed what is known as the "Connecticut Compromise," by which the Federal legislature was made to consist of two houses, the upper having equal representation from each state, the lower being chosen on the basis of population. Ellsworth also made a determined stand against a national paper currency. Being compelled to leave the convention before its adjournment, he did not sign the instrument, but used his influence to secure its ratification by his native state. From 1789 to 1796 he was one of the first senators from Connecticut under the new Constitution. In the senate he was looked upon as President Washington's personal spokesman and as the leader of the Administration party. His most important service to his country was without a doubt in connexion with the establishment of the Federal judiciary. As chairman of the committee having the matter in charge, he drafted the bill by the enactment of which the system of Federal courts, almost as it is to-day, was established. He also took a leading part in the senate in securing the passage of laws for funding the national debt, assuming the state debts and establishing a United States bank. It was Ellsworth who suggested to Washington the sending of John Jay to England to negotiate a new treaty with Great Britain, and he probably did more than any other man to induce the senate, despite widespread and violent opposition, to ratify that treaty when negotiated. By President Washington's appointment he became chief justice of the Supreme Court of the United States in March 1796, and in 1799 President John Adams sent him, with William Vans Murray (1762-1803) and William R. Davie (1756-1820), to negotiate a new treaty with France. It was largely through the influence of Ellsworth, who took the principal part in the negotiations, that Napoleon consented to a convention, of the 30th of September 1800, which secured for citizens of the United States their ships captured by France but not yet condemned as prizes, provided for freedom of commerce between the two nations, stipulated that "free ships shall give a freedom to goods," and contained provisions favourable to neutral commerce. While he was abroad, failing health compelled him (1800) to resign the chief-justiceship, and after some months in England he returned to America in 1801. In 1803 he was again elected to the governor's council, and in 1807, on the reorganization of the Connecticut judiciary, was appointed chief justice of the new Supreme Court. He never took office, however, but died at his home in Windsor on the 27th of November 1807.

See W.G. Brown's *Oliver Ellsworth* (New York, 1905), an excellent biography. There is also an appreciative account of Ellsworth's life and work in H.C. Lodge's *A Fighting Frigate, and Other Essays and Addresses* (New York, 1902), which contains in an appendix an interesting letter by Senator George F. Hoar concerning Ellsworth's work in the constitutional convention.

ELLSWORTH, a city, port of entry and the county seat of Hancock county, Maine, U.S.A., at the head of navigation on the Union river (and about 3¾ m. from its mouth), about 30 m. S.E. of Bangor. Pop. (1890) 4804; (1900) 4297 (189 foreign-born); (1910) 3549. It is served by the Maine Central railway. The fall of the river, about 85 ft. in 2 m., furnishes good water-power, and the city has various manufactures, including lumber, shoes, woollens, sails, carriages and foundry and machine shop products, besides a large lumber trade. Shipbuilding was formerly important. There is a large United States fish hatchery here. The city is the port of entry for the Frenchman's Bay customs district, but its foreign trade is unimportant. Ellsworth was first settled in 1763 and for some time was called New Bowdoin; but when it was incorporated as a town in 1800 the present name was adopted in honour of Oliver Ellsworth. A city charter was secured in 1869.

ELLWANGEN, a town of Germany in the kingdom of Württemberg, on the Jagst, 12 m. S.S.E. from Crailsheim on the railway to Goldshöfe. Pop. 5000. It is romantically situated between two hills, one crowned by the castle of Hohen-Ellwangen, built in 1354 and now used as an agricultural college, and the other, the Schönenberg, by the pilgrimage church of Our Lady of Loreto, in the Jesuit style of architecture. The town possesses one Evangelical and five Roman Catholic churches, among the latter the Stiftskirche, the old abbey church, a Romanesque building dating from 1124, and the Gothic St Wolfgangskirche. The classical and modern schools (Gymnasium and Realschule) occupy the buildings of a suppressed Jesuit college. The industries include the making of parchment covers, of envelopes, of wooden hafts and handles for tools, &c., and tanneries. There are also a wool-market and a horse-market, the latter famous in Germany.

The Benedictine abbey of Ellwangen is said to have been founded in 764 by Herulf, bishop of Langres; there is, however, no record of it before 814. In 1460 the abbey was converted, with the consent of Pope Pius II., into a *Ritterstift* (college or institution for noble pensioners) under a secular provost, who, in 1555, was raised to the dignity of a prince of the Empire. The provostship was secularized in 1803 and its territories were assigned to Württemberg. The town of Ellwangen, which grew up round the abbey and received the status of a town about the middle of the 14th century, was until 1803 the capital of the provostship.

See Seckler, *Beschreibung der gefürsteten Probstei Ellwangen* (Stuttgart, 1864); *Beschreibung des Oberamts Ellwangen*, published by the statistical bureau (Landesamt) at Ellwangen (1888). For a list of the abbots and provosts see Stokvis, *Manuel d'histoire* (Leiden, 1890-1893), iii. p. 242.

ELLWOOD, THOMAS (1639-1714), English author, was born at Crowell, in Oxfordshire, in 1639. He is chiefly celebrated for his connexion with Milton, and the principal facts of his life are related in a very interesting autobiography, which contains much information as to his intercourse with the poet. While he was still young his father removed to London, where Thomas became acquainted with a Quaker family named Pennington, and was led to join the Society of Friends, a connexion which subjected him to much persecution. It was through the Penningtons that he was introduced in 1662 to Milton in the capacity of Latin reader. He spent nearly every afternoon in the poet's house in Jewin Street, until the intercourse was interrupted by an illness which compelled him to go to the country. After a period of imprisonment in the old Bridewell prison and in Newgate for Quakerism, Ellwood resumed his visits to Milton, who was now residing at a house his friend had taken for him at Chalfont St Giles. In 1665 Ellwood was again arrested and imprisoned in Aylesbury gaol. When he visited Milton after his release the poet gave him the manuscript of the *Paradise Lost* to read. On returning the manuscript Ellwood said, "Thou hast said much here of Paradise lost; but what hast thou to say of Paradise found?" and when Milton long afterwards in London showed him *Paradise Regained*, it was with the remark, "This is owing to you, for you put it into my head at Chalfont." Ellwood was the friend of Fox and Penn, and was the author of several polemical works in defence of the Quaker position, of which *Forgery no Christianity* (1674) and *The Foundation of Tithes Shaken* (1678) deserve mention. His *Sacred Histories of the Old and New Testaments* appeared in 1705 and 1709. He also published some volumes of poems, among them a *Davideis* in five books. He died on the 1st of March 1714.

The History of the Life of Thomas Ellwood: written by his own hand (1714) has been many times reprinted.

ELM, the popular name for the trees and shrubs constituting the genus *Ulmus*, of the natural order Ulmaceae. The genus contains fifteen or sixteen species widely distributed throughout the north temperate zone, with the exception of western North America, and extending southwards as far as Mexico in the New and the Sikkim Himalayas in the Old World.

The common elm, *U. campestris*, a doubtful native of England, is found throughout a great part of Europe, in North Africa and in Asia Minor, whence it ranges as far east as north Asia and Japan. It grows in woods and hedge-rows, especially in the southern portion of Britain, and on almost all soils, but thrives best on a rich loam, in open, low-lying, moderately moist situations, attaining a height of 60 to 100, and in some few cases as much as 130 or 150 ft. The branches are numerous and spreading, and often pendulous at the extremities; the bark is rugged; the leaves are alternate, ovate, rough, doubly serrate, and, as in other species of *Ulmus*, unequal at the base. The flowers are small, hermaphrodite, numerous, in purplish-brown tufts, and each with a fringed basal bract; the bell-shaped calyx is often four-toothed and surrounds four free stamens; the pistil bears two spreading hairy styles. They appear before the leaves in March and April. The seed-vessels are green, membranous, one-seeded and deeply cleft. Unlike the wych elm, the common elm rarely perfects its seed in England, where it is propagated by means of root suckers from old trees, or preferably by layers from stools. In the first ten years of its growth it ordinarily reaches a height of 25 to 30 ft. The wood, at first brownish white, becomes, with growth, of a brown colour having a greenish shade. It is close-grained, free from knots, without apparent medullary rays, and is hard and tough, but will not take a polish. All parts of the trunk, including the sapwood, are available in carpentry. By drying, the wood loses over 60% of its weight, and has then a specific gravity of 0.588. It has considerable transverse strength, does not crack when once seasoned, and is remarkably durable under water, or if kept quite dry; though it decays rapidly on exposure to the weather, which in ten to eighteen months causes the bark to fall off, and gives to the wood a yellowish colour—a sign of deterioration in quality. To prevent shrinking and warping it may be preserved in water or mud, but it is best worked up soon after felling. Analyses of the ash of the wood have given a percentage of 47.8% of lime, 21.9% of potash, and 13.7% of soda. In summer, elm trees often exude an alkaline gummy substance, which by the action of the air becomes the brown insoluble body termed *ulmin*. Elm wood is used for keels and bilge-planks, the blocks and dead-eyes of rigging, and ships' pumps, for coffins, wheels, furniture, carved and turned articles, and for general carpenters' work; and previous to the common employment of cast iron was much in request for waterpipes. The inner bark of the elm is made into bast mats and ropes. It contains mucilage, with a little tannic acid, and was formerly much employed for the preparation of an antiscorbutic decoction, now obsolete. The bark of *Ulmus fulva*, the slippery or red elm of the United States and Canada, serves the North American Indians for the same purpose, and also as a vulnerary. The leaves as well as the young shoots of elms have been found a suitable food for live stock. For ornamental purposes elm trees are frequently planted, and in avenues, as at the park of Stratfieldsaye, in Hampshire, are highly effective. They were first used in France for the adornment of public walks in the reign of Francis I. In Italy, as in ancient times, it is still customary to train the vine upon the elm—a practice to which frequent allusion has been made by the poets. The cork-barked elm, *U. campestris*, var. *suberosa*, is distinguished chiefly by the thick deeply fissured bark with which its branches are covered. There are numerous cultivated forms differing in size and shape of leaf, and manner of growth.

The Scotch or wych elm, *U. montana*, is indigenous to Britain and is the common elm of the northern portion of the island; it usually attains a height of about 50 ft., but among tall-growing trees may reach 120 ft. It has drooping branches and a smoother and thinner bark, larger and more tapering leaves, and a far less deeply notched seed-vessel than *U. campestris*. The wood, though more porous than in that species, is a tough and hard material when properly seasoned, and, being very flexible when steamed, is well adapted for boat-building. Branches of the wych elm were formerly manufactured into bows, and if forked were employed as divining-rods. The weeping elm, the most ornamental member of the genus, is a variety of this species. The Dutch or sand elm is a tree very similar to the wych elm, but produces inferior timber. The American or white elm, *U. americana*, is a hardy and very handsome species, of which the old tree on Boston (Mass.) Common was a representative. This tree is supposed to have been in existence before the settlement of Boston, and at the time of its destruction by the storm of the 15th of February 1876 measured 22 ft. in circumference.

ELMACIN (Elmakin or Elmacinus), **GEORGE** (*c.* 1223-1274), author of a history of the Saracens, which extends from the time of Mahomet to the year 1118 of our era. He was a Christian of Egypt, where he was born; is known in the east as Ibn-Amid; and after holding an official position under the sultans of Egypt, died at Damascus. His history is principally occupied with the affairs of the Saracen empire, but it contains passages which relate to the Eastern Christians. It was published in Arabic and Latin at Leiden in 1625. The Latin version is a translation by Erpenius, under the title, *Historia saracenica*, and from this a French translation was made by Wattier as *L'Histoire mahométane* (Paris, 1657).

ELMALI ("apple-town"), a small town of Asia Minor in the vilayet of Konia, the present administrative centre of the ancient Lycia, but not itself corresponding to any known ancient city. It lies about 25 m. inland, at the head of a long upland valley (5000 ft.) inhabited by direct descendants of the ancient Lycians, who have preserved a distinctive facial type, noticeable at once in the town population. There are about fifty Greek families, the rest of the population (4000) being Moslem. The district is agricultural and has no manufactures of importance.

ELMES, HARVEY LONSDALE (1813-1847), British architect, son of James Elmes (*q.v.*), was born at Chichester in 1813. After serving some time in his father's office, and under a surveyor at Bedford and an architect at Bath, he became partner with his father in 1835, and in the following year he was successful among 86 competitors for a design for St George's Hall, Liverpool. The foundation stone of this building was laid en the 28th of June 1838, but, Elmes being successful in a competition for the Assize Courts in the same city, it was finally decided to include the hall and courts in a single building.

In accordance with this idea, Elmes prepared a fresh design, and the work of erection commenced in 1841. He superintended its progress till 1847, when from failing health he was compelled to delegate his duties to Charles Robert Cockerell, and leave for Jamaica, where he died of consumption on the 26th of November 1847.

ELMES, JAMES (1782-1862), British architect, civil engineer, and writer on the arts, was born in London on the 15th of October 1782. He was educated at Merchant Taylors’ school, and, after studying building under his father, and architecture under George Gibson, became a student at the Royal Academy, where he gained the silver medal in 1804. He designed a large number of buildings in the metropolis, and was surveyor and civil engineer to the port of London, but is best known as a writer on the arts. In 1809 he became vice-president of the Royal Architectural Society, but this office, as well as that of surveyor of the port of London, he was compelled through partial loss of sight to resign in 1828. He died at Greenwich on the 2nd of April 1862. His publications were:—*Sir Christopher Wren and his Times* (1823); *Lectures on Architecture* (1823); *The Arts and Artists* (1825); *General and Biographical Dictionary of the Fine Arts* (1826); *Treatise on Architectural Jurisprudence* (1827), and *Thomas Clarkson: a Monograph* (1854).

ELMHAM, THOMAS (d. *c.* 1420), English chronicler, was probably born at North Elmham in Norfolk. He became a Benedictine monk at Canterbury, and then joining the Cluniacs, was prior of Lenton Abbey, near Nottingham; he was chaplain to Henry V., whom he accompanied to France in 1415, being present at Agincourt. Elmham wrote a history of the monastery of St Augustine at 297
Canterbury, which has been edited by C. Hardwick for the Rolls Series (1858); and a *Liber metricus de Henrico V.*, edited by C.A. Cole in the *Memorials of Henry V.* (1858). It is very probable that Elmham wrote the famous *Gesta Henrici Quinti*, which is the best authority for the life of Henry V. from his accession to 1416. This work, often referred to as the “chaplain’s life,” and thought by some to have been written by Jean de Bordin, has been published for the English Historical Society by B. Williams (1850). Elmham, however, did not write the *Vita et Gesta Henrici V.*, which was attributed to him by T. Hearne and others.

See C.L. Kingsford, *Henry V.* (1901).

ELMINA, a town on the Gold Coast, British West Africa, in 5° 4′ N., 1° 20′ W. and about 8 m. W. of Cape Coast. Pop. about 4000. Facing the Atlantic on a rocky peninsula is Fort St George, considered the finest fort on the Guinea coast. It is built square with high walls, and has accommodation for 200 soldiers. On the land side were formerly two moats, cut in the rock on which the castle stands. The castle is the residence of the commissioner of the district and other officials. The houses in the native quarter are mostly built of stone, that material being plentiful in the vicinity.

Elmina is the earliest European settlement on the Gold Coast, and was visited by the Portuguese in 1481. Christopher Columbus is believed to have been one of the officers who took part in this voyage. The Portuguese at once began to build the castle now known as Fort St George, but it was not completed till eighty years afterwards. Another defensive work is Fort St Jago, built in 1666, which is behind the town and at some distance from the coast. (In the latter half of the 19th century it was converted into a prison.) Elmina was captured by the Dutch in 1637, and ceded to them by treaty in 1640. They made it the chief port for the produce of Ashanti. With the other Dutch possessions on the Guinea coast, it was transferred to Great Britain in April 1872. The king of Ashanti, claiming to be ground landlord, objected to its transfer, and the result was the Ashanti war of 1873-1874. For many years the greatest output of gold from this coast came from Elmina. The annual export is said to have been nearly £3,000,000 in the early years of the 18th century, but the figure is probably exaggerated. Since 1900 the bulk of the export trade in gold has been transferred to Sekondi (*q.v.*). Prempeh, the ex-king of Ashanti, was detained in the castle (1896) until his removal to the Seychelles. (See Ashanti: *History*, and Gold Coast: *History*.)

ELMIRA, a city and the county-seat of Chemung county, New York, U.S.A., 100 m. S.E. of Rochester, on the Chemung river, about 850 ft. above sea-level. Pop. (1890) 30,893; (1900) 35,672, of whom 5511 were foreign-born (1988 Irish and 1208 German); (1910 census) 37,176. It is served by the Erie, the Pennsylvania, the Delaware, Lackawanna & Western, the Lehigh Valley, and the Tioga Division railways, the last of which connects it with the Pennsylvania coalfields 48 m. away. The city is attractively situated on both sides of the river, and has a fine water-supply and park system, among the parks being Eldridge, Rorick's Glen, Riverside, Brand, Diven, Grove, Maple Avenue and Wisner; in the last-named is a statue of Thomas K. Beecher by J.S. Hartley. The city contains a Federal building, a state armoury, the Chemung county court house and other county buildings, the Elmira orphans' home, the Steele memorial library, home for the aged, the Arnot-Ogden memorial hospital, the Elmira free academy, and the Railway Commercial training school. Here, also, is Elmira College (Presbyterian) for women, founded in 1855. This institution, chartered in 1852 as Auburn Female University and then situated in Auburn, was rechartered in 1855 as the Elmira Female College; it was established largely through the influence and persistent efforts of the Rev. Samuel Robbins Brown (1810-1880) and his associates, notably Simeon Benjamin of Elmira, who gave generously to the newly founded college, and was the first distinctively collegiate institution for women in the United States, and the first, apparently, to grant degrees to women. The most widely known institution in the city is the Elmira reformatory, a state prison for first offenders between the ages of sixteen and thirty, on a system of general indeterminate sentences. Authorized by the state legislature in 1866 and opened in 1876 under the direction of Zebulon Reed Brockway (b. 1827), it was the first institution of the sort and has served as a model for many similar institutions both in the United States and in other countries (see Juvenile Offenders). Elmira is an important railway centre, with large repair shops, and has also extensive manufactories (value of production in 1900, $8,558,786, of which $6,596,603 was produced under the "factory system"; in 1905, under the "factory system," $6,984,095), including boot and shoe factories, a large factory for fire-extinguishing apparatus, iron and steel bridge works, steel rolling mills, large valve works, steel plate mills, knitting mills, furniture, glass and boiler factories, breweries and silk mills. Near the site of Elmira occurred on the 29th of August 1779 the battle of Newtown, in which General John Sullivan decisively defeated a force of Indians and Tories under Sir John Johnson and Joseph Brant. There were some settlers here at the close of the War of Independence, but no permanent settlement was made until 1788. The village was incorporated as Newtown in 1815, and was reincorporated as Elmira in 1828. A city charter was secured in 1864. In 1861 a state military camp was established here, and in 1864-1865 there was a prison camp here for Confederate soldiers.

ELMSHORN, a town of Germany, in the Prussian province of Schleswig-Holstein, on the Krückau, 19 m. by rail N.W. from Altona. Pop. (1905) 13,640. Its industries include weaving, dyeing, brewing, iron-founding and the manufacture of leather goods, boots and shoes and machines. There is a considerable shipping trade.

ELMSLEY, PETER (1773-1825), English classical scholar. He was educated at Westminster and Christ Church, Oxford, and having inherited a fortune from his uncle, a well-known bookseller, devoted himself to the study of classical authors and manuscripts. In 1798 he was appointed to the chapelry of Little Horkesley in Essex, which he held till his death. He travelled extensively in France and Italy, and spent the winter of 1818 in examining the MSS. in the Laurentian library at Florence. In 1819 he was commissioned, with Sir Humphry Davy, to decipher the papyri found at Herculaneum, but the results proved insignificant. In 1823 he was appointed principal of St Alban's Hall, Oxford, and Camden professor of ancient history. He died in Oxford on the 8th of March 1825. Elmsley was a man of most extensive learning and European reputation, and was considered to be the best ecclesiastical scholar in England. But it is chiefly by his collation of the MSS. of the Greek tragedians and his critical labours on the restoration of their text that he will be remembered. He edited the *Acharnians* of Aristophanes, and several of the plays and scholia of Sophocles and Euripides. He was the first to recognize the importance of the Laurentian MS. (see Sandys, *Hist. of Class. Schol.* iii. (1908).

ELNE, a town of south-western France in the department of Pyrénées-Orientales, 10 m. S.S.E. of Perpignan by rail. Pop. (1906) 3026. The hill on which it stands, once washed by the sea, which is now over 3 m. distant, commands a fine view over the plain of Roussillon. From the 6th century till 1602 the town was the seat of a bishopric, which was transferred to Perpignan. The cathedral of St Eulalie, a Romanesque building completed about the beginning of the 12th century, has a beautiful cloister in the same style, with interesting sculptures and three early Christian sarcophagi. Remains of the ancient ramparts flanked by towers are still to be seen. Silk-worm cultivation is carried on. Elne, the ancient *Illiberis*, was named *Helena* by the emperor Constantine in memory of his mother. Hannibal encamped under its walls on his march to Rome in 218 B.C. The emperor Constans was assassinated there in A.D. 350. The town several times sustained siege and capture between its occupation by the Moors in the 8th century and its capitulation in 1641 to the troops of Louis XIII.

EL OBEID, chief town of the mudiria (province) of Kordofan, Anglo-Egyptian Sudan, and 230 m. S.W. by S. of Khartum in a direct line. Pop. (1905) about 10,000. It is situated about 2000 ft. above the 298
sea, at the northern foot of Jebel Kordofan, in 13° 11′ N. and 30° 14′ E. It is an important trade centre, the chief articles of commerce being gum, ivory, cattle and ostrich feathers. A considerable part of the trade of Darfur with Egypt passes through El Obeid.

El Obeid, which appears to be a place of considerable antiquity and the ancient capital of the country, was garrisoned by the Egyptians on their conquest of Kordofan in 1821. In September 1882 the town was assaulted by the troops of the mahdi, who, being repulsed, laid siege to the place, which capitulated on the 17th of January 1883. During the Mahdia the city was destroyed and deserted, and when Kordofan passed, in 1899, into the possession of the Anglo-Egyptian authorities nothing was left of El Obeid but a part of the old government offices. A new town was laid out in squares, the mudiria repaired and barracks built. (See Kordofan, and Sudan: *Anglo-Egyptian*.)

ELOI [Eligius], **SAINT** (588-659), apostle of the Belgians and Frisians, was born at Cadillac, near Limoges, in 588. Having at an early age shown artistic talent he was placed by his parents with the master of the mint at Limoges, where he made rapid progress in goldsmith’s work. He became coiner to Clotaire II., king of the Franks, and treasurer to his successor Dagobert. Both kings entrusted him with important works, among which were the composition of the bas-reliefs which ornament the tomb of St Germain, bishop of Paris, and the execution (for Clotaire) of two chairs of gold, adorned with jewels, which at that time were reckoned *chefs-d’œuvre*. Though he was amassing great wealth, Eloi acquired a distaste for a worldly life, and resolved to become a priest. At first he retired to a monastery, but in 640 was raised to the bishopric of Noyon. He made frequent missionary excursions to the pagans of the Low Countries, and also founded a great many monasteries and churches. He died on the 1st of December 659. A mass of legend has gathered round the life of St Eloi, who as the patron saint of goldsmiths is still very popular.

His life was written by his friend and contemporary St Ouen (Audoenus); French translations of the *Vita S. Eligii auctore Audoeno* were published by L. de Montigny (Paris, 1626), by C. Barthélemy in *Études hist., litt. et art.* (*ib.* 1847), and by Parenty, with notes (2nd ed., *ib.* 1870). For bibliography see Potthast, *Bibliotheca hist. med. aevi* (Berlin, 1896), s.v. “Vita S. Eligii Noviomensis,” and Ulysse Chevalier, *Rép. des sources hist., Bio-bibl.* (Paris, 1894), s. “Eloi.”

ELONGATION, strictly “lengthening”; in astronomy, the apparent angular distance of a heavenly body from its centre of motion, as seen from the earth; designating especially the angular distance of the planet Mercury or Venus from the sun, or the apparent angle between a satellite and its primary. The greatest elongation of Venus is about 45°; that of Mercury generally ranges between 18° and 27°.

EL PASO, a city, port of entry, and the county-seat of El Paso county, Texas, U.S.A., on the E. bank of the Rio Grande, in the extreme W. part of the state, at an altitude of 3710 ft. Pop. (1880) 736; (1890) 10,338; (1900) 15,906, of whom 6309 were foreign-born and 466 were negroes; (1910 census) 39,279. Many of the inhabitants are of Mexican descent. El Paso is an important railway centre and is served by the following railways: the Atchison, Topeka & Santa Fé, of which it is the S. terminus; the

El Paso & South-Western, which connects with the Chicago, Rock Island & El Paso (of the Rock Island system); the Galveston, Harrisburg & San Antonio, of which it is the W. terminus; the Mexican Central, of which it is the N. terminus; the Texas & Pacific, of which it is the W. terminus; a branch of the Southern Pacific, of which it is the E. terminus; and the short Rio Grande, Sierra Madre & Pacific, of which it is the N. terminus. The city is regularly laid out on level bottom lands, stretching to the table-lands and slopes to the N.E. and N.W. of the city. Opposite, on the W. bank of the river, is the Mexican town of Ciudad Juarez (until 1885 known as Paso del Norte), with which El Paso is connected by bridges and by electric railway. The climate is mild, warm and dry, El Paso being well known as a health resort, particularly for sufferers from pulmonary complaints. Among the city’s public buildings are a handsome Federal building, a county court house, a city hall, a Y.M.C.A. building, a public library, a sanatorium for consumptives, and the Hotel Dieu, a hospital maintained by Roman Catholics. El Paso is the seat of St Joseph’s Academy and of the El Paso Military Institute. Three miles E. of the city limits is Fort Bliss, a U.S. military post, with a reservation of about 2 sq. m. El Paso’s situation on the Mexican frontier gives it a large trade with Mexico; it is the port of entry of the Paso del Norte customs district, one of the larger Mexican border districts, and in 1908 its imports were valued at $2,677,784 and its exports at $5,661,901. Wheat, boots and shoes, mining machinery, cement, lime, lumber, beer, and denatured alcohol are among the varied exports; the principal imports are ore, sugar, cigars, oranges, drawn work and Mexican curios. El Paso has extensive manufactories, especially railway car shops, which in 1905 employed 34.5% of the factory wage-earners. Just outside the city limits are important lead smelting works, to which are brought ores for treatment from western Texas, northern Mexico, New Mexico and Arizona. Among the city’s manufactures are cement, denatured alcohol, ether, varnish, clothing and canned goods. The value of the city’s total factory product in 1905 was $2,377,813, 96% greater than that in 1900. El Paso lies in a fertile agricultural valley, and in 1908 the erection of an immense dam was begun near Engle, New Mexico (100 m. above El Paso), by the U.S. government, to store the flood waters of the Rio Grande for irrigating this area. Before the Mexican War, following which the first United States settlement was made, the site of El Paso was known as Ponce de Leon Ranch, the land being owned by the Ponce de Leon family. El Paso was first chartered as a city in 1873, and in 1907 adopted the commission form of government.

ELPHINSTONE, MOUNTSTUART (1779-1859), Indian statesman and historian, fourth son of the 11th Baron Elphinstone in the peerage of Scotland, was born in 1779. Having received an appointment in the civil service of the East India Company, of which one of his uncles was a director, he reached Calcutta in the beginning of 1796. After filling several subordinate posts, he was appointed in 1801 assistant to the British resident at Poona, at the court of the peshwa, the most powerful of the Mahratta princes. Here he obtained his first opportunity of distinction, being attached in the capacity of diplomatist to the mission of Sir Arthur Wellesley to the Mahrattas. When, on the failure of negotiations, war broke out, Elphinstone, though a civilian, acted as virtual aide-de-camp to General Wellesley. He was present at the battle of Assaye, and displayed such courage and knowledge of tactics throughout the whole campaign that Wellesley told him he had mistaken his profession, and that he ought to have been a soldier. In 1804, when the war closed, he was appointed British resident at Nagpur. Here, the times being uneventful and his duties light, he occupied much of his leisure in reading classical and general literature, and acquired those studious habits which clung to him throughout life. In 1808 he was appointed the first British envoy to the court of Kabul, with the object of securing a friendly alliance with the Afghans; but this proved of little value, because Shah Shuja was driven from the throne by his brother before it could be ratified. The most valuable permanent result of the embassy was the literary fruit it bore several years afterwards in Elphinstone’s great work on Kabul. After spending about a year in Calcutta arranging the report of his mission, Elphinstone was appointed in 1811 to the important and difficult post of resident at Poona. The difficulty arose from the general complication of Mahratta politics, and especially from the weak and treacherous character of the peshwa, which Elphinstone rightly read from the first. While the mask of friendship was kept up Elphinstone carried out the only suitable policy, that of vigilant quiescence, with admirable tact and patience; when in 1817 the mask was thrown aside and the peshwa ventured to declare war, the English resident proved for the second time the truth of Wellesley’s assertion that he was born a soldier. Though his own account of his share in the campaign is characteristically modest, one can gather from it that the success of the British troops was chiefly owing to his 299
assuming the command at an important crisis during the battle of Kirkee.

The peshwa being driven from his throne, his territories were annexed to the British dominions, and Elphinstone was nominated commissioner to administer them. He discharged the responsible task with rare judgment and ability. In 1819 he was appointed lieutenant-governor of Bombay and held this post till 1827, his principal achievement being the compilation of the “Elphinstone code.” He may fairly be regarded as the founder of the system of state education in India, and he probably did more than any other Indian administrator to further every likely scheme for the promotion of native education. His connexion with the Bombay presidency was appropriately commemorated in the endowment of the Elphinstone College by the native communities, and in the erection of a marble statue by the European inhabitants.

Returning to England in 1829, after an interval of two years' travel, Elphinstone retained in his retirement and enfeebled health an important influence on public affairs. He twice refused the offer of the governor-generalship of India. Long before his return he had made his reputation as an author by his *Account of the Kingdom of Cabul and its Dependencies in Persia and India* (1815). Soon after his arrival in England he commenced the preparation of a work of wider scope, a history of India, which was published in 1841. It embraces the Hindu and Mahommedan periods, and is still a work of high authority. He died on the 20th of November 1859.

See J.S. Cotton, *Mountstuart Elphinstone* ("Rulers of India" series), (1892); T.E. Colebrooke, *Life of Mountstuart Elphinstone* (1884); and G.W. Forrest, *Official Writings of Mountstuart Elphinstone* (1884).

ELPHINSTONE, WILLIAM (1431-1514), Scottish statesman and prelate, founder of the university of Aberdeen, was born in Glasgow, and educated at the university of his native city, taking the degree of M.A. in 1452. After practising for a short time as a lawyer in the church courts, he was ordained priest, becoming rector of St Michael's church, Trongate, Glasgow, in 1465. Four years later he went to continue his studies at the university of Paris, where he became reader in canon law, and then, proceeding to Orleans, became lecturer in the university there. Before 1474 he had returned to Scotland, and was made rector of the university, and official of the see of Glasgow. Further promotion followed, but soon more important duties were entrusted to Elphinstone, who was made bishop of Ross in 1481. He was a member of the Scots parliament, and was sent by King James III. on diplomatic errands to Louis XI. of France, and to Edward IV. of England; in 1483 he was appointed bishop of Aberdeen, although his consecration was delayed for four years; and he was sent on missions to England, both before and after the death of Richard III. in 1485. Although he attended the meetings of parliament with great regularity he did not neglect his episcopal duties, and the fabric of the cathedral of Aberdeen owes much to his care. Early in 1488 the bishop was made lord high chancellor, but on the king's death in the following June he vacated this office, and retired to Aberdeen. As a diplomatist of repute, however, his services were quickly required by the new king, James IV., in whose interests he visited the kings of England and France, and the German king, Maximilian I. Having been made keeper of the privy seal in 1492, and having arranged a dispute between the Scotch and the Dutch, the bishop's concluding years were mainly spent in the foundation of the university of Aberdeen. The papal bull for this purpose was obtained in 1494, and the royal charter which made old Aberdeen the seat of a university is dated 1498. A small endowment was provided by the king, and the university, modelled on that of Paris and intended principally to be a school of law, soon became the most famous and popular of the Scots seats of learning, a result which was largely due to the wide experience and ripe wisdom of Elphinstone and of his friend, Hector Boece, the first rector. The building of the college of the Holy Virgin in Nativity, now King's College, was completed in 1506, and the bishop also rebuilt the choir of his cathedral, and built a bridge over the Dee. Continuing to participate in public affairs he opposed the policy of hostility towards England which led to the disaster at Flodden in September 1513, and died in Edinburgh on the 25th of October 1514. Elphinstone was partly responsible for the introduction of printing into Scotland, and for the production of the *Breviarium Aberdonense*. He may have written some of the lives in this collection, and gathered together materials concerning the history of Scotland; but he did not, as some have thought, continue the *Scotichronicon*, nor did he write the *Lives of Scottish Saints*.

See Hector Boece, *Murthlacensium et Aberdonensium episcoporum vitae*, edited and translated by J. Moir (Aberdeen, 1894); *Fasti Aberdonenses*, edited by C. Innes (Aberdeen, 1854); and A. Gardyne, *Theatre of Scottish Worthies and Lyf of W. Elphinston*, edited by D. Laing (Aberdeen, 1878).

EL RENO, a city and the county-seat of Canadian county, Oklahoma, U.S.A., on the N. fork of the Canadian river, about 26 m. W. of Oklahoma City. Pop. (1890) 285; (1900) 3383; (1907) 5370 (401 were of negro descent and 7 were Indians); (1910) 7872. It is served by the Chicago, Rock Island & Pacific, the Choctaw, Oklahoma & Gulf (owned by the Chicago, Rock Island & Pacific), and the St Louis, El Reno & Western railways, the last extending from El Reno to Guthrie. El Reno lies on the rolling prairie lands, about 1360 ft. above the sea, in an Indian corn, wheat, oats and cotton-producing and dairying region, and has a large grain elevator, a cotton compress, and various manufacturing establishments, among the products being flour, canned goods and crockery. El Reno has a Carnegie library, and within the city's limits is Bellamy's Lake (180 acres), a favourite resort. Near the city is a Government boarding school for the Indians of the Cheyenne and the Arapahoe Reservation. Fort Reno, a U.S. military post, was established near El Reno in 1876, and in 1908 became a supply depot of the quartermaster's department under the name of "Fort Reno Remount Depot." The first settlement here, apart from the fort, was made in the autumn of 1889; in 1892 El Reno received a city charter.

ELSFLETH, a maritime town of Germany, in the grand-duchy of Oldenburg, in a fertile district at the confluence of the Hunte with the Weser, on the railway Hude-Nordenham. Pop. 2000. It has an Evangelical church, a school of navigation, a harbour and docks. It has considerable trade in corn and timber and is one of the centres of the North Sea herring fishery.

ELSINORE (Dan. *Helsingör*), a seaport of Denmark in the *amt* (county) of Frederiksborg, on the east coast of the island of Zealand, 28 m. N. of Copenhagen by rail. Pop. (1901) 13,902. It stands at the narrowest part of the Sound, opposite the Swedish town of Helsingborg, 3 m. distant. Communication is maintained by means of a steam ferry. Its harbour admits vessels of 20 ft. draught, and the roadstead affords excellent anchorage. There are shipbuilding yards, with foundry, engineering shops, &c.; the chief export is agricultural produce; imports, iron, coal, cereals and yarn. Helsingör received town-privileges in 1425. In 1522 it was taken and burnt by Lübeck, but in 1535 was retaken by Christian II. It is celebrated as the Elsinore of Shakespeare's tragedy of *Hamlet*, and was the birthplace of Saxo Grammaticus, from whose history the story of Hamlet is derived. A pile of rocks surrounded by trees is shown as the grave of Hamlet, and Ophelia's brook is also pointed out, but both are, of course, inventions. On a tongue of land east of the town stands the castle of Kronberg or Kronenberg, a magnificent, solid and venerable Gothic structure built by Frederick II. towards the end of the 16th century, and extensively restored by Christian IV. after a fire in 1637. It was taken by the Swedes in 1658, but its possession was again given up to the Danes in 1660. From its turrets, one of which serves as a lighthouse, there are fine views of the straits and of the neighbouring countries. The Flag Battery is the "platform before the castle" where the ghost appears in *Hamlet*. Within it the principal object of interest is the apartment in which Matilda, queen of Christian VII. and sister of George III. of England, was imprisoned before she was taken to Hanover. The chapel contains fine wood-carving of the 17th century. North-west of the town is Marienlyst, originally a royal château, but 300
now a seaside resort.

ELSSLER, FANNY (1810-1884), Austrian dancer, was born in Vienna on the 23rd of June 1810. From her earliest years she was trained for the ballet, and made her appearance at the Kärntner-Thor theatre in Vienna before she was seven. She almost invariably danced with her sister Theresa, who was two years her senior; and, after some years' experience together in Vienna, the two went in 1827 to Naples. Their success there—to which Fanny contributed more largely than her sister, who used to efface herself in order to heighten the effect of Fanny's more brilliant powers—led to an engagement in Berlin in 1830. This was the beginning of a series of triumphs for Fanny's personal beauty and skill in dancing. After captivating all hearts in Berlin and Vienna, and inspiring the aged statesman Friedrich von Gentz (*q.v.*) with a remarkable passion, she paid a visit to London, where she received much kindness at the hands of Mr and Mrs Grote, who practically adopted the little girl who was born three months after the mother's arrival in England. In September 1834 Fanny Elssler appeared at the Opera in Paris, a step to which she looked forward with much misgiving on account of Taglioni's supremacy on that stage. The result, however, was another triumph for her, and the temporary eclipse of Taglioni, who, although the finer artist of the two, could not for the moment compete with the newcomer's personal fascination. It was conspicuously in her performance of the Spanish *cachuca* that Fanny Elssler outshone all rivals. In 1840 she sailed with her sister for New York, and after two years' unmixed success they returned to Europe, where during the following five years Fanny appeared in Germany, Austria, France, England and Russia. In 1845, having amassed a fortune, she retired from the stage and settled near Hamburg. A few years later her sister Theresa contracted a morganatic marriage with Prince Adalbert of Prussia, and was ennobled under the title of Baroness von Barnim. Fanny Elssler died at Vienna on the 27th of November 1884. Theresa was left a widow in 1873, and died on the 19th of November 1878.

ELSTER, the name of two rivers of Germany. (1) The Schwarze (Black) Elster rises in the Lausitz range, on the southern border of Saxony, flows N. and N.W., and after a course of 112 m. enters the Elbe a little above Wittenberg. It is a sluggish stream, winding its way through sandy soil and frequently along a divided channel. (2) The Weisse (White) Elster rises in the north-western corner of Bohemia, a little north of Eger, cuts through the Vogtland in a deep and picturesque valley, passing Plauen, Greiz, Gera and Zeitz on its way north to Leipzig, just below which city it receives its most important tributary, the Pleisse. At Leipzig it divides, the main stream turning north-west and entering the Saale from the right a little above Halle; the other arm, the Luppe, flowing parallel to the main stream and south of it enters the Saale below Merseburg. Total length, 121 m.; total descent, 1286 ft.

ELSTER, a spa and inland watering-place of Germany, in the kingdom of Saxony, on the Weisse Elster, close to the Bohemian frontier on the railway Plauen-Eger, and 20 m. S. of the former. It has some industries of lace-making and weaving, and a population of about 2000, in addition to visitors. The mineral springs, saline-chalybeate, specific in cases of nervous disorders and feminine ailments, have been lately supplemented by baths of various kinds, and these, together with the natural attractions of the place as a climatic health resort, have combined to make it a fashionable watering-place during the summer season. The number of visitors amounts annually to about 10,000.

See Flechsig, *Bad Elster* (Leipzig, 1884).

ELSWICK, a ward of the city of Newcastle-upon-Tyne, England, in the western part of the borough, bordering the river Tyne. The name is well known in connexion with the great ordnance and naval works of Sir W.G. Armstrong, Mitchell & Co. Elswick Park, attached to the old mansion of the same name, is now a public recreation ground.

EL TEB, a halting-place in the Anglo-Egyptian Sudan near the coast of the Red Sea, 9 m. S.W. of the port of Trinkitat on the road to Tokar. At El Teb, on the 4th of February 1884, a heterogeneous force under General Valentine Baker, marching to the relief of the Egyptian garrison of Tokar, was completely routed by the Mahdists (see Egypt: *Military Operations*).

ELTON, CHARLES ISAAC (1839-1900), English lawyer and antiquary, was born at Southampton on the 6th of December 1839. Educated at Cheltenham and Balliol College, Oxford, he was elected a fellow of Queen’s College in 1862. He was called to the bar at Lincoln’s Inn in 1865. His remarkable knowledge of old real property law and custom helped him to an extensive conveyancing practice and he took silk in 1885. He sat in the House of Commons for West Somerset in 1884-1885 and from 1886 to 1892. In 1869 he succeeded to his uncle’s property of Whitestaunton, near Chard, in Somerset. During the later years of his life he retired to a great extent from legal practice, and devoted much of his time to literary work. He died at Whitestaunton on the 23rd of April 1900. Elton’s principal works were *The Tenures of Kent* (1867); *Treatise on Commons and Waste Lands* (1868); *Law of Copyholds* (1874); *Origins of English History* (1882); *Custom and Tenant Right* (1882).

ELTVILLE (Elfeld), a town of Germany, in the Prussian province of Hesse-Nassau, on the right bank of the Rhine, 5 m. S.W. from Wiesbaden, on the railway Frankfort-on-Main-Cologne, and with a branch to Schlangenbad. Pop. 3700. It has a Roman Catholic and a Protestant church, ruins of a feudal castle, a Latin school, and a monument to Gutenberg. It has a considerable trade in the wines of the district and two manufactories of sparkling wines. Eltville (originally *Adeldvile*, Lat. *Altavilla*) is first mentioned in a record of the year 882. It was given by the emperor Otto I. to the archbishops of Mainz, who often resided here. It received town rights in 1331 and was a place of importance during the middle ages. In 1465 Gutenberg set up his press at Eltville, under the patronage of Archbishop Adolphus of Nassau, shortly afterwards handing over its use to the brothers Heinrich and Nikolaus Bechtermünz. Several costly early examples of printed books issued by this press survive, the earliest being the *Vocabularium Latino-Teutonicum*, first printed in 1467.

ELTZ, a small river of Germany, a left bank tributary of the Mosel. It rises in the Eifel range, and, after a course of 5 m., joins the latter river at Moselkern. Just above its confluence stands the romantic castle of Eltz, crowning a rocky summit 900 ft. high, and famous as being one of the best preserved medieval strongholds of Germany. It is the ancestral seat of the counts of Eltz and contains numerous antiquities.

See Roth, *Geschichte der Herren und Grafen zu Eltz* (2 vols., Mainz, 1889-1890).

ELVAS, an episcopal city and frontier fortress of Portugal, in the district of Portalegre and formerly included in the province of Alemtejo; 170 m. E. of Lisbon, and 10 m. W. of the Spanish fortress of Badajoz, by the Madrid-Badajoz-Lisbon railway. Pop. (1900) 13,981. Elvas is finely situated on a hill 5 m. N.W. of the river Guadiana. It is defended by seven bastions and the two forts of Santa Luzia and Nossa Senhora da Graça. Its late Gothic cathedral, which has also many traces of Moorish influence in its architecture, dates from the reign of Emmanuel I. (1495-1521). A fine aqueduct, 4 m. long, supplies the city with pure water; it was begun early in the 15th century and completed in 1622. For some distance it includes four tiers of superimposed arches, with a total height of 120 ft. The surrounding lowlands are very fertile, and Elvas is celebrated for its excellent olives and plums, the last-named being exported, either fresh or dried, in large quantities. Brandy is distilled and pottery manufactured in the city. The fortress of Campo Maior, 10 m. N.E., is famous for its siege by the French and relief by the British under Marshal Beresford in 1811—an exploit commemorated in a ballad by Sir Walter Scott.

Elvas is the Roman *Alpesa* or *Helvas*, the Moorish *Balesh*, the Spanish *Yelves*. It was wrested from the Moors by Alphonso VIII. of Castile in 1166; but was temporarily recaptured before its final occupation by the Portuguese in 1226. In 1570 it became an episcopal see. From 1642 until modern times it was the chief frontier fortress S. of the Tagus; and it twice withstood sieges by the Spanish, in 1658 and 1711. The French under Marshal Junot took it in March 1808, but evacuated it in August, after the conclusion of the convention of Cintra (see Peninsular War). 301

ELVEY, SIR GEORGE JOB (1816-1893), English organist and composer, was born at Canterbury on the 27th of March 1816. He was a chorister at Canterbury cathedral under Highmore Skeats, the organist. Subsequently he became a pupil of his elder brother, Stephen, and then studied at the Royal Academy of Music under Cipriani Potter and Dr Crotch. In 1834 he gained the Gresham prize medal for his anthem, “Bow down thine ear,” and in 1835 was appointed organist of St George’s chapel, Windsor, a post he filled for 47 years, retiring in 1882. He took the degree of Mus. B. at Oxford in 1838, and in 1840 that of Mus. D. Anthems of his were commissioned for the Three Choirs Festivals of 1853 and 1857, and in 1871 he received the honour of knighthood. He died at Windlesham in Surrey on the 9th of December 1893. His works, which are nearly all for the Church, include two oratorios, a great number of anthems and services, and some pieces for the organ. A memoir of him, by his widow, was published in 1894.

ELVIRA, SYNOD OF, an ecclesiastical synod held in Spain, the date of which cannot be determined with exactness. The solution of the question hinges upon the interpretation of the canons, that is, upon whether they are to be taken as reflecting a recent, or as pointing to an imminent, persecution.

Thus some argue for a date between 300 and 303, *i.e.* before the Diocletian persecution; others for a date between 303 and 314, after the persecution, but before the synod of Arles; still others for a date between the synod of Arles and the council of Nicaea, 325. Mansi, Hardouin, Hefele and Dale are in substantial agreement upon 305 or 306, and this is probably the closest approximation possible in the present state of the evidence. The place of meeting, Elvira, was not far from the modern Granada, if not, as Dale thinks, actually identical with it. There the nineteen bishops and twenty-four presbyters, from all parts of Spain, but chiefly from the south, assembled, probably at the instigation of Hosius of Cordova, but under the presidency of Felix of Accis, with a view to restoring order and discipline in the church. The eighty-one canons which were adopted reflect with considerable fulness the internal life and external relations of the Spanish Church of the 4th century. The social environment of Christians may be inferred from the canons prohibiting marriage and other intercourse with Jews, pagans and heretics, closing the offices of *flamen* and *duumvir* to Christians, forbidding all contact with idolatry and likewise participation in pagan festivals and public games. The state of morals is mirrored in the canons denouncing prevalent vices. The canons respecting the clergy exhibit the clergy as already a special class with peculiar privileges, a more exacting moral standard, heavier penalties for delinquency. The bishop has acquired control of the sacraments, presbyters and deacons acting only under his orders; the episcopate appears as a unit, bishops being bound to respect one another’s disciplinary decrees. Worthy of special note are canon 33, enjoining celibacy upon all clerics and all who minister at the altar (the most ancient canon of celibacy); canon 36, forbidding pictures in churches; canon 38, permitting lay baptism under certain conditions; and canon 53, forbidding one bishop to restore a person excommunicated by another.

See Mansi ii. pp. 1-406; Hardouin i. pp. 247-258; Hefele (2nd ed.) i. pp. 148 sqq. (English translation, i. pp. 131 sqq.); Dale, *The Synod of Elvira* (London, 1882); and Hennecke, in Herzog-Hauck, *Realencyklopädie* (3rd ed.), s.v. “Elvira,” especially bibliography.

(T. F. C.)

EL WAD, a town in the Algerian Sahara, 125 m. in a straight line S.S.E. of Biskra, and 190 m. W. by S. of Gabes. Pop. (1906) 7586. El Wad is one of the most interesting places in Algeria. It is surrounded by huge hollows containing noble palm groves; and beyond these on every side stretches the limitless desert with its great billows of sand, the encroachments of which on the oasis are only held at bay by ceaseless toil. The town itself consists of a mass of one-storeyed stone houses, each surmounted by a little dome, clustering round the market-place with its mosque and minaret. By an exception rare in Saharan settlements, there are no defensive works save the fort containing the government offices, which the French have built on the south side of the town. The inhabitants are of two distinct tribes, one, the Aduan, of Berber stock, the other a branch of the Sha`ambah Arabs. El Wad possesses a curious currency known as *flous*, consisting of obsolete copper coins of Algerian and Tunisian dynasties. Seven flous are regarded as equal to the French five-centime piece.

El Wad oasis is one of a group known collectively as the Suf. Five miles N.W. is Kuinine (pop. 3541) and 6 m. farther N.W. Guemar (pop. 6885), an ancient fortified town noted for its manufacture of carpets. Linen weaving is carried on extensively in the Suf. Administratively El Wad is the capital of an annexe to the territory of Tuggurt.

ELWOOD, a city of Madison county, Indiana, U.S.A., on Duck Creek, about 38 m. N.E. of Indianapolis. Pop. (1880) 751; (1890) 2284; (1900) 12,950 (1386 foreign-born); (1910) 11,028. Elwood is served by the Lake Erie & Western and the Pittsburg, Cincinnati, Chicago & St Louis railways, and by an interurban electric line. Its rapid growth in population and as a manufacturing centre was due largely to its situation in the natural gas region; the failure of the gas supply in 1903 caused a decrease in manufacturing, but the city gradually adjusted itself to new conditions. It has large tin plate mills, iron and steel foundries, saw and planing mills, wooden-ware and furniture factories, bottling works and lamp-chimney factories, flour mills and packing houses. In 1905 the value of the city’s factory product was $6,111,083; in 1900 it was $9,433,513; the glass product was valued at $223,766 in 1905, and at $1,011,803 in 1900. There are extensive brick-yards in the vicinity, and the surrounding agricultural country furnishes large supplies of grain, live-stock, poultry and produce, for which Elwood is the shipping centre. The site was first settled under the name of Quincy; the present name was adopted in 1869; and in 1891 Elwood received a city charter.

ELY, RICHARD THEODORE (1854-), American economist, was born at Ripley, New York, on the 13th of April 1854. Educated at Columbia and Heidelberg universities, he held the professorship of economics at Johns Hopkins University from 1881 to 1892, and was subsequently professor of economics at Wisconsin University. Professor Ely took an active part in the formation of the American Economic Association, was secretary from 1885 to 1892 and president from 1899 to 1901. He published a useful *Introduction to Political Economy* (1889); *Outlines of Economics* (1893); *The Labour Movement in America* (1883); *Problems of To-day* (1888); *Social Aspects of Christianity* (1889); *Socialism and Social Reform* (1894); *Monopolies and Trusts* (1900), and *Studies in the Evolution of Industrial Society* (1903).

ELY, a cathedral city and market-town, in the Newmarket parliamentary division of Cambridgeshire, England, 16 m. N.N.E. of Cambridge by the Great Eastern railway. Pop. of urban district (1901) 7713. It stands on a considerable eminence on the west (left) bank of the Ouse, in the Isle of Ely, which rises above the surrounding fens. Thus its situation, before the great drainage operations of the 17th century, was practically insular. The magnificent cathedral, towering above the town, is a landmark far over the wide surrounding level. The soil in the vicinity is fertile and market-gardening is carried on, fruit and vegetables (especially asparagus) being sent to the London markets. The town has a considerable manufacture of tobacco pipes and earthenware, and there are in the neighbourhood mills for the preparation of oil from flax, hemp and cole-seed. Besides the cathedral Ely has in St Mary’s church, lying almost under the shadow of the greater building, a fine structure ranging in style from Norman to Perpendicular, but in the main Early English. The sessions house and
corn exchange are the principal public buildings. The grammar school, founded by Henry VIII. in 302
1541, occupies (together with other buildings) the room over the gateway of the monastery, known as the Porta, and the chapel built by Prior John de Cranden (1321-1341) is restored to use as a school chapel. A theological college was founded in 1876 and opened in 1881.

The foundation of the present cathedral was laid by its first Norman abbot, Simeon, in 1083. But the reputation of Ely had been established long before Etheldreda (Æthelthryth), daughter of Anna, king of East Anglia, was married to Ecgfrith, king of Northumbria, against her will, as she had vowed herself wholly to a religious life. Her husband opposed himself to her vow, but with the help of Wilfrid, archbishop of York, she took the veil, and found refuge from her husband in the marsh-girt Isle of Ely. Here she founded a religious house, in all probability a mixed community, in 673, becoming its first abbess, and giving the whole Isle of Ely to the foundation. In 870 the monastery was destroyed by the Danes, as were also the neighbouring foundations at Soham, Thorney, Crowland and Peterborough, and it remained in ruins till 970, when Æthelwold, bishop of Winchester, founded a new Benedictine monastery here. King Edgar in 970 endowed the monks with the former possessions of the convent and also granted them the secular causes of two hundreds within and of five hundreds without the marshes, all charges belonging to the king in secular disputes in all their lands and every fourth penny of public revenue in the province of Grantecestre. The wealth and importance of Ely rose, and its abbots held the post of chancellors of the king’s court alternately with the abbots of Glastonbury and of St Augustine’s, Canterbury. But Ely again became a scene of contest in the desperate final struggle against William the Conqueror of which Hereward “the Wake” was the hero. Finally, in 1071, the monks agreed to surrender the Isle of Ely to the king on condition of the confirmation of all the possessions and privileges, held by them in the time of Edward the Confessor. Abbot Simeon (1081-1094), who now began the reconstruction of the church, was related to William and brother to Walkelin, first Norman bishop of Winchester. Under Abbot Richard (1100-1107) the translation from the Saxon church of the bodies of St Etheldreda and of the two abbesses who had followed her, and their enshrinement in the new edifice, took place; and it was due to the honour in which the memory of the foundresses was held that Ely maintained the position of dignity which it kept henceforth until the dissolution of the monasteries. The feast of St Etheldreda, or St Awdrey as she was generally called, was the occasion every year for a large fair here, at which “trifling objects” were sold to pilgrims by way of souvenirs; whence the word “tawdrey,” a contraction of St Awdrey. In 1109 the Isle of Ely, most of Cambridgeshire, and the abbeys of Thorney and Cetricht were separated from the diocese of Lincoln, and converted into a new diocese, Ely being the seat of the bishopric, and after the dissolution of the monasteries Henry VIII. converted the conventual church into a cathedral (1541). The diocese is extensive. It covers nearly the whole of Cambridgeshire, Huntingdonshire and Bedfordshire, part of Suffolk, and small portions of Essex, Norfolk, Northamptonshire, Hertfordshire and Buckinghamshire.

The cathedral is a cruciform structure, 537 ft. long and 190 ft. across the great transepts (exterior measurements). A relic of the Saxon foundation is preserved in the cross of St Osyth (*c.* 670), and a pre-Norman window is kept in the triforium, having been dug up near the cathedral. Of the work of the first two Norman abbots all that remains is the early Norman lower storey of the main transept. The foundations of Abbot Simeon’s apse were discovered below the present choir. The nave, which is Norman throughout, is 208 ft. in length, 72 ft. 9 in. to the top of the walls, and 77 ft. 3 in. broad, including the aisles. The upper parts of the western tower and the transept were begun by Bishop Geoffrey Ridel (d. 1189), and continued by his successor William Longchamp, chancellor of England.

The tower, which is 215 ft. high, is surmounted by a Decorated octagon with partly detached side turrets, and underwent alteration and strengthening in the Perpendicular period. The north-western transept wing is in ruins; it is not known when it fell. The Galilee, or western porch, by which the cathedral is entered, is the work of Bishop Eustace (d. 1215), and is a perfect example of Early English style. In 1322 the Norman central tower, erected by Abbot Simeon, fell. Alan of Walsingham, sacrist of the church, designed its restoration in the form of the present octagon, a beautiful and unique conception. Instead of the ordinary four-arched central crossing, an octagon is formed at the crossing, the arches of the nave aisles and choir aisles being set obliquely. Both without and within, the octagon is the principal feature in the unusual general appearance of the cathedral, which gives it a peculiar eminence among English churches. The octagon was completed in 1328, and upon the ribbed vaulting of wood above it rose the lofty lantern, octagonal also, with its angles set opposite those of the octagon below. The total height of the structure is 170 ft. 7 in. Alan of Walsingham was further employed by Bishop John of Hotham (d. 1337) as architect of the Lady chapel, a beautiful example of Decorated work, which served from 1566 onward as a parish church. Of the seven bays of the choir the four easternmost, as well as the two beyond forming the retrochoir, were built by Bishop Hugh of Northwold (d. 1254). The three western bays were destroyed by the fall of the tower in 1321, and were rebuilt by Alan of Walsingham. The earlier portion is a superb example of Early English work, while the later is perhaps the best example of pure Decorated in England. The wooden canopies of the choir stalls are Decorated (1337) and very elaborate. The Perpendicular style is represented by windows and certain other details, including supporting arches to the western tower. There are also some splendid chantry chapels and tombs in this style—the chapels of Bishop John Alcock (d. 1500) and Bishop Nicolas West (d. 1534), in the north and south choir aisles respectively, are completely covered with the most delicate ornamentation; while the tomb of Bishop Richard Redman (d. 1505) has a remarkably beautiful canopy. Among earlier monuments the canopied tomb of Bishop William de Luda (1290-1298) and the finely-carved effigy of Bishop Northwold (1254) are notable. Between 1845 and 1884 the cathedral underwent restoration under the direction of Sir Gilbert Scott. The work included the erection of the modern reredos and choir-screen, both designed by Scott, and the painting of the nave roof by Styleman le Strange (d. 1862), who was succeeded by Gambier Parry. Parry also richly ornamented the octagon and lantern in the style of the 14th century.

Remains of the monastic buildings are fragmentary but numerous. Mention has been made of the Ely "Porta" or gateway (1396), which is occupied by the grammar school, and of Prior John de Cranden's beautiful little Decorated chapel. But many of the remains, the bulk of which are incorporated in the deanery and canons' and other residences to the south of the cathedral, are of much earlier date. Thus the fine early Norman undercroft of the prior's hall is probably of the time of Abbot Simeon. Another notable fragment is the transitional Norman chancel of the infirmary chapel. The remnants of the cloisters show a reconstruction in the 15th century, but the prior's and monks' doorways from the cloisters into the cathedral are highly decorated late Norman. The bishop's palace to the west of the cathedral has towers erected by Bishop Alcock at the close of the 15th century. In the muniment room of the chapter is preserved, among many ancient documents of great interest, the *liber Eliensis*, a history of the monastery by the monk known as Thomas of Ely (d. *c.* 1174), of which the first part, which extends to the year 960, contains a life of St Etheldreda, while the second is continued to the year 1107.

Ely, which according to Bede (*Hist. eccl.* iv. 19) derives its name from the quantity of eels in the waters about it (A.S. *æl*, eel, *-ig*, island), was a borough by prescription at least as early as the reign of William the Conqueror. It owed its importance entirely to the monastery, and for a long time the abbot and afterwards the bishop had almost absolute power in the town. The bailiff who governed the town was chosen by the bishop until 1850, when a local board was appointed. Richard I. granted the bishop 303
of Ely a fair there, and in 1319-1320 John of Hotham, a later bishop, received licence to hold a fair on the vigil and day of Ascension and for twenty days following. The markets are claimed by an undated charter by the bishop, who also continues to hold the fairs. In 1295 Ely sent two members to parliament, but has never been represented since.

See C.W. Stubbs, *Ely Cathedral* (London, 1897); *Victoria County History, Cambridgeshire.*

ELYOT, SIR THOMAS (*c.* 1490-1546), English diplomatist and scholar. His father, Sir Richard Elyot (d. 1522), who held considerable estates in Wiltshire, was made (1503) serjeant-at-law and attorney-general to the queen consort, and soon afterwards was commissioned to act as justice of assize on the western circuit, becoming in 1513 judge of common pleas. Thomas was the son of his first marriage with Alice Fynderne, but neither the date nor place of his birth is accurately known. Anthony à Wood claimed him as an *alumnus* of St Mary Hall, Oxford, while C.H. Cooper in the *Athenae Cantabrigienses* put in a claim for Jesus College, Cambridge. Elyot himself says in the preface to his *Dictionary* that he was educated under the paternal roof, and was from the age of twelve his own tutor. He supplies, in the introduction to his *Castell of Helth*, a list of the authors he had read in philosophy and medicine, adding that a "worshipful physician" read to him Galen and some other authors. In 1511 he accompanied his father on the western circuit as clerk to the assize, and he held this position until 1528. In addition to his father's lands in Wiltshire and Oxfordshire he inherited in 1523 the Cambridge estates of his cousin, Thomas Fynderne. His title was disputed, but Wolsey decided in his favour, and also made him clerk of the privy council. Elyot, in a letter addressed to Thomas Cromwell, says that he never received the emoluments of this office, while the barren honour of knighthood conferred on him when he was displaced in 1530 merely put him to further expense. In that year he sat on the commission appointed to inquire into the Cambridgeshire estates of his former patron, Cardinal Wolsey. He married Margaret Barrow, who is described (Stapleton, *Vita Thomae Mori*, p. 59, ed. 1558) as a student in the "school" of Sir Thomas More.

In 1531 he produced the *Boke named the Governour*, dedicated to King Henry VIII. The work advanced him in the king's favour, and in the close of the year he received instructions to proceed to the court of the emperor Charles V. to induce him to take a more favourable view of Henry's projected divorce from Catherine of Aragon. With this was combined another commission, on which one of the king's agents, Stephen Vaughan, was already engaged. He was, if possible, to apprehend William Tyndale. It is probable that Elyot was suspected, as Vaughan certainly was, of lukewarmness in carrying out the king's wishes, but this has not prevented his being much abused by Protestant writers. As ambassador Elyot had been involved in ruinous expense, and on his return he wrote to Thomas Cromwell, begging to be excused from serving as sheriff of Cambridgeshire and Huntingdonshire, on the score of his poverty. The request was not granted. He was one of the commissioners in the inquiry instituted by Cromwell prior to the suppression of the monasteries, but he did not obtain any share of the spoils. There is little doubt that his known friendship for Thomas More militated against his chances of success, for in a letter addressed to Cromwell he admitted his friendship for More, but protested that he rated higher his duty to the king. William Roper, in his *Life* of More, says that Elyot was on a second embassy to Charles V., in the winter of 1535-1536, when he received at Naples the news of More's execution. He had been kept in the dark by his own government, but heard the news from the emperor. The story of an earlier embassy to Rome (1532), mentioned by Burnet, rests on a late endorsement of instructions dated from that year, which cannot be regarded as authoritative. In 1542 he represented the borough of Cambridge in parliament. He had purchased from Cromwell the manor of Carleton in Cambridgeshire, where he died on the 26th of March 1546.

Sir Thomas Elyot received little reward for his services to the state, but his scholarship and his books were held in high esteem by his contemporaries. The *Boke named the Governour* was printed by Thomas Berthelet (1531, 1534, 1536, 1544, &c.). It is a treatise on moral philosophy, intended to direct the education of those destined to fill high positions, and to inculcate those moral principles which alone could fit them for the performance of their duties. The subject was a favourite one in the 16th century, and the book, which contained many citations from classical authors, was very popular. Elyot expressly acknowledges his obligations to Erasmus's *Institutio Principis Christiani*; but he makes no reference to the *De regno et regis institutione* of Francesco Patrizzi (d. 1494), bishop of Gaeta, on which his work was undoubtedly modelled. As a prose writer, Elyot enriched the English language with many new words. In 1534 he published *The Castell of Helth*, a popular treatise on medicine, intended to place a scientific knowledge of the art within the reach of those unacquainted with Greek. This work, though scoffed at by the faculty, was appreciated by the general public, and speedily went through many editions. His Latin *Dictionary*, the earliest comprehensive dictionary of the language, was completed in 1538. The copy of the first edition in the British Museum contains an autograph letter from Elyot to Thomas Cromwell, to whom it originally belonged. It was edited and enlarged in 1548 by Thomas Cooper, bishop of Winchester, who called it *Bibliotheca Eliotae*, and it formed the basis in 1565 of Cooper's *Thesaurus linguae Romanae et Britannicae*.

Elyot's translations include:—*The Doctrinal of Princes* (1534), from Isocrates; *Cyprianus, A Swete and Devoute Sermon of Holy Saynt Ciprian of the Mortalitie of Man* (1534); *Rules of a Christian Life* (1534), from Pico della Mirandola; *The Education or Bringing up of Children* (*c.* 1535), from Plutarch; and *Howe one may take Profite of his Enymes* (1535), from the same author is generally attributed to him. He also wrote: *The Knowledge which maketh a Wise Man* and *Pasquyll the Playne* (1533); *The Bankette of Sapience* (1534), a collection of moral sayings; *Preservative agaynste Deth* (1545), which contains many quotations from the Fathers; *Defence of Good Women* (1545). His *Image of Governance, compiled of the Actes and Sentences notable of the most noble Emperor Alexander Severus* (1540) professed to be a translation from a Greek MS. of the emperor's secretary Encolpius (or Eucolpius, as Elyot calls him), which had been lent him by a gentleman of Naples, called Pudericus, who asked to have it back before the translation was complete. In these circumstances Elyot, as he asserts in his preface, supplied the other maxims from different sources. He was violently assailed by Humphrey Hody and later by William Wotton for putting forward a pseudo-translation; but Mr H.H.S. Croft has discovered that there was a Neapolitan gentleman at that time bearing the name of Poderico, or, Latinized, Pudericus, with whom Elyot may well have been acquainted. Roger Ascham mentions his *De rebus memorabilibus Angliae*; and Webbe quotes a few lines of a lost translation of the *Ars poëtica* of Horace.

A learned edition of the *Governour* (2 vols., 1880), by H.H.S. Croft, contains, besides copious notes, a valuable glossary of 16th century English words.

ELYRIA, a city and the county-seat of Lorain county, Ohio, U.S.A., on the Black river, 8 m. from Lake Erie, and about 25 m. W.S.W. of Cleveland. Pop. (1890) 5611; (1900) 8791, of whom 1397 were foreign-born; (1910 census) 14,825. It is served by the Baltimore & Ohio, and the Lake Shore & Michigan Southern railways. Elyria is about 720 ft. above sea-level, and lies at the junction of the two forks of the Black river, each of which falls about 50 ft. here, furnishing water-power. Among the city’s manufactures are oxide of tin and other chemicals, iron and steel, leather goods, automobiles and bicycles, electrical and telephone supplies, butted tubing, gas engines, screws and bolts, silk, lace and hosiery. In 1905 the city’s factory products were valued at $2,933,450—140.2% more than their value in 1900. Flagging, building-stones and grindstones, taken from quarries in the vicinity (known as the Berea Grit quarries), are shipped from Elyria in large quantities. Elyria was founded about 1819 by Heman Ely, in whose honour it was named; it was selected as the site for the county seat in 1823, and was chartered as a city in 1892.

ELYSIUM, in Greek mythology, the Elysian fields, the abode of the righteous after their removal from earth. In Homer (*Od.* iv. 563) this region is a plain at the farthest end of the earth on the banks of the river Oceanus, where the fair-haired Rhadamanthys rules, and where the people are vexed by 304
neither snow nor storm, heat nor cold, the air being always tempered by the zephyr wafted from the ocean. It is no dwelling of the dead nor part of the lower world, but distinguished heroes are translated thither without dying, to live a life of perfect happiness. In Hesiod (*W. and D.* 166) the same description is given of the Islands of the Blessed under the rule of Cronus, which yield three harvests yearly. Here, according to Pindar, Rhadamanthys sits by the side of his father Cronus and administers judgment (*Ol.* ii. 61, *Frag.* 95). All who have successfully gone through a triple probation on earth are admitted to share these blessings. In later accounts (*Aeneid*, vi. 541) Elysium was regarded as part of the underworld, the home of the righteous dead adjudged worthy of it by the tribunal of Minos, Rhadamanthys and Aeacus. Those who had lived evil lives were thrust down into Tartarus, where they suffered endless torments.

ELZE, KARL (1821-1889), German scholar and Shakespearian critic, was born at Dessau on the 22nd of May 1821. Having studied (1839-1843) classical philology, and modern, but especially English, literature at the university of Leipzig, he was a master for a time in the Gymnasium (classical school) at Dessau, and in 1875 was appointed extraordinary, and in 1876 ordinary, professor of English philology at the university of Halle, in which city he died on the 21st of January 1889. Elze began his literary career with the *Englischer Liederschatz* (1851), an anthology of English lyrics, edited for a while a critical periodical *Atlantis*, and in 1857 published an edition of Shakespeare’s *Hamlet* with critical notes. He also edited Chapman’s *Alphonsus* (1867) and wrote biographies of Walter Scott, Byron and Shakespeare; *Abhandlungen zu Shakespeare* (English translation by D. Schmitz, as *Essays on Shakespeare*, London, 1874), and the excellent treatise, *Notes on Elizabethan Dramatists with conjectural emendations of the text* (3 vols., Halle, 1880-1886, new ed. 1889).

ELZEVIR, the name of a celebrated family of Dutch printers belonging to the 17th century. The original name of the family was Elsevier, or Elzevier, and their French editions mostly retain this name; but in their Latin editions, which are the more numerous, the name is spelt Elzeverius, which was gradually corrupted in English into Elzevir as a generic term for their books. The family originally came from Louvain, and there Louis, who first made the name Elzevir famous, was born in 1540. He learned the business of a bookbinder, and having been compelled in 1580, on account of his Protestantism and his adherence to the cause of the insurgent provinces, to leave his native country, he established himself as bookbinder and bookseller in Leiden. His *Eutropius*, which appeared in 1592, was long regarded as the earliest Elzevir, but the first is now known to be *Drusii Ebraicarum quaestionum ac responsionum libri duo*, which was produced in 1583. In all he published about 150 works. He died on the 4th of February 1617. Of his five sons, Matthieu, Louis, Gilles, Joost and Bonaventure, who all adopted their father’s profession, Bonaventure, who was born in 1583, is the most celebrated. He began business as a printer in 1608, and in 1626 took into partnership Abraham, a son of Matthieu, born at Leiden in 1592. Abraham died on the 14th of August 1652, and Bonaventure about a month afterwards. The fame of the Elzevir editions rests chiefly on the works issued by this firm. Their Greek and Hebrew impressions are considered inferior to those of the Aldi and the Estiennes, but their small editions in 12mo, 16mo and 24mo, for elegance of design, neatness, clearness and regularity of type, and beauty of paper, cannot be surpassed. Especially may be mentioned the two editions of the New Testament in Greek (Ἡ καινὴ διαθήκη, *Novum Testamentum*, &c.), published in 1624 and 1633, of which the latter is the more beautiful and the more sought after; the *Psalterium Davidis*, 1653; *Virgilii opera*, 1636; *Terentii comediae*, 1635; but the works which gave their press its chief celebrity are their collection of French authors on history and politics in 24mo, known under the name of the *Petites Républiques*, and their series of Latin, French and Italian classics in small 12mo. Jean, son of Abraham, born in 1622, had since 1647 been in partnership with his father and uncle, and when they died Daniel, son of Bonaventure, born in 1626, joined him. Their partnership did not last more than two years, and after its dissolution Jean carried on the business alone till his death in 1661. In 1654 Daniel joined his cousin Louis (the third of that name and son of the second Louis), who was born in 1604, and had established a printing press at Amsterdam in 1638. From 1655 to 1666 they published a series of Latin classics in 8vo, *cum notis variorum*; *Cicero* in 4to; the *Etymologicon linguae Latinae*; and a magnificent *Corpus juris civilis* in folio, 2 vols., 1663. Louis died in 1670, and Daniel in 1680. Besides Bonaventure, another son of Matthieu, Isaac, born in 1593, established a printing press at Leiden, where he carried on business from 1616 to 1625; but none of his editions attained much fame. The last representatives of the Elzevir printers were Peter, grandson of Joost, who from 1667 to 1675 was a bookseller at Utrecht, and printed seven or eight volumes of little consequence; and Abraham, son of the first Abraham, who from 1681 to 1712 was university printer at Leiden.

Some of the Elzevir editions bear no other typographical mark than simply the words *Apud Elzeverios*, or *Ex officina Elseveriana*, under the *rubrique* of the town. But the majority bear one of their special devices, four of which are recognized as in common use. Louis Elzevir, the founder of the family, usually adopted the arms of the United Provinces, an eagle on a cippus holding in its claws a sheaf of seven arrows, with the motto *Concordia res parvae crescunt*. About 1620 the Leiden Elzevirs adopted a new device, known as "the solitary," and consisting of an elm tree, a fruitful vine and a man alone, with a motto *Non solus*. They also used another device, a palm tree with the motto, *Assurgo pressa*. The Elzevirs of Amsterdam used for their principal device a figure of Minerva with owl, shield and olive tree, and the motto, *Ne extra oleas*. The earliest productions of the Elzevir press are marked with an angel bearing a book and a scythe, and various other devices occur at different times. When the Elzevirs did not wish to put their name to their works they generally marked them with a sphere, but of course the mere fact that a work printed in the 17th century bears this mark is no proof that it is theirs. The total number of works of all kinds which came from the presses of the Elzevirs is given by Willems as 1608; there were also many forgeries.

See "Notice de la collection d'auteurs latins, français, et italiens, imprimée de format petit en 12, par les Elsévier," in Brunet's *Manuel du libraire* (Paris, 1820); A. de Reume, *Recherches historiques, généalogiques, et bibliographiques sur les Elsévier* (Brussels, 1847); Paul Dupont, *Histoire de l'imprimerie*, in two vols. (Paris, 1854); Pieters, *Annales de l'imprimerie Elsévirienne* (2nd ed., Ghent, 1858); Walther, *Les Elséviriennes de la bibliothèque impériale de St-Pétersbourg* (St Petersburg, 1864); Alphonse Willems, *Les Elzévier* (Brussels, 1880), with a history of the Elzevir family and their printing establishments, a chronological list and detailed description of all works printed by them, their various typographical marks, and a plate illustrating the types used by them; Kelchner, *Catalogus librorum officinae Elsevirianae* (Paris, 1880); Frick, *Die Elzevirschen Republiken* (Halle, 1892); Berghman, *Études sur la bibliographie Elzévirienne* (Stockholm, 1885), and *Nouvelles études, &c.* (*ib.* 1897).

EMANATION (Lat. *emanatio*, from *e-*, out, *manare*, to flow), in philosophy and theology, the name of one of the three chief theories of existence, *i.e.* of the relation between God and men—the One and the Many, the Universal and the Particular. This theory has been propounded in many forms, but the central idea is that the universe of individuals consists of the involuntary "outpourings" of the ultimate divine essence. That essence is not only all-inclusive, but absolutely perfect, while the "emanated" individuals degenerate in proportion to the degree of their distance from the essence. The existence of evil in opposition to the perfect goodness of God, as thus explained, need not be attributed to God's agency, inasmuch as the whole emanation-process is governed by necessary—as it were mechanical—laws, which may be compared to those of the physical universe. The doctrine of emanation is thus to be distinguished from the cosmogonic theory of Judaism and Christianity, which explains human existence as due to a single creative act of a moral agent. The God of Judaism and Christianity is essentially a *person* in close *personal* relation to his creatures; emanation is the denial of personality both for God and for man. The emanation theory is to be contrasted, on the other hand, with the theory of evolution. The two theories are alike in so far as both recognize the existence of individuals as due to a necessary process of differentiation and a scale of existence. They differ, however, fundamentally in this respect, that, whereas evolution regards the process as from the indeterminate lower towards the determinate higher, emanation regards it as from the highest to the indefinitely lower. 305

There is considerable superficial similarity between evolution and emanation, especially in their formal statements. The process of evolution from the indeterminate to the determinate is often expressed as a progress from the universal to the particular. Thus the primordial matter assumed by the early Greek physicists may be said to be the universal substance out of which particular things arise. The doctrine of emanation also regards the world as a process of particularization. Yet the resemblance is more apparent than real. The universal is, as Herbert Spencer remarked, a subjective idea, and the general forms, existing *ante res*, which play so prominent a part in Greek and medieval philosophy, do not in the least correspond to the homogeneous matter of the physical evolutionists. The one process is a logical operation, the other a physical. The theory of emanation, which had its source in certain moral and religious ideas, aims first of all at explaining the origin of mental or spiritual existence as an effluence from the divine and absolute spirit. In the next place, it seeks to account for the general laws of the world, for the universal forms of existence, as ideas which emanate from the Deity. By some it was developed into a complete philosophy of the world, in which matter itself is viewed as the lowest emanation from the absolute. In this form it stands in sharp antithesis to the doctrine of evolution, both because the former views the world of particular things and events as essentially unreal and illusory, and because the latter, so far as it goes, looks on matter as eternal, and seeks to explain the general forms of things as we perceive them by help of simpler assumptions. In certain theories known as doctrines of emanation, only mental existence is referred to the absolute source, while matter is viewed as eternal and distinct from the divine nature. In this form the doctrine of emanation approaches certain forms of the evolution theory (see Evolution).

The doctrine of emanation is correctly described as of oriental origin. It appears in various forms in Indian philosophy, and is the characteristically oriental element in syncretic systems like Neoplatonism and Gnosticism. None the less it is easy to find it in embryo in the speculations of the essentially European philosophers of Greece. Plato, whose philosophy was strongly opposed to the evolution theory, distinctly inclines to the emanation idea in his doctrine that each particular thing is what it is in virtue of a pre-existent idea, and that the particulars are the lowest in the scale of existence, at the head of, or above, which is the idea of the good. The view of Xenocrates is based on the same ideas. Or again, we may compare the Stoic doctrine of ἀπόρροιαι (literally “emanations”) from the divine essence. It is, however, only in the last eclectic period of Greek philosophy that the emanation doctrine was definitely established in the doctrines, *e.g.* Plotinus.

See especially articles Evolution, Neoplatonism, Gnosticism.

EMANUEL I. [Portuguese *Manoel*] (1469-1521), fourteenth king of Portugal, surnamed the Happy, knight of the Garter and of the Golden Fleece, was the son of Duke Ferdinand of Vizeu and of Beatrice of Beja, grandchildren of John I. of Portugal. He was born at Alcochete on the 3rd of May 1469, or, according to Barbosa Machado, on the 1st of June. His early education was directed by a Sicilian named Cataldo. In 1495 he became king in succession to his cousin John II. In 1497 he married Isabella, daughter of Ferdinand and Isabella of Castile, who had previously been married to Alphonso, the heir of John II. She died in the next year in giving birth to a son named Miguel, who until his death two years later was considered heir to the entire Iberian Peninsula. Emanuel’s next wife was Maria, another daughter of Ferdinand and Isabella, whom he married in 1500. Two of their children, John and Henry, later became kings of Portugal. Maria died in 1516, and in 1518 her niece Leonora, a sister of the emperor Charles V., became Emanuel’s third wife. Emanuel’s reign is noteworthy for the continuance of the Portuguese discoveries and the extension of their chain of trading-posts, Vasco da Gama’s opening an all-sea route to India, Cabral’s landing in Brazil, Corte-Real’s voyage to Labrador, the exploration of the Indian seas and the opening of commercial relations with Persia and China, bringing Portugal international prominence, colonial pre-eminence and a hitherto unparalleled degree of national prosperity. His intense religious zeal variously manifested itself in his persecutions of the Jews, whom at the beginning of his reign he had been disposed to tolerate, his strenuous endeavours to promote an international crusade against the Turks, his eager missionary enterprise throughout his new possessions, and his erection of twenty-six monasteries and two cathedrals, including the stately monastic church of the Jeronymos at Belem (see Lisbon). His jealously despotic character was accentuated by the enormous increase the Indies furnished to his personal wealth, and exemplified in his assumption of new titles and in a magnificent embassy to Pope Leo X. He died at Lisbon on the 13th of December 1521.

The best authorities for the history of Emanuel’s reign are the contemporary 16th-century *Chronica d’el Rei D. Manoel*, by Damião de Goes, and *De rebus Emanuelis*, by J. Osorio. *El Rei D. Manoel*, by M.B. Branco (Lisbon, 1888), is a valuable but ill-arranged biography. See also the *Ordenações do S.R.D. Manoel* (Coimbra University Press, 1797). For further bibliography see Barbosa Machado, *Bibliographica Lusitana*, vol. iii. pp. 161-166.

EMBALMING (Gr. βάλσαμον, balsam; Ger. *Einbalsamiren*; Fr. *embaumement*), the art of preparing dead bodies, chiefly by the use of medicaments, in order to preserve them from putrefaction and the attacks of insects. The ancient Egyptians carried the art to great perfection, and embalmed not only human beings, but cats, crocodiles, ichneumons, and other sacred animals. It was at one time suggested that the origin of embalming in Egypt was to be traced to a want of fuel for the purpose of cremation, to the inadvisability or at some times impossibility of burial in a soil annually disturbed by the inundation of the Nile, and to the necessity, for sanitary reasons, of preventing the decomposition of the bodies of the dead when placed in open sepulchres. As, however, the corpses of the embalmed must have constituted but a small proportion of the aggregate mass of animal matter daily to be disposed of, the above explanation would in any case be far from satisfactory; and there is no doubt (see Mummy) that embalming originated in the idea of preserving the body for a future life. According to W.H. Prescott, it was a belief in a resurrection of the body that led the ancient Peruvians to preserve the air-dried corpses of their dead with so much solicitude (see *Conquest of Peru*, bk. i. chap. iii.). And J.C. Prichard (*Egyptian Mythology*, p. 200) properly compared the Egyptian practice with the views which rendered “the Greeks and Romans so anxious to perform the usual rites of sepulture to their departed warriors, namely, ... that these solemnities expedited the journey of the soul to the appointed region, where it was to receive judgment for its former deeds, and to have its future doom fixed accordingly.” It has been supposed by some that the discovery of the preservation of bodies interred in saline soils may have been the immediate origin of embalming in Egypt. In that country certain classes of the community were specially appointed for the practice of the art. Joseph, we are told in Gen. l. 2, “commanded his servants the physicians to embalm his father.”

Herodotus (ii. 86) gives an account of three of the methods of embalming followed by the Egyptians. The most expensive of these, which cost a talent of silver (£243: 15s.), was as follows. The brains were in part removed through the nostrils by means of a bent iron implement, and in part by the injection of drugs. The intestines having been drawn out through an incision in the left side, the abdomen was cleansed with palm-wine, and filled with myrrh, cassia and other materials, and the opening was sewed up. This done, the body was steeped seventy days in a solution of litron or natron.[1] Diodorus (i. 306
91) relates that the cutter (παρασχίστης) appointed to make the incision in the flank for the removal of the intestines, as soon as he had performed his office, was pursued with stones and curses by those about him, it being held by the Egyptians a detestable thing to commit any violence or inflict a wound on the body. After the steeping, the body was washed, and handed over to the swathers, a peculiar class of the lowest order of priests, called by Plutarch *cholchytae*, by whom it was bandaged in gummed cloth; it was then ready for the coffin. Mummies thus prepared were considered to represent Osiris. In another method of embalming, costing twenty-two minae (about £90), the abdomen was injected with “cedar-tree pitch” (κεδρία), which, as it would seem from Pliny (*Nat. Hist.* xvi. 21), was the liquid distillate of the pitch-pine. This is stated by Herodotus to have had a corrosive and solvent action on the viscera. After injection the body was steeped a certain number of days in natron; the contents of the abdomen were allowed to escape; and the process was then complete. The preparation of the bodies of the poorest consisted simply in placing them in natron for seventy days, after a previous rinsing of the abdomen with “syrmaea.” The material principally used in the costlier modes of embalming appears to have been asphalt; wax was more rarely employed. In some cases embalming seems to have been effected by immersing the body in a bath of molten bitumen. Tanning also was resorted to. Occasionally the viscera, after treatment, were in part or wholly replaced in the body, together with wax figures of the four genii of Amenti. More commonly they were embalmed in a mixture of sand and asphalt, and buried in vases, or *canopi*, placed near the mummy, the abdomen being filled with chips and sawdust of cedar and a small quantity of natron. In one jar were placed the stomach and large intestine; in another, the small intestines; in a third, the lungs and heart; in a fourth, the gall-bladder and liver. Porphyry (*De abstinentia*, iv. 10) mentions a custom of enclosing the intestines in a box and consigning them to the Nile, after a prayer uttered by one of the embalmers, but his statement is regarded by Sir J.G. Wilkinson as unworthy of belief. The body of Nero’s wife Poppaea, contrary to the usage of the Romans, was not burnt, but as customary among other nations with the bodies of potentates, was honoured with embalmment (see Tacitus, *Ann.* xvi. 6). The body of Alexander the Great is said to have been embalmed with honey (Statius, *Silv.* iii. 2. 117), and the same material was used to preserve the corpse of Agesipolis I. during its conveyance to Sparta for burial. Herodotus states (iii. 24) that the Ethiopians, in embalming, dried the body, rubbed it with gypsum (or chalk), and, having painted it, placed it in a block of some transparent substance. The Guanches, the aborigines of the Canaries, employed a mode of embalming similar to that of the Egyptians, filling the hollow caused by the removal of the viscera with salt and an absorbent vegetable powder (see Bory de Saint Vincent, *Essais sur les Îles Fortunées*, 1803, p. 495). Embalming was still in vogue among the Egyptians in the time of St Augustine, who says that they termed mummies *gabbarae* (*Serm.* 120, cap. 12).

In modern times numerous methods of embalming have been practised. Dr Frederick Ruysch of Amsterdam (1665-1717) is said to have utilized alcohol for this purpose. By William Hunter essential oils, alcohol, cinnabar, camphor, saltpetre and pitch or rosin were employed, and the final desiccation of the body was effected by means of roasted gypsum placed in its coffin. J.P. Boudet (1778-1849) embalmed with tan, salt, asphalt and Peruvian bark, camphor, cinnamon and other aromatics and corrosive sublimate. The last-mentioned drug, chloride and sulphate of zinc, acetate and sulphate of alumina, and creasote and carbolic acid have all been recommended by various modern embalmers.

See Mummy; Louis Penicher, *Traité des embaumements* (Paris, 1669); S. Blancard, *Anatomia reformata, et de balsamatione nova methodus* (Lugd. Bat., 1695); Thomas Greenhill, *The Art of Embalming* (London, 1705); J.N. Marjolin, *Manuel d’anatomie* (Paris, 1810); Pettigrew, *History of*

Mummies (London, 1834); Gannal, *Traité d'embaumements* (Paris, 1838; 2nd ed., 1841); Magnus, *Das Einbalsamiren der Leichen* (Brunsw., 1839); Sucquet, *Embaumement* (Paris, 1872); Lessley, *Embalming* (Toledo, Ohio, 1884); Myers, *Textbook of Embalming* (Springfield, Ohio, 1900); Rawlinson, *Herodotus*, vol. ii. p. 141; G. Elliot Smith, *A Contribution to the Study of Mummification in Egypt* (Cairo, 1906).

1 Neutral carbonate of sodium, Na_2CO_3, found at the natron lakes in the Libyan desert, and at El Hegs, in Upper Egypt.

EMBANKMENT, in engineering, a mound of earth or stone, usually narrow in comparison with its length, artificially raised above the prevailing level of the ground. Embankments serve for two main classes of purpose. On the one hand, they are used to preserve the level of railways, canals and roads, in cases where a valley or piece of low-lying ground has to be crossed. On the other, they are employed to stop or limit the flow of water, either constituting the retaining wells of reservoirs constructed in connexion with water-supply schemes, or protecting low-lying tracts of land from river floods or the encroachments of the sea. The word embankment has thus come to be used for the mass of material, faced and supported by a stone wall and protected by a parapet, placed along the banks of a river where it passes through a city, whether to guard against floods or to gain additional space. Such is the Thames Embankment in London, which carries a broad roadway, while under it runs the Underground railway. In this sense an embankment is distinguished from a quay, though the mechanical construction may be the same, the latter word being confined to places where ships are loaded and unloaded, thus differing from the French *quai*, which is used both of embankments and quays, *e.g.* the *Quais* along the Seine at Paris.

EMBARGO (a Spanish word meaning "stoppage"), in international law, the detention by a state of vessels within its ports as a measure of public, as distinguished from private, utility. In practice it serves as a mode of coercing a weaker state. In the middle ages war, being regarded as a complete rupture between belligerent states, operated as a suspension of all respect for the person and property of private citizens; an article of Magna Carta (1215) provided that "... if there shall be found any such merchants in our land in the beginning of a war, they shall be attached, without damage to their bodies or goods, until it may be known unto us, or our Chief Justiciary, how our merchants are treated who happen to be in the country which is at war with us; and if ours be safe there, theirs shall be safe in our lands" (art. 48).

Embargoes in anticipation of war have long since fallen into disuse, and it is now customary on the outbreak of war for the belligerents even to grant a respite to the enemy's trading vessels to leave their ports at the outbreak of war, so that neither ship nor cargo is any longer exposed to embargo. This has been confirmed in one of the Hague Conventions of 1907 (convention relative to the status of enemy merchant ships at the outbreak of hostilities, Oct. 18, 1907), which provides that "when a merchant ship belonging to one of the belligerent powers is at the commencement of hostilities in an enemy port, *it is desirable* that it should be allowed to depart freely, either immediately, or after a reasonable number of days of grace, and to proceed, after being furnished with a pass, direct to its port of destination, or any other port indicated" (art. 1). The next article of the same convention limits the option apparently granted by the use of the word "desirable," providing that "a merchant ship unable, owing to circumstances of *force majeure*, to leave the enemy port within the period contemplated (in the previous article), or which was not allowed to leave, *cannot* be confiscated. The belligerent may only detain it, without compensation, but subject to the obligation of restoring it after the war, or requisition it on payment of compensation" (art. 2).

(T. Ba.)

EMBASSY, the office of an ambassador, or, more generally, the mission on which an ambassador of one power is sent to another, or the body of official personages attached to such a mission, whether temporary or permanent. Hence "embassy" is often quite loosely used of any mission, diplomatic or otherwise. The word is also used of the official residence of an ambassador. "Embassy" was originally "ambassy," the form used in the 17th century, but by the time of Johnson considered quite obsolete. "Ambassy" is from the O. Fr. *ambassée*, derived through such forms as the Port. *ambassada*, Ital. *ambasciata* from a lost Med. Lat. *ambactiata*, *ambactiare*, to go on a mission. (See further Ambassador, 307

EMBER DAYS and **EMBER WEEKS**, the four seasons set apart by the Western Church for special prayer and fasting, and the ordination of clergy, known in the medieval Church as *quatuor tempora*, or *jejunia quatuor temporum*. The Ember weeks are the complete weeks next following Holy Cross day (September 14), St Lucy’s day (December 13), the first Sunday in Lent and Whitsun day. The Wednesdays, Fridays and Saturdays of these weeks are the Ember days distinctively, the following Sundays being the days of ordination. These dates are given in the following memorial distich with a frank indifference to quantity and metre—

“Vult Crux, Lucia, Cinis, Charismata dia
Quod det vota pia quarta sequens feria.”

The word has been derived from the A.S. *ymb-ren*, a circuit or revolution (from *ymb*, around, and *rennen*, to run); or by process of agglutination and phonetic decay, exemplified by the Ger. *quatember*, Dutch *quatertemper* and Dan. *kvatember*, from the Lat. *quatuor tempora*. The occurrence of the Anglo-Saxon compounds *ymbren-tid*, *ymbren-wucan*, *ymbren-fæstan*, *ymbren-dagas* for Ember tide, weeks, fasts, days, favours the former derivation, which is also confirmed by the use of the word *imbren* in the acts of the council of Ænham, A.D. 1009 (“jejunia quatuor tempora quae *imbren* vocant”). It corresponds also with Pope Leo the Great’s definition, “jejunia ecclesiastica per totius anni circulum distributa.”

The observance of the Ember days is confined to the Western Church, and had its origin as an ecclesiastical ordinance in Rome. They were probably at first merely the fasts preparatory to the three great festivals of Christmas, Easter and Pentecost. A fourth was subsequently added, for the sake of symmetry, to make them correspond with the four seasons, and they became known as the *jejunium vernum*, *aestivum*, *autumnale* and *hiemale*, so that, to quote Pope Leo’s words, “the law of abstinence might apply to every season of the year.” An earlier mention of these fasts, as four in number—the first known—is in the writings of Philastrius, bishop of Brescia, in the middle of the 4th century. He also connects them with the great Christian festivals (*De haeres.* 119). In Leo’s time, A.D. 440-461, Wednesday, Friday and Saturday were already the days of special observance. From Rome the Ember days gradually spread through the whole of Western Christendom. Uniformity of practice, however, was of somewhat slow growth. Neither in Gaul nor Spain do they seem to have been generally recognized much before the 8th century. Their introduction into Britain appears to have been earlier, dating from Augustine, A.D. 597, acting under the authority of Gregory the Great. The general period of the four fasts being roughly fixed, the precise date appears to have varied considerably, and in some cases to have lost its connexion with the festivals altogether. The *Ordo Romanus* fixes the spring fast in the first week of March (then the first month); the summer fast in the second week of June; the autumnal fast in the third week of September; and the winter fast in the complete week next before Christmas eve. Other regulations prevailed in different countries, until the inconveniences arising from the want of uniformity led to the rule now observed being laid down under Pope Urban II. as the law of the church, in the councils of Piacenza and Clermont, A.D. 1095.

The present rule which fixes the ordination of clergy in the Ember weeks cannot be traced farther back than the time of Pope Gelasius, A.D. 492-496. In the early ages of the church ordinations took place at any season of the year whenever necessity required. Gelasius is stated by ritual writers to have been the first who limited them to these particular times, the special solemnity of the season being in all probability the cause of the selection. The rule once introduced commended itself to the mind of the church, and its observance spread. We find it laid down in the pontificate of Archbishop Ecgbert of York, A.D. 732-766, and referred to as a canonical rule in a capitulary of Charlemagne, and it was finally established as a law of the church in the pontificate of Gregory VII., *c.* 1085.

Authorities.—Muratori, *Dissert. de jejun. quat. temp.*, c. vii., anecdot. tom. ii. p. 262; Bingham, *Antiq. of the Christ. Church*, bk. iv. ch. vi. § 6, bk. xxi. ch. ii. §§ 1-7; Binterin, *Denkwürdigkeiten*, vol. v. part 2, pp. 133 ff.; Augusti, *Handbuch der christlich. Archäol.* vol. i. p. 465, iii. p. 486.

(E. V.)

EMBEZZLEMENT (A.-Fr. *embesilement*, from *beseler* or *besillier*, to destroy), in English law, a peculiar form of theft, which is distinguished from the ordinary crime in two points:—(1) It is committed by a person who is in the position of clerk or servant to the owner of the property stolen; and (2) the property when stolen is in the possession of such clerk or servant. The definition of embezzlement as a special form of theft arose out of the difficulties caused by the legal doctrine that to constitute larceny the property must be taken out of the possession of the owner. Servants and others were thus able to steal with impunity goods entrusted to them by their masters. A statute of Henry VIII. (1529) was passed to meet this case; and it enacted that it should be felony in servants to convert to their own use caskets, jewels, money, goods or chattels delivered to them by their masters. “This act,” says Sir J.F. Stephen (*General View of the Criminal Law of England*), “assisted by certain subtleties according to which the possession of the servant was taken under particular circumstances to be the possession of the master, so that the servant by converting the goods to his own use took them out of his own possession *qua* servant (which was his master’s possession) and put them into his own possession *qua* thief (which was a felony), was considered sufficient for practical purposes for more than 200 years.” In 1799 a clerk who had converted to his own use a cheque paid across the counter to him by a customer of his master was held to be not guilty of felony; and in the same year an act was passed, which, meeting the difficulty in such cases, enacted that if any clerk or servant, or any person employed as clerk or servant, should, by virtue of such employment, receive or take into his possession any money, bonds, bills, &c., for or in the name or on account of his employers, and should fraudulently embezzle the same, every such offender should be deemed to have stolen the same. The same definition is substantially repeated in a Consolidation Act passed in 1827. Numberless difficulties of interpretation arose under these acts, *e.g.* as to the meaning of “clerk or servant,” as to the difference between theft and embezzlement, &c.

The law now in force, or the Larceny Act 1861, defines the offence thus (section 68):—“Whosoever, being a clerk or servant, or being employed for the purpose or in the capacity of a clerk or servant, shall fraudulently embezzle any chattel, money or valuable security which shall be delivered to or received or taken into possession by him for or in the name or on the account of his master or employer, or any part thereof, shall be deemed to have feloniously stolen the same from his master or employer, although such chattel, money or security was not received into the possession of such master or employer otherwise than by the actual possession of his clerk, servant or other person so employed, and being convicted thereof shall be liable, at the discretion of the court, to be kept in penal servitude for any time not exceeding fourteen years, and not less than three years,” or imprisonment with or without hard labour for not more than two years. To constitute the offence thus described three things must concur:—(1) The offender must be a clerk or servant; (2) he must receive into his possession some chattel on behalf of his master; and (3) he must fraudulently embezzle the same. A clerk or servant has been defined to be a person bound either by an express contract of service or by conduct implying such a contract to obey the orders and submit to the control of his master in the transaction of the business which it is his duty as such clerk or servant to transact. (Stephen’s *Digest of the Criminal Law*, Art. 309.)

The Larceny Act 1901, amending sections 75 and 76 of the Larceny Act 1861, also describes similar offences on the part of persons, not being clerks or servants, to which the name embezzlement is not 308
uncommonly applied. The act makes the offence of fraudulently misappropriating property entrusted to a person by another, or received by him on behalf of another a misdemeanour punishable by penal servitude for a term not exceeding seven years, or to imprisonment, with or without hard labour, for a term not exceeding two years. So also trustees fraudulently disposing of trust property, and directors of companies fraudulently appropriating the company’s property or keeping fraudulent accounts, or wilfully destroying books or publishing fraudulent statements, are misdemeanants punishable in the same way.

In the United States the law of embezzlement is founded mainly on the English statute passed in 1799, but the statutes of most states are so framed that larceny includes embezzlement. The latter is sometimes denominated statutory larceny. The punishment varies in the different states, otherwise there is little substantive difference in the laws of the two countries.

Statutes have been passed in some states providing that one indicted for larceny may be convicted of embezzlement. But it is doubtful whether such statutes are valid where the constitution of the state provides that the accused must be informed of the nature and cause of the accusation against him. (See also Larceny.)

EMBLEM (Gr. ἔμβλημα, something put in or inserted, from ἐμβάλλειν, to throw in), a word originally applied in Greek and Latin (*emblema*) to a raised or inlaid ornament on vases and other vessels, &c., and also to mosaic or tessellated work. It is in English confined to a symbolical representation of some object, particularly when used as a badge or heraldic device.

EMBLEMENTS (from O. Fr. *emblavence de bled*, *i.e.* corn sprung up above ground), a term applied in English law to the corn and other crops of the earth which are produced annually, not spontaneously, but by labour and industry. Emblements belong therefore to the class of *fructus industriales*, or "industrial growing crops" (Sale of Goods Act 1893, § 62). They include not only corn and grain of all kinds, but everything of an artificial and annual profit that is produced by labour and manuring, *e.g.* hemp, flax, hops, potatoes, artificial grasses like clover, but not fruit growing on trees, which come under the general rule *quicquid plantatur solo, solo cedit*. Emblements are included within the definition of goods in s. 62 of the Sale of Goods Act 1893. Where an estate of uncertain duration terminates unexpectedly by the death of the tenant, or some other event due to no fault of his own, the law gives to the personal representative the profits of crops of this nature as compensation for the tilling, manuring and sowing of the land. If the estate, although of uncertain duration, is determined by the tenant's own acts, the right to emblements does not arise. The right to emblements has become of no importance in England since 1851, when it was provided by the Landlord and Tenant Act 1851 (s. 1) that any tenant at rack-rent, whose lease was determined by the death or cesser of the estate, of a landlord entitled only for his life, or for any other uncertain interest, shall, instead of emblements, be entitled to hold the lands until the expiration of the current year of his tenancy. The right to emblements still exists, however, in favour of (*a*) a tenant not within the Landlord and Tenant Act 1851, whose estate determines by an event which could not be foreseen, (*b*) the executor, as against the heir of the owner in fee of land in his own occupation, (*c*) an execution creditor under a writ directing seizure of goods and chattels. A person entitled to emblements may enter upon the lands after the determination of the tenancy for the purpose of cutting and carrying away the crops. Emblements are liable to distress by the landlord for arrears of rent, or rent during the period of holding on under the act of 1851 (the Distress for Rent Act 1737; see Bullen on *Distress*, 4th ed., 1893).

The term "emblements" is unknown in *Scots law*, but the heir or representative of a life-rent tenant, a liferenter of lands, has an analogous right to reap the crop (on paying a proportion of the rent) and a right to recompense for labour in tilling the ground. The Landlord and Tenant Act 1851 (s. 1) was in force in *Ireland* till 1860, when it was replaced by the Land Act 1860, which gave to the tenant an almost identical right to emblements (s. 34).

In the *United States* the English common law of emblements has been generally preserved. In North Carolina there has been legislation on the lines of the English Landlord and Tenant Act 1851. In some states the tenant is entitled to compensation also from the person succeeding to the possession.

Under the French Code Civil, the outgoing tenant is entitled to convenient housing for the consumption of his fodder and for the harvests remaining to be got in (art. 1777). The same rule is in force in Belgium (Code Civil, art. 1777); and in Holland (Civil Code, art. 1635) and Spain (art. 1578). Similar rights are secured to the tenant under the German Civil Code (arts. 592 et seq.). French law is in force in Mauritius. The common law of England and the Landlord and Tenant Act 1851 (14 & 15 Vict., c. 25, s. 1) are in force in many of the British colonies acquired by settlement. In other colonies they have been recognized by statute (*e.g.* Victoria, Landlord and Tenant Act 1890, No. 1108, ss. 45-48: Tasmania, Landlord and Tenant Act 1874, 38 Vict. No. 12).

Authorities.—English Law: Fawcett on the *Law of Landlord and Tenant* (3rd ed., London, 1905); Foà, *Landlord and Tenant* (4th ed., London, 1907). Scots Law: Bell's *Principles* (10th ed., Edinburgh, 1899). Irish Law: Noland and Kanes, *Statutes relating to the Law of Landlord and Tenant in Ireland* (10th ed.), by Kelly (Dublin, 1898). American Law: Stimson, *American Statute Law* (Boston, 1886); Bouvier, *Law Dictionary*, ed. by Rawle (Boston and London, 1897); *Ruling Cases* (London and Boston, 1894-1901), tit. "Emblements" (American Notes).

(A. W. R.)

EMBOSSING, the art of producing raised portions or patterns on the surface of metal, leather, textile fabrics, cardboard, paper and similar substances. Strictly speaking, the term is applicable only to raised impressions produced by means of engraved dies or plates brought forcibly to bear on the material to be embossed, by various means, according to the nature of the substance acted on. Thus raised patterns produced by carving, chiselling, casting and chasing or hammering are excluded from the range of embossed work. Embossing supplies a convenient and expeditious medium for producing elegant ornamental effects in many distinct industries; and especially in its relations to paper and cardboard its applications are varied and important. Crests, monograms, addresses, &c., are embossed on paper and envelopes from dies set in small handscrew presses, a force or counter-die being prepared in leather faced with a coating of gutta-percha. The dies to be used for plain embossing are generally cut deeper than those intended to be used with colours. Colour embossing is done in two ways—the first and ordinary kind that in which the ink is applied to the raised portion of the design. The colour in this case is spread on the die with a brush and the whole surface is carefully cleaned, leaving only ink in the depressed parts of the engraving. In the second variety—called cameo embossing—the colour is applied to the flat parts of the design by means of a small printing roller, and the letters or design in relief is left uncoloured. In embossing large ornamental designs, engraved plates or electrotypes therefrom are employed, the force or counterpart being composed of mill-board faced with gutta-percha. In working these, powerful screw-presses, in principle like coining or medal-striking presses, are employed. Embossing is also most extensively practised for ornamental purposes in the art of bookbinding. The blocked ornaments on cloth covers for books, and the blocking or imitation tooling on the cheaper kinds of leather work, are effected by means of powerful embossing or arming presses. (See Book-binding.) For impressing embossed patterns on wall-papers, textiles of various kinds, and felt, cylinders of copper, engraved with the patterns to be raised, are employed, and these are mounted in calender frames, in which they press against rollers having a yielding surface, or so constructed that depressions in the engraved cylinders fit into corresponding elevations in those against which they press. The operations of embossing and colour printing are also sometimes effected together in a modification of the ordinary cylinder printing machine used in calico-printing, in which it is only necessary to introduce suitably engraved cylinders. For many purposes the embossing rollers must be maintained at a high temperature while in operation; and they are heated either by steam, by gas jets, or by the introduction of red-hot irons within them. The stamped or struck ornaments in sheet metal, used especially in connexion with the brass and Britannia-metal trades, are obtained by a process of embossing—hard steel dies with forces or counterparts of soft metal being used in their production. A kind of embossed ornament is formed on the surface of soft wood by first compressing and consequently sinking the parts intended to be embossed, then planing the whole surface level, after which, when the wood is placed in water, the previously depressed portion swells up and rises to its original level. Thus an embossed pattern is produced which may be subsequently sharpened and finished by the ordinary process of carving (see Chasing and Repoussé). 309

EMBRACERY (from the O. Fr. *embraseour*, an embracer, *i.e.* one who excites or instigates, literally one who sets on fire, from *embraser*, to kindle a fire; "embrace," *i.e.* to hold or clasp in the arms, is from O. Fr. *embracer*, Lat. *in* and *bracchia*, arms), in law, the attempting to influence a juryman corruptly to give his verdict in favour of one side or the other in a trial, by promise, persuasions, entreaties, money, entertainments and the like. It is an offence both at common law and by statute, and punishable by fine and imprisonment. As a statutory offence it dates back to 1360. The offence is complete, whether any verdict has been given or not, and whether the verdict is in accordance with the weight of evidence or otherwise. The person making the attempt, and any juryman who consents, are equally punishable. The false verdict of a jury, whether occasioned by embracery or otherwise, was formerly considered criminal, and jurors were severely punished, being proceeded against by writ of attaint (*q.v.*). The Juries Act of 1825, in abolishing writs of attaint, made a special exemption as regards jurors guilty of embracery (§ 61). Prosecution for the offence has been so extremely rare that when a case occurred in 1891 (*R.* v. *Baker*, 113, Cent. Crim. Ct. Sess. Pap. 374) it was stated that no precedent could be found for the indictment. The defendant was fined £200, afterwards reduced to £100.

EMBRASURE, in architecture, the opening in a battlement between the two raised solid portions or merlons, sometimes called a crenelle (see Battlement, Crenelle); also the splay of a window.

EMBROIDERY (M.E. *embrouderie*, from O. Fr. *embroder*, Mod. Fr. *broder*), the ornamentation of textile fabrics and other materials with needlework. The beginnings of the art of embroidery probably date back to a very primitive stage in the history of all peoples, since plain stitching must have been one of the earliest attainments of mankind, and from that it is but a short step to decorative needlework of some kind. The discovery of needles among the relics of Swiss lake-dwellings shows that their primitive inhabitants were at least acquainted with the art of stitching.

Plate I.

Fig. 6.—PANEL OF PETIT-POINT EMBROIDERY, WITH A REPRESENTATION OF COURTLY FIGURES IN A LANDSCAPE. English work of the end of the reign of Queen Elizabeth. Scale: $\frac{1}{6}$th.

Fig. 7.—PORTION OF THE "BAYEUX TAPESTRY," A BAND OF EMBROIDERY WITH THE STORY OF THE NORMAN CONQUEST OF ENGLAND. In the museum at Bayeux, 11th century work. Scale: $\frac{1}{4}$th.

Plate II.

Fig. 8.—HANGING OF WOOLLEN CLOTH, EMBROIDERED WITH THE FIVE WISE AND THE FIVE FOOLISH VIRGINS.
German work, dated 1598. Scale: $\frac{1}{10}$th.

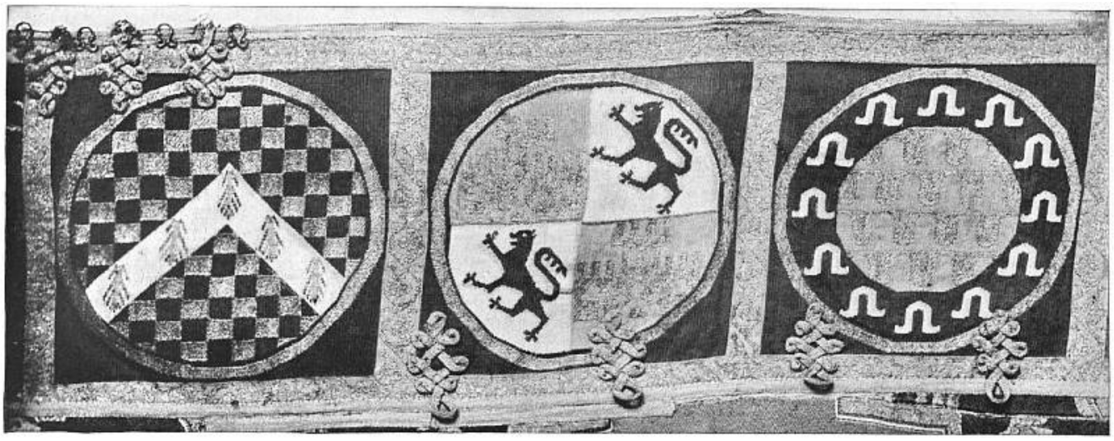

Fig. 9.—PORTION OF THE ORPHREY OF THE “SYON COPE,” EMBROIDERED WITH SHIELDS OF ARMS.
The cope, formerly in the monastery of Syon near Isleworth, is now in the Victoria and Albert Museum.
English work of the 13th century. Scale: $^{5}/_{16}$ths.

Fig. 10.—PORTION OF A BAND OF LOOSE LINEN, EMBROIDERED IN WHITE THREAD WITH FIGURES AND ANIMALS.
German work of the later part of the 14th century. Scale: $^{2}/_{7}$ths.

In concerning ourselves solely with those periods of which examples survive, we must pass over a wide gap and begin with the anciently-civilized land of Egypt. The sandy soil and dry climate of that country have led to the preservation of woven stuffs and embroideries of unique historic interest. The principal, and by far the earliest, known pieces which have a bearing on the present subject, found in 1903 in the tomb of Tethmosis (Thoutmôsis, or Thothmes) IV. at Thebes, are now in the Cairo Museum. There are three fragments, entirely of linen, inwrought with patterns in blue, red, green and black (fig. 1). A kind of tapestry method is used, the patterns being wrought upon the warp threads of the ground, instead of upon the finished web or woven material. Such a process, generally supplemented, as in this case, by a few stitches of fine needlework, was still in common use at a far later time. The largest of the three fragments at Cairo bears, in addition to rows of lotus flowers and papyrus inflorescences, a cartouche containing the name of Amenophis (Amenhotep) II. (*c.* 15th century B.C.); another is inwrought with the name of Tethmosis III. (*c.* 16th century B.C.).[1]

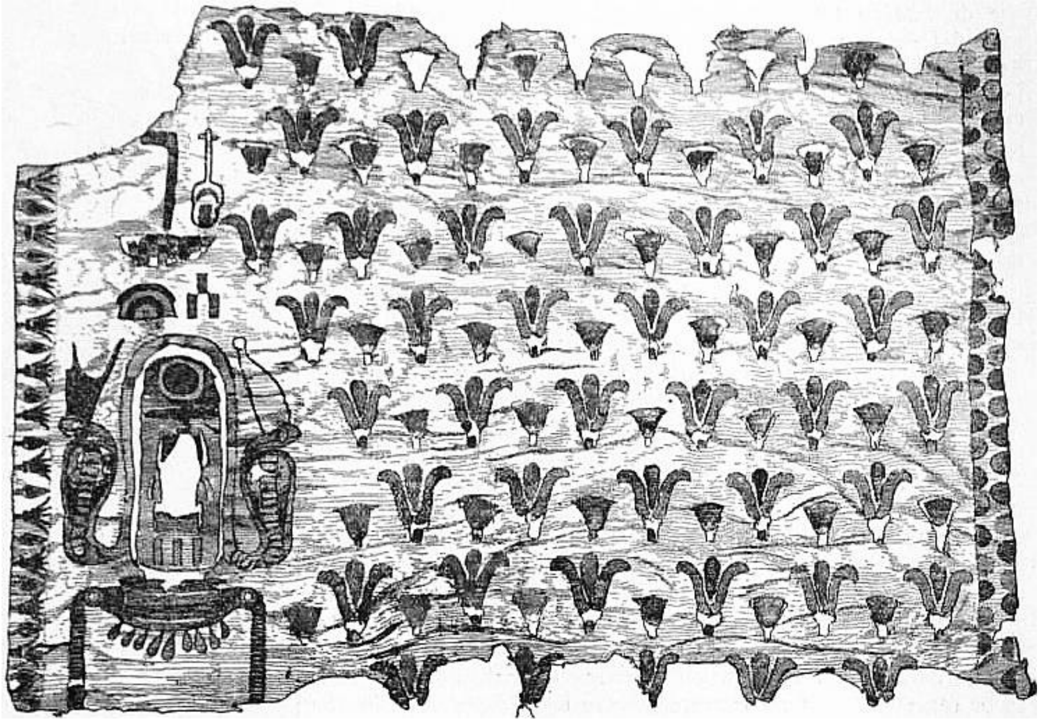

FIG. 1.—Fragment of a linen robe, found in the tomb of Tethmosis (Thothmes) IV. at Thebes, and now in the Cairo Museum. The cartouche has the name of Amenophis (Amenhotep) II. (*c.* 15th century B.C.).

No other embroidered stuffs which can be assigned to so early a date have hitherto come to light in the Nile valley (nor indeed elsewhere), and the student who wishes to gain a fuller knowledge of the textile patterns of the ancient Egyptians must be referred to the wall-paintings and sculptured reliefs which have been preserved in considerable numbers.

From the ancient civilizations of Babylon and Assyria no fragments of embroidery, nor even of woven stuffs, have come down to us. The fine series of wall-reliefs from Nineveh in the British Museum give some idea of the geometrical and floral patterns and diapers which adorned the robes of the ancient Assyrians. The discovery of the ruins of the palace of Darius I. (521-485 B.C.) at Susa in 1885 has thrown some light upon the textile art of the ancient Persians. They evidently owed much to the nations whom they had supplanted. The famous relief from this palace (now in the Louvre) represents a procession of archers, wearing long robes covered with small diaper patterns, perhaps of embroidery.

The exact significance of the words used in the book of Exodus in describing the robes of Aaron (ch. xxviii.) and the hangings and ornaments of the Tabernacle (ch. xxvi.) cannot be determined, and the "broidered work" of the prophecy of Ezekiel (ch. xxvii.) at a later time is also of uncertain meaning. It seems likely that much of this ancient work was of the tapestry class, such as we have found in the early fragments from Thebes.

The methods of the ancient Greek embroiderer, or "variegator" (ποικιλτής) to whom woven garments were submitted for enrichment, can only be conjectured. The *peplos* or woven cloth made every fifth year to cover or shade the statue of Athena in the Parthenon at Athens, and carried at the Panathenaic festival,[2] was ornamented with the battles of the gods and giants. The late Dr J.H. Middleton thought that very possibly most of the elaborate work upon these *peploi* was done by the needle. That true embroidery, in the modern sense—the decoration by means of the needle of a finished woven material—was practised among the ancient Greeks, has been demonstrated by the finding of some textile fragments in graves in the Crimea; these are now in the Hermitage at St Petersburg. One of them, of purple woollen material, from a tomb assigned to the 4th century B.C., is embroidered in wools of different colours with a man on horseback, honeysuckle ornament and tendrils. Another woollen piece, attributed to the following century, has a stem and arrow-head leaves worked in gold thread.[3] 310

In turning to ancient Rome, it is well first briefly to notice Pliny's account of the craft (*Nat. Hist.* viii.), as recording the views current in Rome at his time (1st century A.D.). After relating that Homer mentions embroidered garments (*pictas vestes*), he states that the Phrygians first used the needle for embroidered robes, which were thence called Phrygionian (*Phrygioniae*), and that Attalic garments were named from Attalus II., king of Pergamum (159-138 B.C.), the inventor of the art of embroidering in gold. He further relates that Babylon gave the name to embroideries of divers colours, for the production of which that city was famous. By the Romans the art was designated as "painting with the needle" (*acu pingere*), a term used by Virgil in speaking of the decoration of robes, by Ovid (who describes it as an art taught by Minerva), and by Roman writers generally when referring to embroidery.[4] It is to be regretted that no examples have been discovered in the neighbourhood of the Roman capital. For embroideries made under Roman influence we must again look to Egypt. They formed the decoration of garments[5] and mummy-wrappings from the cemeteries in Upper and Middle Egypt, which have been so extensively rifled of late years. Those of Roman type date approximately from the first five centuries of the Christian era. The earliest represent human figures, animals, birds, geometrical and interlacing ornaments, vases, fruit, flowers and foliage (especially the vine). They are generally done in purple wool and undyed linen thread by the tapestry process employed in Egypt at least fifteen centuries earlier, as we have seen; most of the patterns have had the lines more clearly marked out by the ordinary method of needlework. Towards the end of this period a greater choice of colours is seen, and Christian symbols appear. At this time examples worked entirely upon the finished web are found (fig. 2). The transition is easy from such work to the veritable "needle-paintings," representing scenes from the gospels, produced in Egypt shortly after (fig. 3). Such embroideries are evidently akin to those mentioned by Bishop Asterius (330-410), who describes the garments worn by effeminate Christians as painted like the walls of their houses.[6]

From the time of Justinian (527-565) onwards for some centuries, the art of Europe, embroidery with the rest, was dominated by that of the Byzantine empire. To trace the progress of the highly conventionalized Byzantine style, becoming more rigid and stereotyped as time passes, belongs to the general history of art, and such a task cannot be attempted here. Perhaps the most remarkable example of all which have survived to illustrate the work of the Byzantine embroiderers is the blue silk robe known as the dalmatic of Charlemagne or of Leo III., in the sacristy of St Peter's at Rome (fig. 4). According to the present consensus of opinion it belongs to a later time than either of those dignitaries, dating most probably from the 12th century.[7] In front is represented Christ enthroned as Judge of the world, a youthful but majestic figure; on the back is the Transfiguration. These, as well as the minor subjects, are explained by Greek inscriptions. The wide influence of Byzantine art gradually died out after the Latin sack of Constantinople in the year 1204, although the style lingered, and lingers still, in certain localities, notably at Mount Athos.

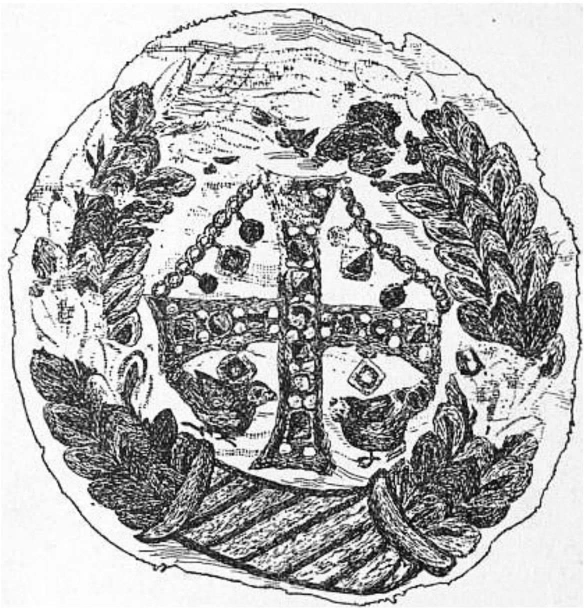

Fig. 2.—Embroidered panel from a linen garment, with a jewelled cross and two birds within a wreath. Found in a cemetery at Akhmīm, Upper Egypt. Egypto-Roman work of the 4th or 5th century A.D.

Fig. 3.—Embroidered panel from a linen garment, with a representation of the Annunciation and the Salutation. Found in a cemetery in Egypt. Coptic work of the 6th or 7th century A.D.

Palermo in Sicily succeeded Byzantium as the capital of the arts in Europe, although its ascendancy was of brief duration. Under the Norman kings of Sicily the style was strongly oriental, consequent upon the earlier occupation of the island by the Saracens, and upon the employment of Saracenic craftsmen by the Normans. The magnificent red silk mantle at Vienna, embroidered in gold thread with a date-palm and two lions springing upon camels, and enriched with pearls and enamel plaques, bears round the edge an Arabic inscription, recording that it was made in the royal factory of the capital of Sicily (Palermo) in the year 528 (= A.D. 1134). At that time Roger, the first Norman king, was on the throne. Another of the imperial coronation-robes—a linen alb with gold embroidery—is also at Vienna.[8] An inscription in Latin and Arabic states that it was made in the year 1181, under the reign of William II. (Norman king of Sicily, 1166-1189).

Fig. 4.—Embroidered robe known as the "Dalmatic of Charlemagne," or of Leo III., preserved in the sacristy of St Peter's at Rome. Byzantine work, probably of the 12th century.

From about that time distinct national styles began to develop in different places. In tracing the progress of the embroiderer's art during the middle ages we must rely mainly upon the many fine examples of ecclesiastical work which have been preserved. The costumes of men and women, as well as curtains and hangings and such articles of domestic use, were often richly adorned with embroidery. These have mostly perished; while the careful preservation and comparatively infrequent use of the vestments and other objects devoted to the service of the church have given us tangible evidence of the attainments of the medieval embroiderer. Much of this work was produced in convents, but old documents show that in monasteries also were to be found men known for their skill in needlework. Other names, both of men and women, are recorded, showing that the craft was by no means exclusively confined to monastic foundations. Gilds of embroiderers existed far back in medieval times.

In England the craft has been a favourite employment for many centuries, and persons of all ranks have occupied their spare hours at needlework. Some embroidered fragments, found in 1826-1827 in the tomb of St Cuthbert at Durham, and now kept in the cathedral library, were worked, chiefly in gold thread, by order of Ælfflæda, queen of Edward the Elder, for Fridestan, bishop of Winchester, early in the 10th century. In the later part of the following century the "Bayeux tapestry" was produced—a work of unique importance (Plate I. fig. 7). It is a band of linen, more than 230 ft. long, embroidered in coloured wools with the story of the Norman conquest of England. (See Bayeux Tapestry.)

Some fragments of metallic embroidery on silk, of the 12th and 13th centuries, may be seen in the library of Worcester cathedral. They were removed from the coffins of two bishops, William de Blois (1218-1236) and Walter de Cantelupe (1236-1266). A fragment of gold embroidery from the tomb of the latter bishop is preserved in the Victoria and Albert Museum at South Kensington, and others are in the British Museum. In the 13th century English embroidery was famous throughout western Europe, and many embroidered objects are described in inventories of that time as being *de opere anglicano*. During that century, and the early part of the next, English work was at its best. The most famous example is the "Syon cope" at South Kensington, belonging to the latter half of the 13th century (see Cope, Plate I. fig. 2). It represents the coronation of the Virgin, the Crucifixion, the archangel Michael transfixing the dragon, the death and burial of the Virgin, our Lord meeting Mary

Magdalene in the garden, the Apostles and the hierarchies of angels. The broad orphrey is embroidered with a series of heraldic shields (Plate II. fig. 9). Other embroideries of the period are at Steeple Aston, Chesterfield (Col. Butler-Bowden), Victoria and Albert and British museums, Rome (St John Lateran), Bologna, Pienza, Anagni, Ascoli, St Bertrand de Comminges, Lyons museum, Madrid (archaeological museum), Toledo and Vich.

During the course of the 14th and 15th centuries embroideries produced in England were not equal to the earlier work. Towards the end of the latter century, and until the dissolution of the monasteries in the next, much ecclesiastical embroidery of effective design was done, and many examples are still to be seen in churches throughout the country. In the Tudor period the costumes of the wealthy were often richly adorned with needlework. The portraits of King Henry VIII., Queen Elizabeth and their courtiers show how magnificent was the embroidery used for such purposes. Many examples, especially of the latter reign, worked with very effective and beautiful floral patterns, have come down to these times. A kind of embroidery known as “black work”, done in black silk on linen, was popular during the same reign. A tunic embroidered for Queen Elizabeth, with devices copied from contemporary woodcuts, is an excellent example of this work. It now belongs to the Viscount Falkland. Another class of work, popular at the same time, was closely worked in wools and silks on open-mesh material like canvas, which was entirely covered by the embroidery. Figures in rich costume were often introduced (Plate I. fig. 6). This method was much practised in France, and the term applied to it in that country, “*au petit point*,” has become generally used. Throughout the 17th and 18th centuries embroidery in England, though sometimes lacking in good taste, maintained generally a high standard, and that done to-day, based on the study of old examples, need not fear comparison with any modern work. During these three centuries bold floral patterns for hangings, curtains and coverlets have been usual (Plate III. fig. 13), but smaller works, such as samplers, covers of work-boxes, and pictorial and landscape subjects (fig. 5), have been produced in large numbers. In the 18th century gentlemen’s coats and waistcoats and ladies’ dresses were extensively embroidered.

In France, embroidery, like all the arts practised by that nation, has been characterized by much grace and beauty, and many good specimens belonging to different periods are known. The vestments associated with the name of St Thomas of Canterbury at Sens may be either of French or English work (12th century). To the later part of the following century belongs a band of embroidery, representing the coronation of the Virgin, the Adoration of the Magi, the presentation in the Temple, and other subjects beneath Gothic arches, preserved in the Hôtel-Dieu at Château Thierry. The mitre of Jean de Marigny, archbishop of Rouen (1347-1351), in the museum at Évreux, embroidered with figures of St 312
Peter and St Eloy, may be regarded as representative of 14th-century work. An altar-frontal with the Annunciation embroidered in silks and gold and silver upon a blue silk damask ground, now in the museum at Lille, is a very beautiful example of Franco-Flemish art in the second half of the 15th century. It was originally in the church at Noyelles-lez-Seclin. An embroidery more characteristically French, and belonging to the same century, is in the museum at Chartres. It is a triptych, having in the middle a *pietà*, on the left wing St John the Evangelist, and on the right St Catherine of Alexandria. Each leaf has a canopy of architecture represented in perspective. In the 16th century an effective style of embroidery was practised in France; the pattern is generally a graceful combination of floral and scroll forms, cut out of velvet, satin or silk, and applied to a thick woollen cloth. Later work, chiefly of a floral character, has served for the decoration of costumes, ecclesiastical vestments, curtains and hangings, and the seats and backs of chairs.

Fig. 5.—Oval picture in silk embroidery: Fame scattering Flowers over Shakespeare’s Tomb. English work of the 18th century.

Under the rule of the dukes of Burgundy in the 15th century art in the southern provinces of the Netherlands prospered greatly, and able artists were found to meet the wishes of those munificent rulers. The local schools of painting, which flourished under their patronage, appear to have very considerably influenced the embroiderers' art. Great care and pains were given to reproduce as accurately as possible the painted cartoon or picture which served as the model. The heads are individualized, and the folds of the draperies are laboriously worked out in detail. The masonry of buildings, the veinings of marble, and the architectural enrichments are often represented with careful fidelity, and landscape backgrounds are shown in every detail. As in the case of the tapestries of the Netherlands—the finest which the world has seen—there can be no doubt that patrons of art and donors, when requiring embroideries to be made, secured the services of eminent painters for the designs. There are many examples of such careful work. A set of vestments known as the *ornement de la Toison d'Or*, now in the Hof-museum at Vienna, is embroidered in the most minute manner with sacred subjects and figures of saints and angels. The stiff disposal of many of these figures, within flattened hexagons arranged in zones, is not pleasing, but the needlework is most remarkable for skill and carefulness. They are of 15th-century work. A cope belonging to the second half of that century was given to the cathedral of Tournay by Guillaume Fillatre, abbot of St Bertin at St Omer, and bishop of Tournay (d. 1473). It is now in the museum there. Upon the orphreys and hood are represented the seven Works of Mercy. The body of the cope, of plain red velvet, is powdered with stags' heads and martlets (the heraldic bearings of the bishop); between the antlers of the stags is worked in each case the initial letter of the bishop's name, and the morse is embroidered with his arms. Some panels of embroidery, once decorating an altar in the abbey of Grimbergen, and now at Brussels, illustrate the best class of Flemish needlework in the 16th century. The scenes are taken from the Gospel: the marriage at Cana, Christ in the house of the Pharisee, Christ in the house of Zacchaeus, the Last Supper, and the supper at Emmaus. In the museum at Bern there are some embroideries of great historic and artistic interest, found in the tent of Charles the Bold, duke of Burgundy, after his defeat at Granson in 1476. They include some armorial panels and two tabards or heralds' coats. A tabard of the following century, with the royal arms of Spain in applied work, and most probably of Flemish origin, is preserved in the archaeological museum at Ghent.

The later art of Holland was largely influenced by the Dutch conquests in the East Indies at the end of the 16th century, and the subsequent founding of the Dutch East India Company. Embroideries were among the articles produced in the East under Dutch influence for exportation to Holland.

Much embroidery for ecclesiastical purposes has been executed in Belgium of late years. It follows medieval models, but is lacking in the qualities which make those of so much importance in the history of the art.

There is perhaps little worthy of special notice in Italy before the beginning of the 14th century, but the embroideries produced at that time show great skill and are very beautiful. The names of two Florentine embroiderers of the 14th century—both men—have come down to us, inscribed upon their handiwork. A fine frontal for an altar, very delicately worked in gold and silver and silks of many colours, is preserved in the archaeological museum at Florence. The subject in the middle is the coronation of the Virgin; on either side is an arcade with figures of apostles and saints. The embroiderer's name is worked under the central subject: *Jacobus Cambi de Florētia me fecit MCCCXXXVIII.* The other example is in the basilica at Manresa in Spain. It also is an altar-frontal, worked in silk and gold upon an embroidered gold ground. There is a large central panel representing the Crucifixion, with nine scenes from the Gospel on each side. The embroidered inscription is as follows: *Geri Lapi rachamatore me fecit in Florentia.* It is of 14th-century work. An embroidered orphrey in the Victoria and Albert Museum belongs to the early part of the same century. It represents the Annunciation, the coronation of the Virgin and figures of apostles and saints beneath arches. In the spandrels are the orders of angels with their names in Italian. In the best period of Italian art successful painters did not disdain to design for embroidery. Francesco Squarcione (1394-1474), the founder of the Paduan school of painting, and master of Mantegna, is called in a document of the year 1423 a tailor and embroiderer (*sartor et recamator*). It is recorded that Antonio del Pollaiuolo painted cartoons which were carried out in embroidery,[9] and Pierino del Vaga, according to Vasari, did likewise. In the 16th and 17th centuries large numbers of towels and linen covers were embroidered in red, green or brown silk with borders of floral patterns, sometimes (especially in the southern provinces) combined with figure subjects and bird and animal forms (Plate IV. fig. 15). Another type of embroidery popular at the same time, both in Italy and Spain, is known as appliqué (or applied) work. The pattern is cut out and applied to a bright-coloured ground, frequently of velvet, as in the example illustrated (Plate III. fig. 14). The later embroidery of Sicily follows that of the mainland. A remarkable coverlet, quilted and padded with wool so as to throw the design into relief, is shown to be of Sicilian origin by the inscriptions which it bears (Plate VI. fig. 18). It represents scenes from the story of Tristan, agreeing in the main part with the *novella* entitled "La Tavola Rotonda o l'istoria di Tristano." The quilt dates from the end of the 14th century. Many pattern-books for embroidery and lace were published in Italy in the 16th and 17th centuries.[10] 313

Plate III.

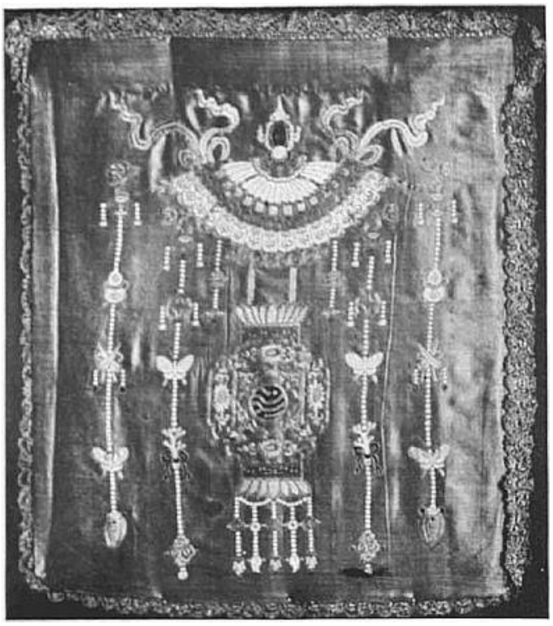

Fig. 11.—SILK PANEL, EMBROIDERED WITH A HANGING LANTERN.
Chinese work of the 17th or 18th century. Scale: ¼th.

Fig. 12.—PORTION OF A LARGE HANGING, EMBROIDERED WITH FIGURES WITHIN MEDALLIONS, AND INSCRIPTIONS.
From a church in Iceland, probably 17th century. Scale: ⅛th.

Fig. 13.—PORTION OF A BED-HANGING, EMBROIDERED WITH FLOWERING TREES GROWING FROM MOUNDS.
English work of the later part of the 17th century. Scale: 1⁄12th.

Fig. 14.—APPAREL FOR A DALMATIC OF GREEN VELVET, EMBROIDERED WITH AN APPLIQUÉ PATTERN.
Italian work of the 16th century. Scale: ¼th.

Plate IV.

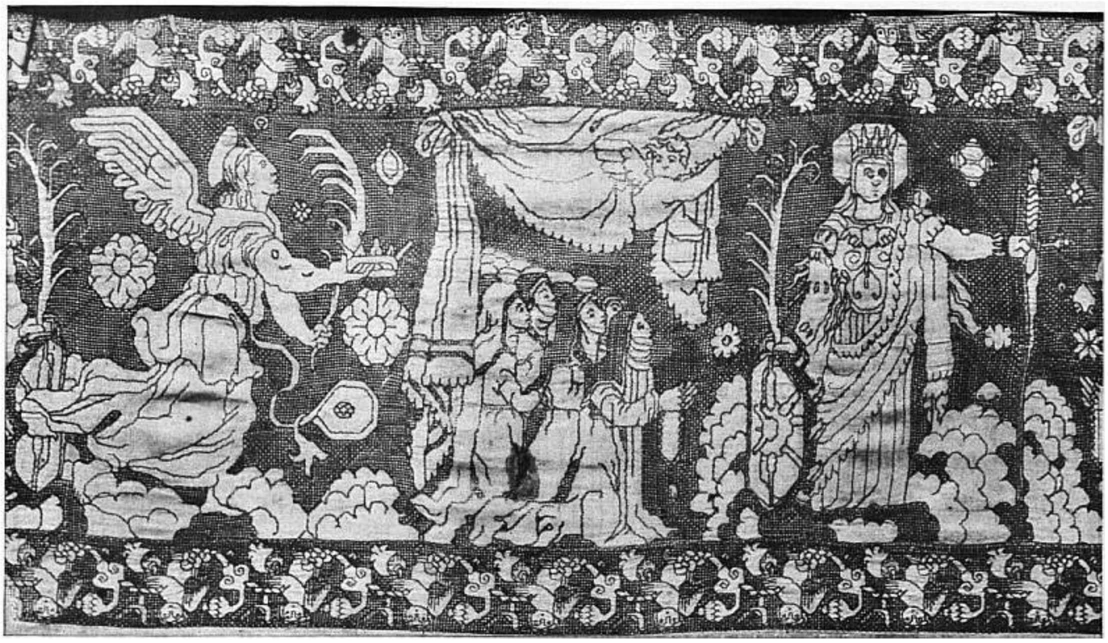

Fig. 15.—PORTION OF THE BORDER OF A LINEN COVER, EMBROIDERED WITH A FIGURE OF ST CATHERINE OF ALEXANDRIA AND KNEELING VOTARIES. Italian work of the 16th century. Scale: $\frac{2}{5}$ths.

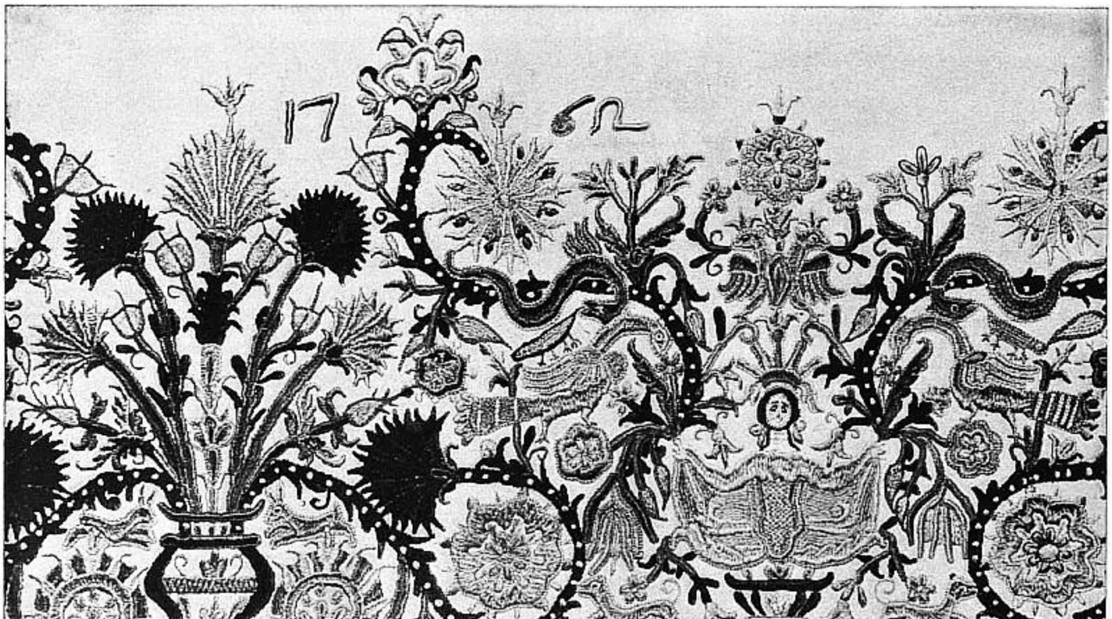

Fig. 16.—LINEN BORDER, EMBROIDERED WITH DEBASED FIGURES, BIRDS AND ANIMALS AMID FLOWERS. Cretan work, dated 1762. Scale: $\frac{4}{9}$ths.

In the greater part of the Spanish peninsula art was for many centuries dominated by the Arabs, who overran the country in the 8th century, and were not finally subdued until the end of the 15th. Hispano-Moorish embroideries of the medieval period usually have interlacing patterns combined with Arabic inscriptions. In the 15th and 16th centuries Italian influence becomes evident. Later the effects of the Spanish conquests in Asia are seen. Eastern influence is, however, stronger in the case of the Portuguese, who seized Goa, on the west coast of the Indian peninsula, early in the 16th century, and during the whole of that century held the monopoly of the eastern trade. Many large embroideries were produced in the Indies, showing eastern floral patterns mingled with representations of Europeans, ships and coats of arms. Embroideries done in Portugal in the 16th and 17th centuries strongly reflect the influence of oriental patterns.

German embroidery of the 12th and 13th centuries adheres closely to the traditions of Byzantine art. A peculiarity of much medieval German work is a tendency to treat the draperies of the figures as flat surfaces to be covered with diaper patterns, showing no folds. A cope from Hildesheim cathedral, now in the Victoria and Albert Museum, is a typical illustration of such work, dating from the end of the 13th century. It is embroidered in silk upon linen with the martyrdom of apostles and saints. Other specimens of embroidery in this manner may be seen at Halberstadt. An altar-frontal from Rupertsburg (Bingen), belonging to the earlier years of the 13th century, is now in the Brussels museum. It is of purple silk, embroidered with Christ in majesty and figures of saints. It was no doubt made in the time of Siegfried, archbishop of Mainz (1201-1230), who is represented upon it. A type of medieval German embroidery is done in white linen thread on a loose linen ground—a sort of darning-work (Plate II. fig. 10). Earlier specimens of this work are often diversified by using a variety of stitches tending to form diaper patterns. The use of long scrolling bands with inscriptions explaining the subjects represented is more usual in German work than in that of any other country. In the 15th century much fine embroidery was produced in the neighbourhood of Cologne. Later German work shows a preference for bold floral patterns, sometimes mingled with heraldry; the larger examples are often worked in wool on a woollen cloth ground (Plate II. fig. 8). The embroidery of the northern nations (Denmark, Scandinavia, Iceland) was later in development than that of the southern peoples. Figure subjects evidently belonging to as late a period as the 17th century are still disposed in formal rows of circles, and accompanied by primitive ornamental forms (Plate III. fig. 12). A remarkable early embroidered fabric covers the relics of St Knud (Canute, king of Denmark, 1080-1086) in his shrine in the church dedicated to him at Odense. It is apparently contemporary work. The pattern consists of displayed eagles within oval compartments, in blue on a red ground.

In Greece and the islands of the eastern Mediterranean embroidery has been much employed for the decoration of costumes, portières and bed-curtains. Large numbers have been acquired in Crete (Plate IV. fig. 16), and patterns of a distinctive character are also found in Rhodes, Cos, Patmos and other islands. Some examples show traces of the influence of the Venetian trading settlements in the archipelago in the 16th and 17th centuries. Among the Turks a great development of the arts followed upon the conquest of Asia Minor and the Byzantine territory in Europe. Their embroideries show a preference for floral forms—chiefly roses, tulips, carnations and hyacinths—which are treated with great decorative skill.

The use of embroidery in Asia—especially in India, China, Turkestan and Persia—dates back to very early times. The conservatism of all these peoples renders the date of surviving examples often difficult to establish, but the greater number of such embroideries now to be seen in Europe are certainly of no great age.

India has produced vast quantities of embroideries of varying excellence. The fine woollen shawls of Kashmir are widely famed; their first production is supposed to date back to a remote period. The somewhat gaudy effect of many Indian embroideries is at times intensified by the addition of beetles’ wings, tinsel or fragments of looking-glass. China is the original home of the silkworm, and the textile arts there reached an advanced stage at a date long before that of any equally skilful work in Europe. Embroideries worked there are generally in silk threads on a ground of the same material. Such work is largely used for various articles of costume, and for coverlets, screens, banners, chair-covers and table-hangings. The ornaments upon the robes especially are prescribed according to the rank of the wearer. The designs include elaborate landscapes with buildings and figures, dragons, birds, animals, symbolic devices, and especially flowers (Plate III. fig. 11). Dr Bushell states that the stuff to be embroidered is first stretched upon a frame, on pivots, and that pattern-books with woodcuts have been published for the workers’ guidance. A kind of embroidery exported in large quantities from Canton to Europe rivals painting in the variety and gradation of its colours, and in the smoothness and regularity of its surface.

Embroidery in Japan resembles in many ways that of China, the country which probably supplied its first models. As a general rule, Japanese work is more pictorial and fanciful than that of China, and the stitching is looser. It frequently happens that the brush has been used to add to the variety of the embroidered work, and in other cases the needle has been an accessory upon a fabric already ornamented with printing or painting. Japanese work is characterized generally by bold and broad treatment, and especial skill is shown in the representation of landscapes—figures, rocks, waterfalls, animals, birds, trees, flowers and clouds being each rendered by a few lines. More elaborate are the large temple hangings, the pattern being frequently thrown into relief, and completely covering the ground material.

Embroidery in Persia has been used to a great extent for the decoration of carpets, for prayer or for use at the bath (Plate V. fig. 17). Robes, hangings, curtains, tablecovers and portières are also embroidered. A preference is shown for floral patterns, but the Mahommedans of Persia had no scruples about introducing the forms of men and animals—the former engaged in hawking or hunting, or feasting in gardens. Panels embroidered with close diagonal bands of flowers were made into loose trousers for women, now obsolete. The embroidered shawls of Kerman are widely celebrated. Hangings and covers of cloth patchwork have been embroidered in many parts of Persia, more particularly at Resht and Ispahan.

In Turkestan, and especially at Bokhara, excellent embroideries have been, and are, produced, some patterns being of a bold floral type, and others conventionalized into hooked and serrated outlines. The work is most usually in bright-coloured silks, red predominating, on a linen material.

In North Africa the embroidery of Morocco and Algeria deserves notice; the former inclines more to geometrical forms and the latter to patterns of a floral character.

Plate V.

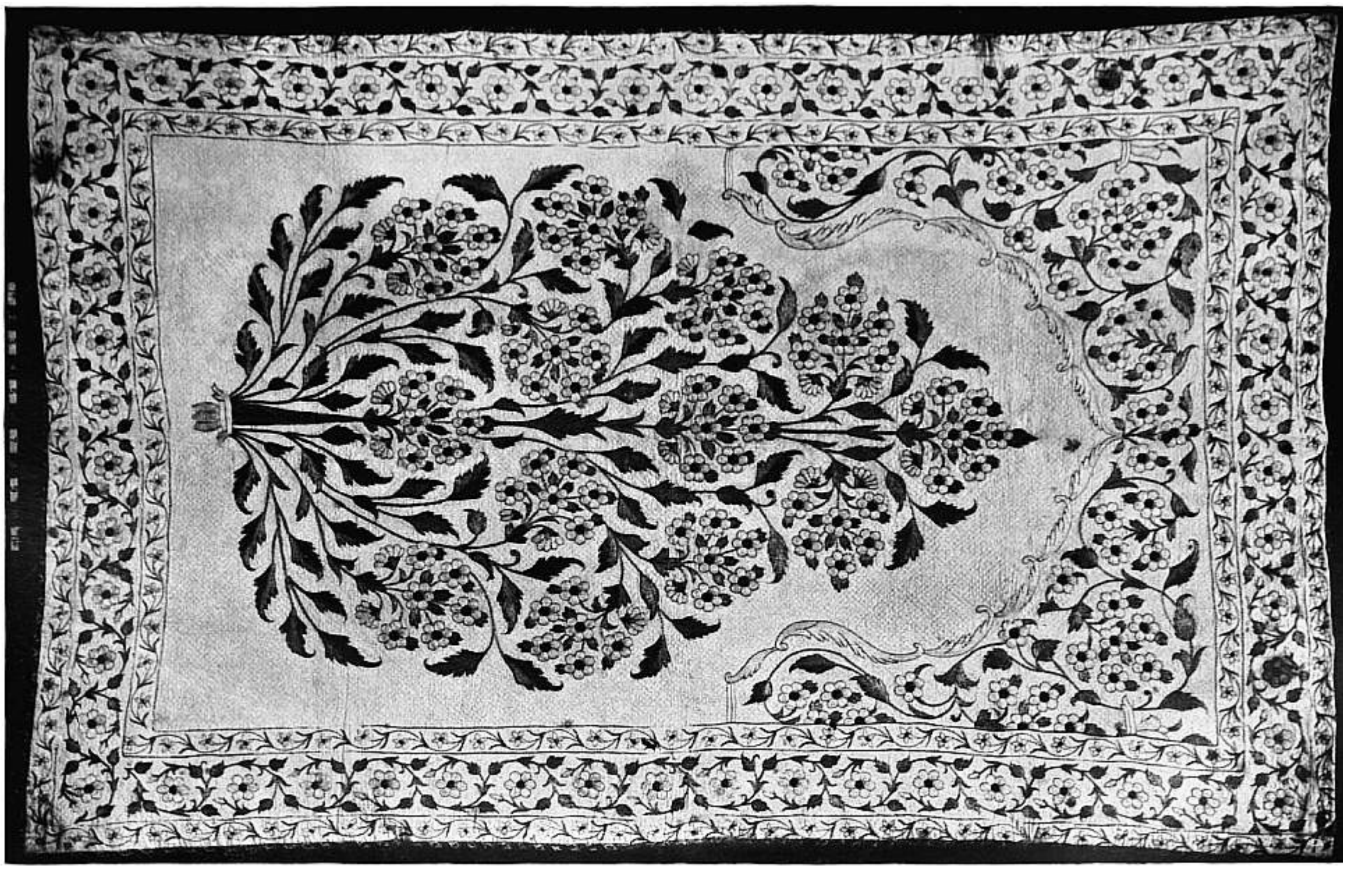

Fig. 17.—LINEN PRAYER CARPET, QUILTED AND EMBROIDERED IN CHAIN STITCH WITH COLOURED SILKS, CHIEFLY WHITE, YELLOW, GREEN AND RED.

The border consists of a wide band set between two narrow ones, each with a waved continuous stem with blossoms in the wavings. Similar floral scrolling and leafy stem ornament fills the space beyond the pointed shape at the upper end, which is edged with acanthus leaf devices. The main ground below the niche or pointed shape is a blossoming plant, with balanced bunches of flowers between which are leaves, formally arranged in a pointed oval shape. Persian work, 18th century, 4 ft. 6 in. × 2 ft. 11 in. (Victoria and Albert Museum.)

Plate VI.

FIG. 18.—PART OF A SICILIAN COVERLET, OF THE END OF THE 14TH CENTURY.

It is of white linen, quilted and padded in wool so as to throw the design into relief. The scenes represented, taken from the Story of Tristan, with inscriptions in the Sicilian dialect, are as follows:—(1) COMU: LU AMOROLDU FA BANDIRI: LU OSTI: IN CORNUUALGIA (How the Morold made the host to go to Cornwall); (2) COMU: LU RRE: LANGUIS: CUMANDA: CHI UAIA: LO OSTI. CORNUAGLIA (How King Languis ordered that the host should go to Cornwall); (3) COMU: LU RRE: LANGUIS: MANDA: PER LU TRABUTU IN CORNUALIA (How King Languis sent to Cornwall for the tribute); (4) COMU: (LI M) ISSAGIERI: SO UINNTI: AL RRE: MARCU: PER LU TRIBUTU DI SECTI ANNI (How the ambassadors are come to King Mark for the tribute of seven years); (5) COMU: LU AMOROLDU UAI: IN CORNUUALGIA (How the Morold comes to Cornwall); (6) COMU: LU AMOROLDU: FA SULDARI: LA GENTI (How the Morold made the people pay); (7) COMU: T(RISTAINU): DAI: LU GUANTU ALLU AMOROLDU DELA BACTAGLIA (How Tristan gives the glove of battle to the Morold); (8) COMU: LU AMOROLDU: E UINUTU: IN CORNUUALGIA: CUM XXXX GALEI: (How the Morold is come to Cornwall with forty galleys); (9) COMU TRISTAINU BUCTA: LA UARCA: ARRETU: INTU: ALLU MARU (How Tristan struck his boat behind him into the sea); (10) COMU: TRISTAINU: ASPECTA: LU AMOROLDU: ALLA ISOLA DI LU MARU: SANSA UINTURA (How Tristan awaits the Morold on the isle Sanza Ventura in the sea); (11) COMU: TRISTAINU FERIU LU AMOROLLDU IN TESTA (How Tristan wounded the Morold in the head); (12) COMU: LU INNA (?) DELU AMOROLDU: ASPECTTAUA LU PATRUNU (How the Morold's page (?) awaited his master); (13) COMU LU AMORODU FERIU: TRISTAINU A TRADIMANTU (How the Morold wounded Tristan by treachery); (14) ... SITA: IN AIRLANDIA (... in Ireland).

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1868); M. Dreger, *Künstlerische Entwicklung der Weberei und Stickerei* (Vienna, 1904); Madame I. Errera, *Collection de broderies anciennes* (Brussels, 1905); L. de Farcy, *La Broderie* (Paris, 1890); R. Forrer, *Die Gräber und Textilfunde von Achmim-Panopolis* (Strassburg, 1891); F.R. Fowke, *The Bayeux Tapestry* (London, 1898); Rev. C.H. Hartshorne, *On English Medieval Embroidery* (*ib.*, 1848); M.B. Huish, *Samplers and Tapestry Embroideries* (*ib.*, 1900); A.F. Kendrick, *English Embroidery* (*ib.*, 1905); *English Embroidery executed prior to the Middle of the 16th Century* (Burlington Fine Arts Club Exhibition, 1905, introduction by A.F. Kendrick); E. Lefebure, *Embroideries and Lace*, translated by A.S. Cole, C.B. (London, 1888); F. Marshall, *Old English Embroidery* (*ib.*, 1894); E.M. Rogge, *Moderne Kunst-Nadelarbeiten* (Amsterdam, 1905); South Kensington Museum, *Catalogue of Special Loan Exhibition of Decorative Art Needlework* (1874); W.G.P. Townshend, *Embroidery* (London, 1899).

For further examples of ecclesiastical embroidery see the articles CHASUBLE, COPE, DALMATIC and MITRE.
(A. F. K.; A. S. C.)

1 See H. Carter and P.E. Newberry, *Cat. gén. des ant. égypt. du musée du Caire* (*1904*), pl. i. and xxviii. A remarkable piece of Egyptian needlework, the funeral tent of Queen Isi em Kheb (XXIst Dynasty), was discovered at Deir el Bahri some years ago. It is described as a mosaic of leatherwork—pieces of gazelle hide of several colours, stitched together (see Villiers Stuart, *The Funeral Tent of an Egyptian Queen, 1882*).

2 The procession at this festival is represented upon the frieze of the Parthenon.

3 See *Compte rendu de la Comm. Imp. Arch., 1878-1879* (St Petersburg), pl. iii. and v.

4 For an account of the conditions under which Greek and Roman embroiderers worked, see Alan S. Cole, "Some Aspects of Ancient and Modern Embroidery," *Journal of the Society of Arts*, vol. liii., 1905, pp. 958, 959.

5 Chiefly tunics with vertical bands (*clavi*) and medallions (*orbiculae*), and an ample outer robe or cloak.

6 The Adoration of the Magi is represented upon the lower border of the long robe worn by the empress Theodora (wife of Justinian) in the mosaic in the church of S. Vitale at Ravenna.

7 Writers have assigned different dates to this vestment: Lady Alford, *Needlework as Art* (earlier than the 13th century); F. Bock, *Die Kleinodien* (12th century); S. Boisserée, *Über die Kaiser-Dalmatica in der St Peterskirche zu Rom* (12th or first half of 13th century); A.S. Cole, *Cantor Lectures at Society of Arts, 1905* (possibly of 9th century); Lord Lindsay, *Christian Art* (12th or early 13th century); A. Venturi, *Storia dell' arte* (10th or 11th century); T. Braun, *Liturg. Gewandung*, p. 305 and note (late 14th or early 15th century).

8 Both are illustrated in F. Bock, *Die Kleinodien*.

9 Some embroideries from vestments, designed by Pollaiuolo, are still preserved in the Museo dell' Opera del Duomo, Florence.

10 Others, sometimes with the same illustrations, appeared in France and Germany, and no doubt forwarded the general tendency towards Italian models at the time. A few pattern-books were also published in England.

EMBRUN, a town in the department of the Hautes Alpes in S.E. France. It is built at a height of 2854 ft. on a plateau that rises above the right bank of the Durance. It is 27½ m. by rail from Briançon and 24 m. from Gap. Its ramparts were demolished in 1884. In 1906 the communal pop. (including the garrison) was 3752. Besides the Tour Brune (11th century) and the old archiepiscopal palace, now occupied by government offices, barracks, &c., the chief object of interest in Embrun is its splendid cathedral church, which dates from the second half of the 12th century. Above its side door, called the *Réal*, there existed till 1585 (when it was destroyed by the Huguenots) a fresco, probably painted in the 13th century, representing the Madonna: this was the object of a celebrated pilgrimage for many centuries. Louis XI. habitually wore on his hat a leaden image of this Madonna, for which he had a very great veneration, since between 1440 and 1461, during the lifetime of his father, he had been the dauphin, and as such ruler of this province.

Embrun was the *Eburodunum* or *Ebredunum* of the Romans, and the chief town of the province of the Maritime Alps. The episcopal see was founded in the 4th century, and became an archbishopric about 800. In 1147 the archbishops obtained from the emperor Conrad III. very extensive temporal rights, and the rank of princes of the Holy Roman Empire. In 1232 the county of the Embrunais passed by marriage to the dauphins of Viennois. In 1791 the archiepiscopal see was suppressed, the region being then transferred to the diocese of Gap, so that the once metropolitan cathedral church is now simply a parish church. The town was sacked in 1585 by the Huguenots and in 1692 by the duke of Savoy. Henri Arnaud (1641-1721), the Waldensian pastor and general, was born at Embrun.

See A. Albert, *Histoire du diocèse d'Embrun* (2 vols., Embrun, 1783); M. Fornier, *Histoire générale des Alpes Maritimes ou Cottiennes et particulière de leur métropolitaine Embrun* (written 1626-1643), published by the Abbé Paul Guillaume (3 vols., Paris and Gap, 1890-1891); A. Fabre, *Recherches historiques sur le pèlerinage des rois de France à N.D. d'Embrun* (Grenoble, 1859); A. Sauret, *Essai historique sur la ville d'Embrun* (Gap, 1860).

(W. A. B. C.)

EMBRYOLOGY. The word embryo is derived from the Gr. ἔμβρυον, which signified the fruit of the womb before birth. In its strict sense, therefore, embryology is the study of the intrauterine young or embryo, and can only be pursued in those animals in which the offspring are retained in the uterus of the mother until they have acquired, or nearly acquired, the form of the parent. As a matter of fact, however, the word has a much wider application than would be gathered from its derivation. All animals above the Protozoa undergo at the beginning of their existence rapid growth and considerable changes of form and structure. During these changes, which constitute the development of the animal, the young organism may be incapable of leading a free life and obtaining its own food. In such cases it is either contained in the body of the parent or it is protruded and lies quiescent within the egg membranes; or it may be capable of leading an independent life, possessing in a functional condition all the organs necessary for the maintenance of its existence. In the former case the young organism is called an *embryo*,[1] in the latter a *larva*. It might thus be concluded that embryology would exclude the study of larvae, in which the whole or the greater part of the development takes place outside the parent and outside the egg. But this is not the case; embryology includes not only a study of embryos as just defined, but also a study of larvae. In this way the scope of the subject is still further widened. As long as embryology confines its attention to embryos, it is easy to fix its limits, at any rate in the higher animals. The domain of embryology ceases in the case of viviparous animals at birth, in the case of oviparous animals at hatching; it ceases as soon as the young form acquires the power of existing when separated from the parent, or when removed from the protection of the egg membranes. But as soon as post-embryonic developmental changes are admitted within the scope of the subject, it becomes on close consideration difficult to limit its range. It must include all the developmental processes which take place as a result of sexual reproduction. A man at birth, when he ceases to be an embryo, has still many changes besides those of simple growth to pass through. The same remark applies to a young frog at the metamorphosis. A chick even, which can run about and feed almost immediately after hatching, possesses a plumage very different from that of the full-grown bird; a starfish at the metamorphosis is in many of its features quite different from the form with which we are familiar. It might be attempted to meet this difficulty by limiting embryology to a study of all those changes which occur in the organism before the attainment of the adult state. But this merely shifts the difficulty to another quarter, and makes it necessary to define what is meant by the adult state. At first sight this may seem easy, and no doubt it is not difficult when man and the higher animals alone are in question, for in these the adult state may be defined comparatively sharply as the stage of sexual maturity. After that period, though changes in the organism still continue, they are retrogressive changes, and as such might fairly be excluded from any account of development, which clearly implies progression, not retrogression. But, as so often happens in the study of organisms, formulae which apply quite satisfactorily to one group require modifications when others are considered. Does sexual maturity always mark the attainment of the adult state? Is the Axolotl adult when it acquires its reproductive organs? Can a larval Ctenophore, which acquires functional reproductive glands and still possesses the power of passing into the form ordinarily described as adult in that group, be considered to have reached the end of its development? Or—to take the case of those animals, such as *Amphioxus*, *Balanoglossus*, and many segmented worms in which important developmental processes occur, *e.g.* formation of new gill slits, of gonadial sacs, or even of whole segments of the body, long after the power of reproduction has been acquired—how is the attainment of the adult state to be defined, for it is clear that in them the attainment of sexual maturity does not correspond with the end of growth and development? If, then, embryology is to be regarded as including not only the study of embryos, but also that of larvae, *i.e.* if it includes the study of the whole developmental history of the individual—and it is impossible to treat the subject rationally unless it is so regarded—it becomes exceeding difficult to fix any definite limit to the period of life with which embryology concerns itself. The beginning of this period can be fixed, but not the end, unless it be the end of life itself, *i.e.* death. The science of embryology, then, is the science of individual development, and includes within its purview all those changes of form and structure, whether embryonic, larval or post-larval, which characterize the life of the individual. The beginning of this period is precise and definite—it is the completion of the fertilization of the ovum, in which the life of the individual has its start. The end, on the other hand, is vague and cannot be precisely defined, unless it be death, in which case the period of life with which embryology concerns itself is coincident with the life of the individual. To use the words of Huxley ("Cell Theory," *Collected Works*, vol. i. p. 267): "Development, therefore, and life are, strictly speaking, one thing, though we are accustomed to limit the former to the progressive half of life merely, and to speak of the retrogressive half as decay, considering an imaginary resting-point between the two as the adult or perfect state."

Reproduction.

There are two kinds of reproduction, the sexual and the asexual. The sexual method has for its results an increase of the number of kinds of individual or organism, whereas the asexual affords an increase in the number of individuals of the same kind. If the asexual method of reproduction alone existed, there would, so far as our knowledge at present extends, be no increase in the number of kinds of organism: no new individuality could arise. The first establishment of a new kind of individual by the sexual process is effected in a very similar manner in all Metazoa. The parent produces by a process of unequal fission, which takes place at a part of the body called the reproductive gland, a small living organism called the reproductive cell. There are always two kinds of reproductive cells, and these are generally produced by different animals called the male and female respectively (when they are produced by the same animal it is said to be hermaphrodite). The reproductive cell produced by the male is called the spermatozoon, and that produced by the female, the ovum. These two organisms agree in being small uninucleated masses of protoplasm, but differ considerably in form. They are without the organs of nutrition, &c., which characterize their parents, but the ovum nearly always possesses, stored up within its protoplasm, a greater or less quantity of vitelline matter or food-yolk, while the spermatozoon possesses in almost all cases the power of locomotion. The object with which these two minute and simple organisms are produced is to fuse with one another and give rise to one resultant uninucleated (for the nuclei fuse) organism or cell, which is called the *zygote*. This process of fusion between the two kinds of reproductive cells, which are termed *gametes*, is called conjugation: it is the process which is sometimes spoken of as the fertilization of the ovum, and its result is the establishment of a new individual. This new individual at first is simply a uninucleated mass of living matter, which always contains a certain amount of food-yolk, and is generally bounded by a delicate cuticular membrane called the vitelline membrane. In form the newly established zygote resembles the female gamete or ovum—so much so, indeed, that it is frequently called the ovum; but it must be clearly understood that although the bulk of its matter has been derived from the ovum, it consists of ovum and spermatozoon, and, as shown by its subsequent behaviour, the spermatozoon has quite as much to do with determining its vital properties as the ovum.

To the unaided eye the main difference between the newly formed zygotes of different species of animals is that of bulk, and this is due to the amount of food-yolk held in suspension in the protoplasm. The ovum of the fowl is 30 mm. in diameter, that of the frog 1·75 mm., while the ova of the rabbit and *Amphioxus* have a diameter of ·1 mm. The food-yolk is deposited in the ovum as a result of the vital activity of its protoplasm, while the ovum is still a part of the ovary of the parent. It is an inert substance which is used as food later on by the developing embryo, and it acts as a dilutant of the living matter of the ovum. It has a profound influence on the subsequent developmental process. The newly formed zygotes of different species of animals have undoubtedly, as staved above, a certain family resemblance to one another; but however great this superficial resemblance may be, the differences must be most profound, and this fact becomes at once obvious when the properties of these remarkable masses of matter are closely investigated.

Causes of development.

As in the case of so many other forms of matter, the more important properties of the zygote do not become apparent until it is submitted to the action of external forces. These forces constitute the external conditions of existence, and the properties which are called forth by their action are called the acquired characters of the organism. The investigation of these properties, particularly of those which are called forth in the early stages of the process, constitutes the science of Embryology. With regard to the manifestation of these properties, certain points must be clearly understood at the outset:—(1) If the zygote is withheld from the appropriate external influences, *e.g.* if a plant-seed be kept in a box free from moisture or at a low temperature, no properties are evolved, and the zygote remains apparently unchanged; (2) the acquisition of the properties which constitutes the growth and development of the organism proceeds in a perfectly definite sequence, which, so far as is known, cannot be altered; (3) just as the features of the growing organism change under the continued action of the external conditions, so the external conditions themselves must change as the organism is progressively evolved. With regard to this last change, it may be said generally that it is usually, if not always, effected by the organism itself, making use of the properties which it has acquired at earlier stages of its growth, and acting in response to the external conditions. There is, to use a phrase of Mr Herbert Spencer, a continuous adjustment between the external and internal relations. For every organism a certain succession of conditions is necessary if the complete and normal evolution of properties is to take place. Within certain limits, these conditions may vary without interfering with the normal evolution of the properties, though such variations are generally responded to by slight but unimportant variation of the properties (variation of acquired characters). But if the variation of the conditions is too great, the evolved properties become abnormal, and are of such a nature as to preclude the normal evolution of the organism; in other words, the action of the conditions upon the organism is injurious, causing abortions and, ultimately, death. For many organisms the conditions of existence are well known for all stages of life, and can be easily imitated, so that they can be reared artificially and kept alive and made to breed in confinement—*e.g.* the common fowl. But in a large number of cases it is not possible, through ignorance of the proper conditions, or on account of the difficulty of imitating them, to make the organism evolve all its properties. For instance, there are many marine larvae which have never been reared beyond a certain point, and there are some organisms which, even when nearly full-grown—a stage of life at which it is generally most easy to ascertain and imitate the natural conditions—will not live, or at any rate will not breed, in captivity. Of late years some naturalists have largely occupied themselves with experimental observation of the effects on certain organisms of marked and definite changes of the conditions, and the name of Developmental Mechanics (or *Physiology of Development*) has been applied to this branch of study (see below).

Gametogeny.

In normal fertilization, as a rule, only one spermatozoon fuses with the ovum. It has been observed in some eggs that a membrane, formed round the ovum immediately after the entrance of the spermatozoon, prevents the entrance of others. If than one spermatozoon enters, a corresponding number of male pronuclei are formed, and the subsequent development, if it takes place at all, is abnormal and soon ceases. An egg by ill-treatment (influence of chloroform, carbonic acid, &c.) can be made to take more than one spermatozoon. In some animals it appears that several spermatozoa may normally enter the ovum (some Arthropoda, Selachians, Amphibians and Mammals), but of these only one forms a male pronucleus (see below), the rest being absorbed. Gametogeny is the name applied to the formation of the gametes, *i.e.* of the ova and spermatozoa. The cells of the reproductive glands are the germ cells (*oögonia*, *spermatogonia*). They undergo division and give rise to the progametes, which in the case of the female are sometimes called *oöcytes*, in the case of the male *spermatocytes*. The oöcytes are more familiarly called the ovarian ova. The nucleus of the oöcyte is called the germinal vesicle. The oöcyte (progamete) gives rise by division to the ovum or true gamete, the nucleus of which is called the *female pronucleus*. As a general rule the oöcyte divides unequally twice, giving rise to two small cells called polar bodies, and to the ovum. The first formed polar body frequently divides when the oöcyte undergoes its second and final division, so that there are three polar bodies as well as the ovum

resulting from the division of the oöcyte or progamete. Sometimes the ovum arises from the oöcyte by one division only, and there is only one polar body (*e.g.* mouse, Sobotta, *Arch. f. mikr. Anat., 1895*, p. 15). The polar bodies are oval, but as a rule they are so small as to be incapable of fertilization. They may therefore be regarded as abortive ova. In one case, however (see Francotte, *Bull. Acad. Belg.* (3), xxxiii., 1897, p. 278), the first formed polar body is nearly as large as the ovum, and is sometimes fertilized and develops. The spermatogonia are the cells of the testis; these produce by division the spermatocytes (progametes), which divide and give rise to the spermatids. In most cases which have been investigated the divisions by which the spermatids arise from the spermatocytes are two in number, so that each spermatocyte gives origin to four spermatids. Each spermatid becomes a 316
functional spermatozoon or male gamete. The gametogeny of the male therefore closely resembles that of the female, differing from it only in the fact that all the four products of the progamete become functional gametes, whereas in the female only one, the ovum, becomes functional, the other three (polar bodies) being abortive. In the spermatogenesis of the bee, however, the spermatocyte only divides once, giving rise to a small polar-body-like structure and one spermatid (Meves, *Anat. Anzeiger*, 24, 1904, pp. 29-32). The nucleus of the male gamete is not called the male pronucleus, as would be expected, that term being reserved for the second nucleus which appears in the ovum after fertilization. As this is in all probability derived entirely from the nucleus of the spermatozoon, we should be almost justified in calling the nucleus of the spermatozoon the male pronucleus. In most forms in which the formation of the gametes from the progamete has been accurately followed, and in which the progamete of both sexes divides twice in forming the gametes, the division of the nucleus presents certain peculiarities. In the first place, between the first division and the second it does not enter into the resting state, but immediately proceeds to the second division. In the second place, the number of chromosomes which appear in the final divisions of the progametes and assist in constituting the nuclei of the gametes is half the number which go to constitute the new nuclei in the ordinary nuclear divisions of the animal. The number of chromosomes of the nucleus of the gamete is therefore reduced, and the divisions by which the gametes arise from the progametes are called reducing (*maiotic*) divisions. It is not certain, however, that this phenomenon is of universal occurrence, or has the significance which is ordinarily attributed to it. In the parthenogenetic ova of certain insects, *e.g. Rhodites rosae* (Henking), *Nematus lacteus* (Doncaster, *Quart. Journal Mic. Science*, 49, 1906, pp. 561-589), reduction does not occur, though two polar bodies are formed.

Fertilization.

As soon as the spermatozoon has conjugated with the ovum, a second nucleus appears in the ovum. This is undoubtedly derived from the spermatozoon, possibly from its nucleus only, and is called the male pronucleus. It possesses in the adjacent protoplasm a well-marked centrosome. The general rule appears to be that the female pronucleus is without a centrosome, and that no centrosome appears in the female in the divisions by which the gamete arises from the progamete. If this is true, the centrosome of the zygote nucleus must be entirely derived from that of the male pronucleus. This accounts for the fact, which has been often observed, that the female pronucleus is not surrounded by protoplasmic radiations, whereas such radiations are present round the male pronucleus in its approach to the female. In the mouse the subsequent events are as follow:—Both pronuclei assume the resting form, the chromatin being distributed over the nuclear network, and the nuclei come to lie side by side in the centre of the egg. A long loop of chromatin then appears in each nucleus and divides up into twelve pieces, the chromosomes. The centrosome now divides, the membranes of both nuclei disappear, and a spindle is formed. The twenty-four chromosomes arrange themselves at the centre of this spindle and split longitudinally, so that forty-eight chromosomes are formed. Twenty-four of these, twelve male and twelve female, as it is supposed, travel to each pole of the spindle and assist in giving rise to the two nuclei. At the next nuclear division twenty-four chromosomes appear in each nucleus, each of which divides longitudinally; and so in all subsequent divisions. The fusion of the two pronuclei is sometimes effected in a manner slightly different from that described for the mouse. In *Echinus*, for instance, the two pronuclei fuse, and the spindle and chromosomes are formed from the zygote nucleus, whereas in the mouse the two pronuclei retain their distinctness during the formation of the chromosomes. There appears, however, to be some variation in this respect: cases have been observed in the mouse in which fusion of the pronuclei occurs before the separation of the chromosomes.

Parthenogenesis.

Parthenogenesis, or development of the female gamete without fertilization, is known to occur in many groups of the animal kingdom. Attempts have been made to connect this phenomenon with peculiarities in the gametogeny. For instance, it has been said that parthenogenetic ova form only one polar body. But, as we have seen, this is sometimes the case in eggs which are fertilized, and parthenogenetic ova are known which form two polar bodies, *e.g.* ova of the honey-bee which produce drones (*Morph. Jahrb.* xv., 1889, p. 85). ova of Rotifera which produce males (*Zool. Anzeiger*, xx., 1897, p. 455), ova of some saw-flies and gall flies which produce females (L. Doncaster, *Quart. Journ. Mic. Sc.*, 49, 1906, pp. 561-589). Again it has been asserted that in parthenogenetic eggs the polar bodies are not extruded from the ovum; in such cases, though the nucleus divides, those of its products which would in other cases be extruded in polar bodies remain in the protoplasm of the ovum. But this is not a universal rule, for in some cases of parthenogenesis polar bodies are extruded in the usual way (*Aphis*, some Lepidoptera), and in some fertilized eggs the polar bodies are retained in the ovum.

It is quite probable that parthenogenesis is more common than has been supposed, and it appears that there is some evidence to show that ova, which in normal conditions are incapable of developing without fertilization, may yet develop if subjected to an altered environment. For instance, it has been asserted that the addition of a certain quantity of chloride of magnesium and other substances to sea-water will cause the unfertilized ova of certain marine animals (*Arbacia*, *Chaetopterus*) to develop (J. Loeb, *American Journal of Physiology*, ix., 1901, p. 423); and according to M.Y. Delage (*Comptes rendus*, 135, 1902. Nos. 15 and 16) such development may occur after the formation of polar bodies, the chromosomes undergoing reduction and the full number being regained in the segmenting stage. These experiments, if authenticated, suggest that ova have the power of development, but are not able to exercise it in their normal surroundings. There is reason to believe that the same assertion may be made of spermatozoa. Phenomena of the nature of parthenogenesis have never been observed in the male gamete, but it has been suggested by A. Giard (*Cinquantenaire de la Soc. de Biol.*, 1900) that the phenomenon of the so-called fertilization of an enucleated ovum which has been described by T. Boveri and Delage in various eggs, and which results in development up to the larval form (*merogony*), is in reality a case in which the male gamete, unable to undergo development in ordinary circumstances on account of its small size and specialization of structure has obtained a nutritive environment which enables it to display its latent power of development. Moreover, A.M. Giard suggests that in some cases of apparently normal fertilization one of the pronuclei may degenerate, the resultant embryo being the product of one pronucleus only. In this way he explains certain cases of hybridization in which the paternal (rarely the maternal) type is exclusively reproduced. For instance, in the batrachiate Amphibia, Héron Royer succeeded in 1883 in rearing, out of a vast number of attempts, a few hybrids between a female *Pelobates fuscus* and a male *Rana fusca*; the product was a *Rana fusca*. He also crossed a female *Bufo vulgaris* with a male *Bufo calamita*; in the few cases which reached maturity the product was obviously a *Bufo calamita*. Finally, H.E. Ziegler (*Arch. f. Ent.-Mech.*, 1898, p. 249) divided the just-fertilized ovum of a sea-urchin in such a way that each half had one pronucleus; the half with the male pronucleus segmented and formed a blastula, the other degenerated. It is said that in a few species of animals males do not occur, and that parthenogenesis is the sole means of reproduction (a species of Ostracoda among Crustacea; species of Tenthredinidae, Cynipidae and Coccidae among Insecta); this is the thelytoky of K.T.E. von Siebold. The number of species in which males are unknown is constantly decreasing, and it is quite possible that the phenomenon does not exist. Parthenogenesis, however, is undoubtedly of frequent occurrence, and is of four kinds, namely, (1) that in which males alone are produced, *e.g.* honey-bees (*arrhenotoky*); (2) that in which females only are produced (*thelytoky*), as in some saw-flies; (3) that in which both sexes are produced (*deuterotoky*), as in some saw-flies; (4) that in which there is an alternation of sexual and parthenogenetic generations, as in Aphidae, many Cynipidae, &c. It would appear that "parthenogenesis does not favour the production of one sex more than another, but it is clear that it decidedly favours the production of a brood that is entirely of one sex, but which sex that is differs according to circumstances" (D. Sharp, *Cambridge Natural History*, "Insects," pt. i. p. 498). In some Insecta and Crustacea exceptional parthenogenesis occurs: a certain proportion of the eggs laid are capable of undergoing either the whole or a part of development parthenogenetically, *e.g.* *Bombyx mori*, &c. (A. Brauer, *Arch. f. mikr. Anat.*, 1893; consult also E. Maupas on parthenogenesis of Rotifera, *Comp. rend.*, 1889-1891, and R. Lauterborn, *Biol. Centralblatt*, xviii., 1898, p. 173).

Determination of sex.

The question of the determination of sex may be alluded to here. Is sex determined at the act of conjugation of the two gametes? Is it, in other words, an unalterable property of the zygote, a genetic character? Or does it depend upon the conditions to which the zygote is subjected in its development? In other words, is it an acquired character? It is impossible in the present state of knowledge to answer these questions satisfactorily, but the balance of evidence appears to favour the view that sex is an unalterable, inborn character. Thus those twins which are believed to come from a split zygote are always of the same sex, members of the same litter which have been submitted to exactly similar conditions are of different sexes, and all attempts to determine the sex of offspring in the higher animals by treatment have failed. On the other hand, the male bee is a portion of a female zygote—the queen-bee. The same remark applies to the male Rotifer, in which the zygote always gives rise to a female, from which the male arises parthenogenetically, but in these cases it does not appear that the production of males is in any way affected by external conditions (see R.C. Punnett, *Proc. Royal Soc.*, 78 B, 1906, p. 223). It is said that in human societies the number of males born increases after wars and famines, but this, if true, is probably due to an affection of the gametes and not of the young zygote. For a review of the whole subject see L. Cuénot, *Bull. sci. France et Belgique*, xxxii., 1899, pp. 462-535.

Cleavage.

The first change the zygote undergoes in all animals is what is generally called the segmentation or cleavage of the ovum. This consists essentially of the division of the nucleus into a number of nuclei, around which the protoplasm sooner or later becomes arranged in the manner ordinarily spoken of as cellular. This division of the nucleus is effected by the process called binary fission; that is to say, it first divides into two, then each of these divides simultaneously again into two, giving four nuclei; each of these after a pause again simultaneously divides into two. So the process continues for some time until the ovum becomes possessed of a large number of nuclei, all of which have proceeded from the original nucleus by a series of binary fissions. This division of the nucleus, which constitutes the essential part of the cleavage of the ovum, continues through the whole of life, but it is only in the earliest period that it is distinguished by a distinct name and used to characterize a stage of development. The nuclear division of cleavage is usually at first a rhythmical process; all the nuclei divide simultaneously, and periods of nuclear activity alternate with periods of rest. Nuclear divisions may be said to be of three kinds, according to the accompanying changes in the surrounding protoplasm: (1) accompanied by no visible change, *e.g.* the multinucleated Protozoon *Actinosphaerium*; (2) accompanied by a rearrangement of the protoplasm around each nucleus, but not by its division into two separate masses, *e.g.* the division which results in the formation of a colony of Protozoa; (3) accompanied by the division of the protoplasm into two parts, so that two distinct cells result, *e.g.* the divisions by which the free wandering leucocytes are produced, the reproduction of uninuclear Protozoa, &c. In the cleavage of the ovum the first two of these methods of division are found, but probably not the third. At one time it was thought that the nuclear divisions of cleavage were always of the third kind, and the result of cleavage was supposed to be a mass of isolated cells, which became reunited in the subsequent development to give rise to the later connexion between the tissues which were known to exist. But in 1885 it was noticed that in the ovum of *Peripatus capensis* (A. Sedgwick, *Quart. Journ. Mic. Science*, xxv., 1885, p. 449) the extra-nuclear protoplasm did not divide in the cleavage of the ovum, but merely became rearranged round the increasing nuclei; the continuity of the protoplasm was not broken, but persisted into the later stages of growth, and gave rise to the tissue-connexions which undoubtedly exist in the adult. This discovery was of some importance, because it rendered intelligible the unity of the embryo so far as its developmental processes are concerned, the maintenance of this unity being somewhat surprising on the previous view. On further inquiry and examination it was found that the ova of many other animals presented a cleavage essentially similar to that of *Peripatus*. Indeed, it was found that the nuclear divisions of cleavage were of the first two kinds just described. In some eggs, *e.g.* the Alcyonaria, the first nuclear divisions are effected on the first plan, *i.e.* they take place without at first producing any visible effect upon the protoplasm of the egg. But in the later stages of cleavage the protoplasm becomes arranged around each nucleus and related to it as to a centre. In the majority of eggs, however, the protoplasm, though not undergoing complete cleavage, becomes rearranged round each nucleus as these are formed. The best and clearest instance of this is afforded by many Arthropodan eggs, in which the nucleus of the just-formed zygote takes up a central position, where it undergoes its first division, subsequent divisions taking place entirely within the egg and not in any way affecting its exterior. The result is to give rise to a nucleated network or foam-work of protoplasm, ramifying through the yolk-particles and containing these in its meshes.

In other Arthropodan eggs the cleavage is on the so-called centrolecithal type, in which the dividing nuclei pass to the cortex of the ovum, and the surface of the ovum becomes indented with grooves corresponding to each nucleus. In this kind of cleavage all the so-called segments are continuous with the central undivided yolk-mass. It sometimes happens that in Arthropods the egg breaks up into masses, which cannot be said to have the value of cells, as they are frequently without nuclei. In other eggs, characterized by a considerable amount of yolk, *e.g.* the ova of Cephalopoda, and of the Vertebrata with much yolk, the first nucleus takes up an eccentric position in a small patch of protoplasm which is comparatively free from yolk-particles. This patch is the germinal disc, and the nuclear divisions are confined to it and to the transitional region, where it merges into the denser yolk which makes up the bulk of the egg. At the close of segmentation the germinal disc consists of a number of nuclei, each surrounded by its own mass of protoplasm, which is, however, not separated from the protoplasm round the neighbouring nuclei, as was formerly supposed, but is continuous at the points of contact. In this manner the germinal disc has become converted into the blastoderm, which consists of a small watch-glass-shaped mass of so-called cells resting on, but continuous with, the large yolk-mass. It is characteristic of this kind of ovum that there is always a row of nuclei, called the yolk-nuclei, placed in the denser yolk immediately adjacent to the blastoderm. These nuclei are continually undergoing division, one of the products of division, together with a little of the sparse yolk protoplasm, passing into the blastoderm to reinforce it (so-called formative cells). The other product of the dividing yolk-nuclei remains in the yolk, in readiness for the next division. In this manner nucleated masses of protoplasm are continually being added to the periphery of the blastoderm and assisting in its growth. But it must be borne in mind that all the nucleated masses of which the blastoderm consists are in continuity with each other and with the sparse protoplasmic reticulum of the subjacent yolk.

In the great majority of eggs, then, the nuclear division of cleavage is not accompanied by a complete division of the ovum into separate cells, but only by a rearrangement of the protoplasm, which produces, indeed, the so-called cellular arrangement, and an appearance only of separate cells. But there still remain to be mentioned those small eggs in which the amount of yolk is inconsiderable, and in which division of the nuclei does appear to be accompanied by a complete division of the surrounding protoplasm into separate unconnected cells—ova of many Annelida, Mollusca, Echinoderma, &c., and of Mammalia amongst Vertebrata. In the case of these also (G.F. Andrews, *Zool. Bulletin*, ii., 1898) it has been shown that the apparently separate spheres are connected by a number of fine anastomosing threads of a hyaline protoplasm, which are not easy to detect and are readily destroyed by the action of reagents. It is therefore probable that the divisions of the nuclei in cleavage are in no case accompanied by complete division of the surrounding protoplasm, and the organism in the cleavage stage is a continuous whole, as it is in all the other stages of its existence.

Division of embryo.

Of late years a great number of experiments have been made to discover the effects of dividing the embryo during its cleavage, and of destroying certain portions of it. These experiments have been made with the object of testing the view, held by some authorities, that certain segments are already set apart in cleavage to give rise to certain adult organs, so that if they were destroyed the organs in question could not be developed. The results obtained have not borne out this view. Speaking generally, it may be said that they have been different according to the stage at which the separation was effected and the conditions under which the experiment was carried out. If the experiment be made at a sufficiently early stage, each part, if not too small, will develop into a normal, though small, embryo. In some cases the embryo remained imperfect for a certain time after the experiment, but the loss is eventually made good by regeneration. (For a summary of the work done on this subject see R.S. Bergh, *Zool. Centralblatt*, vii., 1900, p. 1.)

The end of cleavage is marked by the commencement of the differentiation of the organs. The first differentiation is the formation of the layers. These are three in number, being called respectively the

The layer theory.

ectoderm, endoderm and mesoderm, or, in embryos in which at their first appearance they lie like sheets one above the other, the epiblast, hypoblast and mesoblast. The layers are sometimes spoken of as the primary organs, and their importance lies in the fact that they are supposed to be generally homologous throughout the series of the Metazoa. This view, which is based partly on their origin and partly on their fate, had great influence on the science of comparative anatomy during the last thirty years of the 19th century, for the homology of the layers being admitted, they afforded a kind of final court of appeal in determining questions of doubtful homologies between adult organs. Great importance was therefore attached to them by embryologists, and both their mode of development and the part which they play in forming the adult organs were examined with the greatest care. It is very unusual for all the layers to be established at the same time. As a general rule the ectoderm and endoderm, which may be called the primary layers, come first, and later the mesoderm is developed from one or other of them. There are two main methods in which the first two are differentiated—invagination and delamination. The former is generally found in small eggs, in which the embryo at the close of cleavage assumes the form of a sphere, having a fluid or gelatinous material in its centre, and bounded externally by a thin layer of protoplasm, in which all the nuclei are contained. Such a sphere is called a blastosphere, and may be regarded as a spherical mass of protoplasm, of which the central portion is so much vacuolated that it seems to consist entirely of fluid. The central part of the blastosphere is called the segmentation cavity or blastocoel. The blastosphere soon gives rise, by the invagination of one part of its wall upon the other, and a consequent obliteration of the segmentation cavity, to a double-walled cup with a wide opening, which, however, soon becomes narrowed to a small pore. This cup-stage is called the gastrula stage; the outer wall of the gastrula is the ectoderm, and its inner the endoderm; while its cavity is the enteron, and the opening to the exterior the blastopore. Origin of the primary layers by delamination occurs universally in eggs with large yolks (Cephalopoda and many Vertebrata), and occasionally in others. In it cleavage gives rise to a solid mass, which divides by delamination into two layers, the ectoderm and endoderm. The main difference between the two methods of development lies in the fact that in the first of them the endoderm at its first origin shows the relations which it possesses in the adult, namely, of forming the epithelial wall of the enteric space, whereas in the second method the endoderm is at first a solid mass, in which the enteric space makes its appearance later by excavation. In the delaminate method the enteric space is at first without a blastopore, and sometimes it never acquires this opening, but a blastopore is frequently formed, and the two-layered gastrula stage is reached, though by a very different route from that taken in the formation of the invaginate gastrula. According to the layer-theory, these two layers are homologous throughout the series of Metazoa; their limits can always be accurately defined, they give rise to the same organs in all cases, and the adult organs (excluding the mesodermal organs) can be traced back to one or other of them with absolute precision. Thus the ectoderm gives rise to the epidermis, to the nervous system, and to the lining of the stomodaeum and proctodaeum, if such parts of the alimentary canal are present. The endoderm, on the other hand, gives rise to the lining of the enteron, and of the glands which open into it. 318

So far as these two layers are concerned, and excluding the mesoderm, it would appear that the layer-theory does apply in a very remarkable manner to the whole of the Metazoa. But even here, when the actual facts are closely scanned, there are found to be difficulties, which appear to indicate that the theory may not perhaps be such an infallible guide as it seems at first sight. Leaving out of consideration the case of the Mammalia, in which the differentiation of the segmented ovum is not into ectoderm and endoderm, and the case of the sponges, the most important of these difficulties concern the stomodaeum and proctodaeum. The best case to examine is that of *Peripatus capensis*, in which the blastopore is at first a long slit, and gives rise to both the mouth and the anus of the adult. Here there is always found at the lips of the blastopore, and extending for a short distance inwards as enteric lining, a certain amount of tissue, which by its characters must be regarded as ectoderm. Now, in the closure of the blastopore between the mouth and anus, this tissue, which at the mouth and anus develops into the lining of the stomodaeum and proctodaeum, is left inside, and actually gives rise to the median ventral epithelium of the alimentary canal. Hence the development of *Peripatus capensis* suggests the conclusion, if we strictly apply the layer-theory, that a considerable portion of the true mesenteron is lined by ectoderm, and is not homologous with the corresponding portion of the mesenteron of other animals—a conclusion which will on all hands be admitted to be absurd. The difficulties in the application of the layer-theory become vastly greater when the origin

Mesoderm.

and fate of the mesoderm is considered. The mesoderm is, if we may judge from the number of organs which are derived from it, much the most important of the three layers. It generally arises later than the others, and in its very origin presents difficulties to the theory, which are much increased when we consider its history. It is generally, though not always, developed from the endoderm, either as hollow outgrowths containing prolongations of the enteric cavity, which become the coelom, or as solid proliferations. But in some groups the mesoderm is actually laid down in cleavage, and is present at the end of that process. In others it is entirely derived from the ectoderm (*Peripatus capensis*). In yet others it is partly derived from endoderm and partly from ectoderm (primitive streak of amniotic Vertebrates). Finally, in whatever manner the first rudiments are developed, it frequently receives considerable reinforcements from one of the primary layers. For instance, the structure known as the nerve crest of the vertebrate embryo is not, as was formerly supposed, exclusively concerned with the formation of the spinal nerves and ganglia, but contributes largely to the mesoderm of the axial region of the body. This is particularly clearly seen in the case of the anterior part of the head of Elasmobranch and probably of other vertebrate embryos, where all the mesoderm present is derived from the anterior part of the neural crest (*Quart. Journ. Mic. Science*, xxxvii. p. 92).

The layer-theory, then, will not bear critical examination. It is clear, both from their origin and history, that the layers or masses of cells called ectoderm, endoderm and mesoderm have not the same value in different animals; indeed, it is misleading to speak of three layers. At the most we can only speak of two, for the mesoderm is formed after the others, has a composite origin, and has no more claim to be considered an embryonic layer than has the rudiment of the central nervous system, which in some animals, indeed, appears as soon as the mesoderm. Arguments as to homology, based on derivation or non-derivation from the same embryonic layer, have therefore in themselves but little value.

It has frequently been asserted that the reproductive cells are marked off at a very early stage of the development (*Sagitta*, certain Crustacea, *Scorpio*). Recently it has been asserted that in *Ascaris* (T. Boveri, *Kuppfer's Festschrift*, 1899, p. 383) the reproductive cells are set apart after the first cleavage, and that they can be traced by certain peculiarities of their nuclei into the adult reproductive glands.

Mesenchyme.

It has been already stated that the mesoderm is a composite tissue. This fact is frequently conspicuous at its first establishment. In many Coelomata it is present under two forms from the beginning. One of these is epithelial in character, while the other has the form of a network of protoplasm, with nuclei at the nodes. The former is called simply epithelial mesoderm, the latter mesenchyme. Sometimes the epithelial mesoderm is the first formed, and what little mesenchyme there is is developed from it (*Amphioxus, Balanoglossus*, &c.) Sometimes the mesenchyme is the first to arise, the epithelial mesoderm developing from it (most, if not all, Vertebrates). Finally, it sometimes happens that these two kinds of tissue arise separately from one or other of the primary layers (Echinodermata). As already hinted, in *Balanoglossus* and *Amphioxus* the whole of the mesoderm of the body is at first in an epithelial condition, being developed as an outgrowth of the gut-wall. In *Peripatus capensis* also, and possibly in other Arthropods, it has at first an intermediate form, being derived from a primitive streak and not from the gut-wall, but it rapidly assumes an epithelial structure, from which all the mesodermal tissues are developed. In Annelids the bulk of the mesoderm has at first a modified epithelial form similar to that of Arthropods, but it is formed, not from a primitive streak, but from some peculiar cells produced in cleavage, called pole-cells. In Annelids with trochosphere larvae a certain amount of mesenchyme is formed at an earlier stage and gives rise to the muscular bands of the young larva. In 319
Echinodermata a certain amount of mesenchyme appears before the epithelial mesoderm, which is formed later as gut-diverticula. In these forms the mesenchyme is said to arise as wandering amoeboid cells, which are budded into the blastocoel by the endoderm just before and during its invagination, but the writer has reason to believe that this account of it does not quite describe what happens. It would seem to be more probable that the mesenchyme arises in these forms, as it certainly does in the case of the later-formed mesenchyme of the Vertebrate embryo, as a protoplasmic outflow from its tissue of origin, passing at first along the line of pre-existent protoplasmic strands which traverse the blastocoel, and sending out at the same time processes which branch and anastomose with neighbouring processes (see E.W. MacBride, *Proc. Camb. Phil. Soc.*, 1896, p. 153). In the Vertebrata the whole of the mesoderm has at first the mesenchyme form. Afterwards, when the body-cavity split appears, the bulk of it assumes a kind of modified epithelial condition, which later on yields, by a process of outflow very similar in its character to what has been supposed to occur in the Echinoderm blastula, a considerable mesenchyme of the reticulate character. Mesenchyme is the tissue which in Vertebrate embryology has frequently been called embryonic connective tissue. This name is no doubt due to the fact that it was supposed to consist of isolated stellate cells. It is, however, in no sense of the word connective tissue, because it gives rise to many organs having nothing whatever to do with connective tissue. For instance, in Vertebrata this tissue gives rise to nervous tissue, blood-vessels, renal tubules, smooth muscular fibres, and other structures, as well as to connective and skeletal tissues. The Vertebrata, indeed, are remarkable for the fact that the epithelial tissues of the so-called mesoderm, *e.g.* the epithelial lining of the body-cavity, and of the renal tubules and urogenital tracts, all pass through the mesenchymatous condition, whereas in *Amphioxus*, *Balanoglossus* and presumably *Sagitta* and the Brachiopoda, all the mesodermal tissues pass through the epithelial condition, most of the mesodermal tissues of the adult retaining this condition permanently. As has been implied in the above account, mesenchyme is usually formed from epithelial mesoderm or from endoderm, or from tissue destined to form endoderm. It is also sometimes formed from ectoderm, as in the Vertebrata at the nerve crest and other places. In some Coelenterata also it appears certain that the ectoderm does furnish tissue of a mesenchymatous nature which passes into the jelly, but this phenomenon takes place comparatively late in life, at any rate after the embryonic period. In this connexion it may be interesting to point out that in many Coelenterates all the tissues of the body retain throughout life the epithelial condition, nothing comparable to mesenchyme ever being formed.

Continuity of the layers.

Finally, before leaving this branch of the subject, the fact that the three germinal layers are continuous with one another, and not isolated masses of tissue, may be emphasized. Indeed, an embryo may be defined as a multinucleated protoplasmic mass, in which the protoplasm at any surface—whether internal or external—is in the form of a relatively dense layer, while that in the interior is much vacuolated and reduced to a more or less sparse reticulum, the nuclei either being exclusively found in the surface protoplasm, or if the embryo has any bulk and the internal reticulum is at all well developed, at the nodes of the internal reticulum as well.

The origin of some of the more important organs may now be considered. It is a remarkable fact that the mouth and anus develop in the most diverse ways in different groups, but as a rule either one

Mouth and anus.

or both of them can be traced into relation with the blastopore, the history of which must therefore be examined. In most, if not all, the great groups of the animal kingdom, *e.g.* in Coelenterata, Annelida, Mollusca, Vertebrata, and in Arthropoda, the blastopore or its representative is placed on the neural surface of the body, and, as will be shown later on, within the limits of the central nerve rudiment. Here it undergoes the most diverse fate, even in members of the same group. For instance, in *Peripatus capensis* it extends as a slit along the ventral surface, which closes up in the middle, but remains open at the two ends as the permanent mouth and anus. In other Arthropods, though full details have not yet in all cases been worked out, the following general statement may be made:—A blastopore (certain Crustacea) or its representative is formed on the neural surface of the embryo and always becomes closed, the mouth and anus arising as independent perforations later. Here no one would doubt the homology of the mouth and anus throughout the group; yet within the limits of a single genus—*Peripatus*—they show the most diverse modes of development. In Annelids the blastopore sometimes becomes the mouth (most Chaetopoda); sometimes it becomes the anus (*Serpula*); sometimes it closes up, giving rise to neither, though in this case it may assume the form of a long slit along the ventral surface before disappearing. In Mollusca its fate presents the same variations as in Annelida. Now in these groups no zoologist would deny the homology of the mouth and anus in the different forms, and yet how very different is their history even in closely allied animals. How are these apparently diverse facts to be reconciled? The only satisfactory explanation which has been offered (Sedgwick, *Quart. J. Mic. Science*, xxiv., 1884, p. 43) is that the blastopore is homologous in all the groups mentioned, and is the representative of the original single opening into the enteric cavity, such as at present characterizes the Coelenterata. From it the mouth and anus have been derived, as is indicated by its history in *Peripatus capensis*, and by the variability in its behaviour in closely allied forms; such variability in its subsequent history is due to its specialization as a larval organ, as a result of which it has lost its capacity to give rise to both mouth and anus, and sometimes to either.

That the blastopore does become specialized as a larval organ is obvious in those cases in which it becomes transformed into the single opening with which some larvae are, for a time at least, alone provided, *e.g. Pilidium*, Echinoderm larvae, &c., and that larval characters have been the principal causes of the form of embryonic characters, strong reason to believe will be adduced later on. In the Vertebrata the behaviour of the blastopore (anus of Rusconi) is also variable in a very remarkable manner. As a rule it is slit-like in form and closes completely, but in most cases one portion of it remains open longer than the rest, as the neurenteric canal. In a few forms (*e.g.* Newt, *Lepidosiren*, &c.) the very hindermost portion of the slit-like blastopore remains permanently open as the anus, and from such cases it can be shown that the neurenteric aperture (when present) is derived from a portion of the blastopore just anterior to its hindermost end. The words “hindermost” and “anterior” are used on the assumption that the whole blastopore has retained its dorsal position; as a matter of fact the hindermost part of it—the part which persists or reopens as the anus—loses this position in the course of development and becomes shifted on to the ventral surface. This is clearly seen in *Lepidosiren* (Kerr, *Phil. Trans.* cxcii., 1900), in Elasmobranchii, and in Amniota (primitive streak). Moreover, in *Lepidosiren*, and possibly in some other forms, the anus, *i.e.* the hind end of the blastopore, is at first contained within the medullary plate and bounded behind by the medullary folds. Later the portions of the medullary plate in the neighbourhood of the anus completely atrophy, and this relation is lost. This extension of the hind end of the blastopore on to the ventral surface, and atrophy of the portion of the medullary plate in relation with it, is a highly important phenomenon, and one to which attention will be again called when the relation of the mouth to the blastopore is being considered. The remarkable fact about the Vertebrata, a feature which that group shares in common with all other Chordata (*Amphioxus*, Tunicata, Enteropneusta) and with the Echinodermata, is that the mouth has never been traced into relation with the blastopore. For this reason, among others, it has been held by some zoologists that the mouth of the Vertebrata is not homologous with the mouth of such groups as the Annelida, Arthropoda and Mollusca. But, as has been explained above, in face of the extraordinary variability in the history of the mouth and anus in these groups, this view cannot be regarded as in any way established. On the contrary, there are distinct reasons for thinking that the Vertebrate mouth is a derivate of the blastopore. In the first place, in Elasmobranchii (Sedgwick, *Quart. Journ. Mic. Sci.* xxxiii., 1892, p. 559), and in a less conspicuous form in other vertebrate groups, the mouth has at first a slit-like form, extending from the anterior end of the central nerve-tube backwards along the ventral surface of the anterior part of the embryo. This slit-like rudiment, recalling as it does the form which the blastopore assumes in so many groups and in many Vertebrata, does suggest the view that possibly the mouth of the Vertebrata may in reality be derived from a portion of an originally long slit-like neural blastopore, which has become extended anteriorly on to the ventral surface and has lost its original relation to the nerve rudiment, as has undoubtedly happened with the posterior part, which persists as the anus.

Of the other organs which develop from the two primary layers it is only possible to notice here the central nervous system. This in almost all animals develops from the ectoderm. In Cephalopods among

Central nervous system.

Mollusca—the development of which is remarkable from the almost complete absence of features which are supposed to have an ancestral significance—and in one or two other forms, it has been said to develop from the mesoderm; but apart from these exceptional and perhaps doubtful cases, the central nervous system of all embryos arises as thickenings of the ectoderm, and in the groups above mentioned, namely, Annelida, Mollusca, Arthropoda and Vertebrata, and probably others, from the ectoderm of the blastoporal surface of the body. This surface generally becomes the ventral surface, but in Vertebrata it becomes the dorsal. These thickened tracts of ectoderm in *Peripatus* and a few other forms can be clearly seen to surround the blastopore. This relation is retained in the adult in *Peripatus*, some

Mollusca and some Nemertines, in which the main lateral nerve cords are united behind the anus as well as in front of the mouth; in other forms it cannot always be demonstrated, but it can, as in the case of the Vertebrata just referred to, always be inferred; only, in the Invertebrate groups the part of the nerve rudiment which has to be inferred is the posterior part behind the blastopore, whereas in Vertebrata it is the anterior part, namely, that in front of the blastopore, assuming that the mouth is a blastoporal derivate.

In the Echinodermata, Enteropneusta and one or two other groups, it is not possible, in the present state of knowledge, to bring the mouth into relation with the blastopore, nor can the blastopore be shown to be a perforation of the neural surface. For the Echinoderms, at any rate, this fact loses some of the importance which might at first sight be attributed to it when the remarkable organization of the adult and the sharp contrast which exists between it and the larva is remembered. In some Annelids the central nervous system remains throughout life as part of the outer epidermis, but as a general rule it becomes separated from the epidermis and embedded in the mesodermal tissues. The mode in which this separation is effected varies according to the form and structure of the central nervous system. In the Vertebrata, in which this organ has the form of a tube extending along the dorsal surface of the body, it arises as a groove of the medullary plate, which becomes constricted into a canal. The wall of this canal consists of ectoderm, which at an earlier stage formed part of the outer surface of the body, but which after invagination thickens, to give rise to the epithelial lining of the canal and to the nervous tissue which forms the bulk of the canal wall. The fact that the blastopore remains open at the hind end of the medullary plate explains to a certain extent the peculiar relation which always exists in the embryo between the hind end of the neural and alimentary canals. This communication between the hind end of the neural tube and the gut is one of the most remarkable and constant features of the Vertebrate embryo. As has been pointed out, it is not altogether unintelligible when we remember the relation of the blastopore to the medullary plate of the earlier stage, but to give a complete explanation of it is, and probably always will be, impossible. It is no doubt the impress of some remarkable larval condition of the blastopore of a stage of evolution now long past.

In *Ceratodus* the open part of the blastopore is enclosed by the medullary folds, as in *Lepidosiren*, and probably persists as the anus, the portion of the folds around the anus undergoing atrophy (Semon, *Zool. Forschungsreisen in Australien*, 1893, Bd. i. p. 39). In Urodeles the blastopore persists as anus, so far as is known, but the relation to the medullary folds has not been noticed. The same may be said of *Petromyzon* (A.E. Shipley, *Quart. Journ. Mic. Sci.* xxviii., 1887).

Cranial flexure.

The nerve tube of the Vertebrata at a certain early stage of the embryo becomes bent ventralwards in its anterior portion, in such a manner that the anterior end, which is represented in the adult by the infundibulum, comes to project backwards beneath the mid-brain. This bend, which is called the cranial flexure, takes place through the mid-brain, so that the hind-brain is unaffected by it. The cranial flexure is not, however, confined to the brain: the anterior end of the notochord, which at first extends almost to the front end of the nerve tube (this extension, which is quite obvious in the young embryo of Elasmobranchs, becomes masked in the later stages by the extraordinary modifications which the parts undergo), is also affected by it. Moreover, it affects even other parts, as may be seen by the oblique, almost antero-posterior, direction of the anterior gill slits as compared with the transverse direction of those behind. No satisfactory explanation has ever been offered of the cranial flexure. It is found in all Vertebrates, and is effected at an early stage of the development. In the later stages and in the adult it ceases to be noticeable, on account of an alteration of the relative sizes of parts of the brain. This is due almost entirely to the enormous growth of the cerebral vesicle, which is an outgrowth of the dorsal wall of the fore-brain just short of its anterior end. The anterior end of the fore-brain remains relatively small throughout life as the infundibulum, and the junction of this part of the fore-brain with the part which is so largely developed, as the rudiment of the cerebrum, is marked by the attachment of the optic chiasma. The optic nerve, indeed, is morphologically the first cranial nerve, the olfactory being the second; both are attached to what is morphologically the dorsal side of the nerve tube. The morphological anterior end of the central nerve tube is the point of the infundibulum which is in contact with the pituitary body. While on the subject of the cranial flexure, it may be pointed out that there is a similar downward curve of the hind end of the nervous axis, which leads into the hind end of the enteron. If it be supposed that originally there was a communication between the infundibulum and pituitary body, then the ventral flexure found at both ends of the nerve axis would originally have had the same result, namely, of placing the neural and alimentary canals in communication. Moreover, the mouth would have had much the same relation to this imaginary anterior neurenteric canal that the anus has to the actual posterior one.

In *Amphioxus* and the Tunicata the early development of the central nervous system is very much like that of the Vertebrata, but the later stages are simpler, being without the cranial flexure. The Tunicata are remarkable for the fact that the nervous system, though at first hollow, becomes quite solid in the adult. In *Balanoglossus* the central nervous system is in part tubular, the canal being open at each end. It arises, however, by delamination from the ectoderm, the tube being a secondary acquisition. This is probably due to a shortening of development, for the same feature is found in some Vertebrata (Teleostei, *Lepidosteus*, &c.), where the central canal is secondarily hollowed out in the solid keel-like mass which is separated from the ectoderm. Parts of the central nervous system arise by invagination in other groups; for instance, the cerebral ganglia of *Dentalium* are formed from the walls of two invaginations of ectoderm, which eventually disappear at the anterior end of the body (A. Kowalevsky, *Ann. Mus. Hist. Nat. Marseilles*, “Zoology,” vol. i.). In *Peripatus* the cerebral ganglia arise in a similar way, but in this case the cavities of the invagination become separated from the skin and persist as two hollow appendages on the lower side of the cerebral ganglia. In other Arthropods the cerebral ganglia arise in a similar way, but the invaginations disappear in the adult. In Nemertines the cerebral ganglia contain a cavity which communicates with the exterior by a narrow canal. Finally, in certain Echinodermata the ventral part of the central nervous system arises by the invagination of a linear streak of ectoderm, the cavity of the invagination persisting as the epineural canal.

Peripheral nervous system.

Although the central nervous system is almost always developed from the ectoderm of the embryo, the same cannot be said of the peripheral nerve trunks. These structures arise from the mesoblastic reticulum already described (Sedgwick, *Quart. Journ. Mic. Sci.* xxxvii. 92). Inasmuch as this reticulum is perfectly continuous with the precisely similar though denser tissue in the ectoderm and endoderm, it may well be that a portion of the nerve trunks should be described as being ectodermal and endodermal in origin, though the bulk of them are undoubtedly formed from that portion of the reticulum commonly described as mesoblastic. But, however that may be, the tissue from which the great nerve trunks are developed is continuous on all sides with a similar tissue which pervades all the organs of the body, and in which the nuclei of these organs are contained.

In the early stages of development this tissue is very sparse and not easily seen. It would appear, indeed, that it is of a very delicate texture and readily destroyed by reagents. It is for this reason that the layers of the Vertebrate embryo are commonly represented as being quite isolated from one another, and that the medullary canal is nearly always represented as being completely isolated at certain stages from the surrounding tissues. In reality the layers are all connected together by this delicate tissue—in a sparse form, it is true—which not only extends between them, but also in a denser and more distinct form pervades them. In the germinal layers themselves, and in the organs developing from them, this tissue is in the young stages almost entirely obscured by the densely packed nuclei which it contains. For instance, in the wall of the medullary canal in the Vertebrate embryo, in the splanchnic and somatic layers of mesoderm of the same embryo, and in the developing nerve cords of the *Peripatus* embryo, the nuclei are at first so densely crowded together that it is almost impossible to see the protoplasmic framework in which they rest, but as development proceeds this extra-nuclear tissue becomes more largely developed, and the nuclei are forced apart, so that it becomes visible and receives various names according to its position. In the wall of the medullary canal of the Vertebrate embryo, on the outside of which it becomes especially conspicuous in certain places, and on the dorsal side of the developing nerve cords of the *Peripatus* embryo, it constitutes the white matter of the developing nerve cord; in the mesoblastic tissue outside, where it at the same time becomes more conspicuous (Sedgwick, "Monograph of the Development of *Peripatus capensis*," *Studies from the Morph. Lab. of the University of Cambridge*, iv., 1889, p. 131), it forms the looser network of the mesoblastic reticulum; and connecting the two, in place of the few and delicate strands of this tissue of the former stage, there are at certain places well-marked cords of a relatively dense texture, with the meshes of the reticulum elongated in the direction of the cord. This latter structure is 321
an incipient nerve trunk. It can be traced outwards into the mesoblastic reticulum, from the strands of which it is indeed developed, and with which it is continuous not only at its free end, but also along its whole course. In this way the nerve trunks are developed—by a gathering up, so to speak, of the fibres of the reticulum into bundles. These bundles are generally marked by the possession of nuclei, especially in their cortical parts, which become no doubt the nuclei of the nerve sheath, and, in the neighbourhood of the ganglia, of nerve cells. From this account of the early development of the nerves, it is apparent that they are in their origin continuous with all the other tissues of the body, with that of the central nervous system and with that which becomes transformed into muscular tissue and connective and epithelial tissues. All these tissues are developed from the general reticulum, which in the young embryo can be seen to pervade the whole body, not being confined to the mesoderm, but extending between the nuclei of the ectoderm and endoderm, and forming the extra-nuclear, so-called cellular, protoplasm of those layers. Moreover, it must be remarked that in the stages of the embryo with which we are here concerned the so-called cellular constitution of the tissues, which is such a marked feature of the older embryo and adult, has not been arrived at. It is true, indications of it may be seen in some of the earlier-formed epithelia, but of nerve cells, muscular cells, and many kinds of gland cells no distinct signs are yet visible. This remark particularly applies to nerve cells, which do not make their appearance until a much later stage—not, indeed, until some time after the principal nerve trunks and ganglia are indicated as tracts of pale fibrous substance and aggregations of nuclei respectively.

The embryos of Elasmobranchs—particularly of *Scyllium*—are the best objects in which to study the development of nerves. In many embryos it is difficult to make out what happens, because the various parts of the body remain so close together that the process is obscured, and the loosening of the mesoblastic nuclei is deferred until after the nerves have begun to be differentiated. The process may also be traced in the embryos of *Peripatus*, where the main features are essentially similar to those above described (*op. cit.* p. 131). The development of the motor nerves has been worked out in *Lepidosiren* by J. Graham Kerr (*Trans. Roy. Soc. of Edinburgh*, 41, 1904. p. 119).

To sum up, the development of nerves is not, as has been recently urged, an outgrowth of cell processes from certain cells, but is a differentiation of a substance which was already in position, and from which all other organs of the body have been and are developed. It frequently happens that the young nerve tracts can be seen sooner near the central organ than elsewhere, but it is doubtful if any importance can be attached to this fact, since it is not constantly observed. For instance, in the case of the third nerve of *Scyllium* the differentiation appears to take place earliest near the ciliary ganglion, and to proceed from that point to the base of the mid-brain.

There are two main methods in which new organs are developed. In the one, which indicates the possibility of physiological continuity, the organ arises by the direct modification of a portion of a pre-existing organ; the development of the central nervous system of the Vertebrata from a groove in the embryonic ectoderm may be taken as an example of this method. In the other method there is no continuity which can be in any way interpreted as physiological; a centre of growth appears in one of the parts of the embryo, and gives rise to a mass of tissue which gradually shapes itself into the required organ. The development of the central nervous system in Teleosteans and in other similar exceptional cases may be mentioned as an example of the second plan. Such a centre of growth is frequently called a blastema, and consists of a mass of closely packed nuclei which have arisen by the growth-activity of the nuclei in the neighbourhood. The coelom, an organ which is found in the so-called coelomate animals, and which in the adult is usually divided up more or less completely into three parts, namely, body-cavity, renal organs, generative glands, presents in different animals both these methods of development. In certain animals it develops by the direct modification of a part of the primitive enteron, while in others it arises by the gradual shaping of a mass of tissue which consists of a compact mass of nuclei derived by nuclear proliferation from one or more of the pre-existing tissues of the body. Inasmuch as the first rudiment of the coelom nearly always makes its appearance at an early stage, when the ectoderm and endoderm are almost the only tissues present, and as it then bulks relatively very large and frequently contains within itself the potential centres of growth of other organs, *e.g.* mesenchymal organs (see above), it has come to be regarded by embryologists as being the forerunner of all the so-called mesodermal organs of the body, and has been dignified with the somewhat mysterious rank which attaches to the conception of a germinal layer. Its prominence and importance at an early stage led embryologists, as has already been explained, to overlook the fact that although some of the centres of growth for the formation of other non-coelomic mesodermal organs and tissues may be contained within it, all are not so contained, and that there are centres of mesodermal growth still left in the ectoderm and endoderm after its establishment. If these considerations, and others like them, are correct, it would seem to follow that the conception implied by the word mesoderm has no objective existence, that the tissue of the embryo called mesoderm, though sometimes mainly the rudiment of the coelom, is often much more than this, and contains within itself the rudiment of many, sometimes of all, of the organs appertaining to the mesenchyme. In thus containing within itself the potential centres of growth of other organs and tissues which are commonly ranked as mesodermal, it is not different from the rudiments of the two other organs already formed, namely, the ectoderm and endoderm; for these contain within themselves centres of growth for the production of so-called mesodermal tissues, as witness the nerve-crest of Vertebrata, the growing-point of the pronephric duct, and the formation of blood-vessels from the hypoblast described for some members of the same group.

In Echinodermata, *Amphioxus*, Enteropneusta, and a few other groups, the coelom develops from a portion or portions of the primitive enteron, which eventually becomes separated from the rest and forms a variable number of closed sacs lying between the gut and the ectoderm. The number of these sacs varies in different animals, but the evidence at present available seems to show that the maximum number is five—an unpaired one in front and two pairs behind—and, further, that if a less number of sacs is actually separated from the enteron, the rule is for these sacs so to divide up that they give rise to five sacs arranged in the manner indicated. The Enteropneusta present us with the clearest case of the separation of five sacs from the primitive enteron (W. Bateson, *Quart. Journ. Mic. Sci.* xxiv., 1884). In *Amphioxus*, according to the important researches of E.W. MacBride (*Quart. Journ. Mic. Sci.* xl. 589), it appears that a similar process occurs, though it is complicated by the fact that the sacs of the posterior pair become divided up at an early stage into many pairs. In *Phoronis* there are indications of the same phenomenon (A.T. Masterman, *Quart. Journ. Mic. Sci.* xliii. 375). In the Chaetognatha a single sac only is separated from the enteron, but soon becomes divided up. In the Brachiopoda one pair of sacs is separated from the enteron, but our knowledge of their later history is not sufficient to enable us to say whether they divide up into the typically arranged five sacs. In Echinodermata the number of sacs separated from the enteron varies from one to three; but though the history of these shows considerable differences, there are reasons to believe that the typical final arrangement is one unpaired and two paired sacs. But however many sacs may arise from the primitive enteron, and however these sacs may ultimately divide up and arrange themselves, the important point of development common to all these animals, about which there can be no dispute, is that the coelom is a direct differentiation of a portion of the enteron.

In the majority of the Coelomata the coelomic rudiment does not arise by the simple differentiation of a pre-existing organ, and there is considerable variation in its method of formation. Speaking generally, it may be said to arise by the differentiation of a blastema (see above), which develops at an early stage as a nuclear proliferation from one or more growth-centres in one or both of the primary layers. It appears in this tissue as a sac or as a series of sacs, which become transformed into the body-cavity (except in the Arthropoda), into the renal organs (with the possible exception, again, of some Arthropoda), and into the reproductive glands. In metamerically segmented animals the 322
appearance of the cavities of these sacs is synchronous with, and indeed determines, the appearance of metameric segmentation. In all segmented animals in which the mesoderm (coelomic rudiment) appears as a continuous sheet or band of tissue on each side of the body, the coelomic cavity makes its first appearance not as a continuous space on each side, which later becomes divided up into the structures called mesoblastic somites, but as a series of paired spaces round which the coelomic tissue arranges itself in an epithelial manner. In the Vertebrata, it is true, the ventral portion of the coelom appears at first as a continuous space, at any rate behind the region of the two anterior pairs of somites, but in the dorsal portion the coelomic cavity is developed in the usual way, the coelomic tissue becoming transformed into the muscle plates and rudimentary renal tubules of the later stages. With regard to this ventral portion of the coelom in Vertebrata, it is to be noticed that the cavity in it

never becomes divided up, but always remains continuous, forming the perivisceral portion of the coelom. The probable explanation of this peculiarity in the development of the Vertebrate coelom, as compared with that of *Amphioxus* and other segmented animals, is that the segmented stage of the ventral portion of the coelom is omitted. This explanation derives some support from the fact that even in animals in which the coelom is at its first appearance wholly segmented, it frequently happens that in the adult the perivisceral portion of it is unsegmented, *i.e.* it loses during development the segmentation which it at first possesses. This happens in many Annelida and in *Amphioxus*. The lesson, then, which the early history of the coelom in segmented animals teaches is, that however the coelomic cavity first makes its appearance, whether by evaginations from the primitive enteron, or by the hollowing out of a solid blastema-like tissue which has developed from one or both of the primary layers, it is in its first origin segmented, and forms the basis on which the segments of the adult are moulded. In Arthropoda the origin of the coelom is similar to that of Annelids, but its history is not completely known in any group, with the exception of *Peripatus*. In this genus it develops no perivisceral portion, as in other groups, but gives rise solely to the nephridia and to the reproductive organs. It is probable, though not certainly proved, that the history of the coelom in other Arthropods is essentially similar to that of *Peripatus*, allowance being made for the fact that the nephridial portion does not attain full development in those forms which are without nephridia in the adult.

With regard to the development of the vascular system, little can be said here, except that it appears to arise from the spaces of the mesoblastic reticulum. When this reticulum is sparse or so delicate as to give way in manipulation, these spaces appear to be represented by a continuous space which in the earliest stages of development is frequently spoken of as the blastocoel or segmentation cavity. They acquire special epithelial walls, and form the main trunks and network of smaller vessels found in animals with a canalicular vascular system, or the large sinus-like spaces characteristic of animals with a haemocoelic body-cavity.

Transient embryonic organs.

The existence of a phase at the beginning of life during which a young animal acquires its equipment by a process of growth of the germ is of course intelligible enough; such a phase is seen in the formation of buds, and in the sexual reproduction of both animals and plants. The remarkable point is that while in most cases this embryonic growth is a direct and simple process—*e.g.* animal and plant buds, embryonic development of plant seeds—in many cases of sexual reproduction of animals it is not direct, and the embryonic phase shows stages of structure which seem to possess a meaning other than that of being merely phases of growth. The fact that these stages of structure through which the embryo passes sometimes present for a short time features which are permanent in other members of the same group, adds very largely to the interest of the phenomenon and necessitates its careful examination. This may be divided into two heads: (1) in relation to embryos, (2) in relation to larvae. So far as embryos are concerned, we shall limit ourselves mainly to a consideration of the Vertebrata, because in them are found most instances of that remarkable phenomenon, the temporary assumption by certain organs of the embryo of stages of structure which are permanent in other members of the same group. As is well known, the embryos of the higher Vertebrata possess in the structure of the pharynx and of the heart and vascular system certain features—namely, paired pharyngeal apertures, a simple tubular heart, and a single ventral aorta giving off right and left a number of branches which pass between the pharyngeal apertures—which permanently characterize those organs in fishes. The skeleton, largely bony in the adult, passes through a stage in which it is entirely without bone, and consists mainly of cartilage—the form which it permanently possesses in certain fishes. Further, the Vertebrate embryo possesses for a time a notochord, a segmented muscular system, a continuity between the pericardium and the posterior part of the perivisceral cavity—all features which characterize certain groups of Pisces in the adult state. Instances of this kind might be multiplied, for the work of anatomists and embryologists has of late years been largely devoted to adding to them. Examples of embryonic characters which are not found in the adults of other Vertebrates are the following:—At a certain stage of development the central nervous system has the form of a groove in the skin, there is a communication at the hind end of the body between the neural and alimentary canals, the mouth aperture has at first the form of an elongated slit, the growing end of the Wolffian duct is in some groups continuous with the ectoderm, and the retina is at one stage a portion of the wall of the medullary canal. In the embryos of the lower Vertebrates many other instances of the same interesting character might be mentioned; for instance, the presence of a coelomic sac close to the eye, of another in the jaw, and of a third near the ear (Elasmobranchs), the opening of the Müllerian duct into the front end of the Wolffian duct, and the presence of an aperture of communication between the muscle-plate coelom and the nephridial coelom.

Recapitulation theory.

The interest attaching to these remarkable facts is much increased by the explanation which has been given of them. That explanation, which is a deduction from the theory of evolution, is to the effect that the peculiar embryonic structures and relations just mentioned are due to the retention by the embryo of features which, once possessed by the adult ancestor, have been lost in the course of evolution. This explanation, which at once suggests itself when we are dealing with structures actually present in adult members of other groups, does not so obviously apply to those features which are found in no adult animal whatsoever. Nevertheless it has been extended to them, because they are of a nature which it is not impossible to suppose might have existed in a working animal. Now this explanation, which, it will be observed, can only be entertained on the assumption that the evolution theory is true, has been still further extended by embryologists in a remarkable and frequently unjustifiable manner, and has been

applied to all embryonic processes, finally leading to the so-called recapitulation theory, which asserts that embryonic history is a shortened recapitulation of ancestral history, or, to use the language of modern zoology, that the *ontogeny* or development of the individual contains an abbreviated record of the *phylogeny* or development of the race. A theory so important and far-reaching as this requires very careful examination. When we come to look for the facts upon which it is based, we find that they are non-existent, for the ancestors of all living animals are dead, and we have no means of knowing what they were like. It is true there are fossil remains of animals which have lived, but these are so imperfect as to be practically useless for the present requirements. Moreover, if they were perfectly preserved, there would be no evidence to show that they were ancestors of the animals now living. They might have been animals which have become extinct and left no descendants. Thus the explanation ordinarily given of the embryonic structures referred to is purely a deduction from the evolution theory. Indeed, it is even less than this, for all that can be said is something of this kind: if 323
the evolution theory is true, then it in conceivable that the reason why the embryo of a bird passes through a stage in which its pharynx presents some resemblance to that of a fish is that a remote ancestor of the bird possessed a pharynx with lateral apertures such as are at present found in fishes.

But the explanation is sometimes pushed even further, and it is said that these pharyngeal apertures of the ancestral bird had the same respiratory function as the corresponding structures in modern fishes. That this is going too far a little reflection will show. For if it be admitted that all so-called vestigial structures had once the same function as the homologous structures when fully developed in other animals, it becomes necessary to admit that male mammals must once have had fully developed mammary glands and suckled the young, that female mammals formerly were provided with a functional penis, and that in species in which the females have a trace of the secondary sexual characters of the male the latter were once common to both sexes. The second and more extended form of the explanation plainly introduces a considerable amount of contentious matter, and it will be advisable, in the first instance, at any rate, to confine ourselves to a critical examination of the less ambitious conception. This explanation obviously implies the view that in the course of evolution the tendency has been for structures to persist in the embryo after they have been lost in the adult. Is there any justification for this view? It is clearly impossible to get any direct evidence, because, as explained above, we have no knowledge of the ancestors of living animals; but if we assume the evolution theory to be true, there is a certain amount of indirect evidence which is distinctly opposed to the view. As is well known, living birds are without teeth, but it is generally assumed that their edentulous condition has been comparatively recently acquired, and that they are descended from animals which, at a time not very remote from the present, possessed teeth. Considering the resemblance of birds to other terrestrial vertebrates, and the fact that extinct birds, not greatly differing from birds now living, are known to have had teeth, it must be allowed that there is some warrant for the assumption. Yet in no single case has it been certainly shown that any trace of teeth has been developed in the embryo. The same remark applies to a large number of similar cases; for instance, the reduced digits of the bird’s hand and foot and the limbs of snakes. Moreover, organs which are supposed to have become recently reduced and functionless in the adult are also reduced in the embryo; for instance, digits 3 and 4 of the horse’s foot, the hind limbs of whales (G.A. Guldberg and F. Nansen, “On the Development and Structure of Whales,” *Bergen Museum*, 1894), the spiracle of Elasmobranchii. In fact, considerations of this kind distinctly point to the view that any tendency to the reduction or enlargement of an organ in the adult is shared approximately to the same extent by the embryo. But there are undoubtedly some, though not many, cases in which organs which were presumably present in an ancestral adult have persisted in the embryo of the modern form. As an instance may be mentioned the presence in whale-bone whales of imperfectly formed teeth, which are absorbed comparatively early in foetal life (Julin, *Arch. biologie*, i., 1880, p. 75).

It therefore becomes necessary to inquire why in some cases an organ is retained by the embryo after its loss by the adult, whereas in other cases it dwindles and presumably disappears simultaneously in the embryo and the adult. The whole question is examined and discussed by the present writer in the *Quarterly Journal of Microscopical Science*, xxxvi., 1894, p. 35, and the conclusions there reached are as follows:—A disappearing adult organ is not retained in a relatively greater development by an organism in the earlier stages of its individual growth unless it is of functional importance to the young form. In cases in which the whole development is embryonic this rarely happens, because the conditions of embryonic life are so different from free life that functional embryonic organs are usually organs *sui generis, e.g.* the placenta, amnion, &c., which cannot be traced to a modification of organs previously present in the adult. It does, however, appear to have happened sometimes, and as an instance of it may be mentioned the *ductus arteriosus* of the Sauropsidan and Mammalian embryo. On the other hand, when there is a considerable period of larval life, it does appear that there is a strong case for thinking that organs which have been lost by the adult may be retained and made use of by the larva. The best-known example that can be given of this is the tadpole of the frog. Here we find organs, viz. gills and gill-slits, which are universally regarded as having been attributes of all terrestrial Vertebrata in an earlier and aquatic condition, and we also notice that their retention is due to their being useful on account of the supposed ancient conditions of life having been retained. Many other instances, more or less plausible, of a like retention of ancestral features by larvae might be mentioned, and it must be conceded that there are strong reasons for supposing that larvae often retain traces, more or less complete, of ancestral stages of structure. But this admission does not carry with it any obligation to accept the widely prevalent view that larval history can in any way be regarded as a recapitulation of ancestral history. Far from it, for larvae in retaining some ancestral features are in no way different from adults; they only differ from adults in the features which they have retained. Both larvae and adults retain ancestral features, and both have been modified by an adaptation to their respective conditions of life which has ever been becoming more perfect.

The conclusion, then, has been reached, that whereas larvae frequently retain traces of ancestral stages of adult structure, embryos will rarely do so; and we are confronted again with the question, How are we to account for the presence in the embryo of numerous functionless organs which cannot be explained otherwise than as having been inherited from a previous condition in which they were functional? The answer is that the only organs of this kind which have been retained are organs which have been retained by the larvae of the ancestors after they have been lost by the adult, and have become in this way impressed upon the development. As an illustration taken from current natural history of the manner in which larval characters are in actual process of becoming embryonic may be mentioned the case of the viviparous salamander (*Salamander atra*), in which the gills, &c., are all developed but never used, the animal being born without them. In other and closely allied species of salamander there is a considerable period of larval life in which the gills and gill-slits are functional, but in this species the larval stage, for the existence of which there was a distinct reason, viz. the entirely aquatic habits of life in the young state, has become at one stroke embryonic by its simple absorption into the embryonic period. The view, then, that embryonic development is essentially a recapitulation of ancestral history must be given up; it contains only a few references to ancestral history, namely, those which have been preserved probably in a much modified form by previous larvae.

Law of v. Baer.

We must now pass to the consideration of another supposed law of embryology—the so-called law of v. Baer. This generalization is usually stated as follows:—Embryos of different species of the same group are more alike than adults, and the resemblances are greater the younger the embryo examined. Great importance has been attached to this generalization by embryologists and naturalists, and it is very widely accepted. Nevertheless, it is open to serious criticism. If it were true, we should expect to find that embryos of closely similar species would be indistinguishable, but this is notoriously not the case. On the contrary, they often differ more than do the adults, in support of which statement the embryos of the different species of *Peripatus* may be referred to. The generalization undoubtedly had its origin in the fact that there is what may be called a family resemblance between embryos, but this resemblance, which is by no means exact, is purely superficial, and does not extend to anatomical detail. On the contrary, it may be fairly argued that in some cases embryos of widely dissimilar members of the same group present anatomical differences of a higher morphological value than do the adults (see Sedgwick, *loc. cit.*), and, as stated above the embryos of closely allied animals are distinguishable at all stages of 324
development, though the distinguishing features are not the same as those which distinguish the adults. To say that the development of the organism and of its component parts is a progress from the simple to the complex is to state a truism, but to state that it is also a progress from the general to the special is to go altogether beyond the facts. The bipinnaria larva of an echinoderm, the trochosphere larva of an annelid, the blastodermic vesicle of a mammal are all as highly specialized as their respective adults, but the specialization is for a different purpose, and of a different kind to that which characterizes the adult.

History of embryology.

In its scientific and systematic form embryology may be considered as having only taken birth within the last century, although the germ from which it sprung was already formed nearly half a century earlier. The ancients, it is true, as we see by the writings of Aristotle and Galen, pursued the subject with interest, and the indefatigable Greek naturalist and philosopher had even made continued series of observations on the progressive stages of development in the incubated egg, and on the reproduction of various animals; but although, after the revival of learning, various anatomists and physiologists from time to time made contributions to the knowledge of the foetal structure in its larger organs, yet from the minuteness of the observations required for embryological research, it was not till the microscope came into use for the investigation of organic structure that any intimate knowledge was attained of the nature of organogenesis. It is not to be wondered at, therefore, that during a long period, in this as in other branches of physical inquiry, vague speculations took the place of direct observation and more solid information. This is apparent in most of the works treating of generation during the 16th and part of the 17th centuries.[2]

Harvey was the first to give, in the middle of the latter century, a new life and direction to investigation of this subject, by his discovery of the connexion between the cicatricula of the yolk and the rudiments of the chick, and by his faithful description of the successive stages of development as observed in the incubated egg, as well as of the progress of gestation in some Mammalia. He had also the merit of fixing the attention of physiologists upon general laws of development as deduced from actual observation of the phenomena, by the enunciation of two important propositions, viz.—(1) that all animals are produced out of ova, and (2) that the organs of the embryo arise by new formation, or *epigenesis,* and not by mere enlargement out of a pre-existing invisible condition (*Exercitationes de generatione animalium*, Amstelodami, 1651). Harvey’s observations, however, were aided only by the use of magnifying glasses (perspecillae), probably of no great power, and he saw nothing of the earliest appearances of the embryo in the first thirty-six hours, and believed the blood and the heart to be the parts first formed.

The influence of the work of Harvey, and of the successful application of the microscope to embryological investigation, was soon afterwards apparent in the admirable researches of Malpighi of Bologna, as evinced by his communications to the Royal Society of London in 1672, “De ovo incubato,” and “De formatione pulli,” and more especially in his delineations of some of the earlier phenomena of development, in which, as in many other parts of minute anatomy, he partially or wholly anticipated discoveries, the full development of which has only been accomplished in the present century. Malpighi traced the origin of the embryo almost to its very commencement in the formation of the cerebro-spinal groove within the cicatricula, which he removed from the opaque mass of the yolk; and he only erred in supposing the embryonal rudiments to have pre-existed as such in the egg, in consequence, apparently, of his having employed for observation, in very warm weather, eggs which, though he believed them to be unincubated, had in reality undergone some of the earlier developmental changes.

The works of Walter Needham (1667), Regnier de Graaf (1673), Swammerdam (1685), Vallisneri (1689)—following upon those of Harvey—all contain important contributions to the knowledge of our subject, as tending to show the similarity in the mode of production from ova in a variety of animals with that previously best known in birds. The observations more especially of de Graaf, Nicolas Steno and J. van Horne gave much greater precision to the knowledge of the connexion between the origin of the ovum of quadrupeds and the vesicles of the ovary now termed Graafian, which de Graaf showed always burst and discharged their contents on the occurrence of pregnancy.

These observations bring us to the period of Boerhaave and Albinus in the earlier part of the 18th century, and in the succeeding years to that of Haller, whose vast erudition and varied and accurate original observations threw light upon the entire process of reproduction in animals, and brought its history into a more systematic and intelligible form. A considerable part of the seventh and the whole of the eighth volumes of Haller’s great work, the *Elementa physiologiae*, published at successive times from 1757 to 1766, are occupied with the general view of the function of generation, while his special contributions to embryology are contained in his *Deux mémoires sur la formation du cœur dans le poulet* and *Deux mémoires sur la formation des os*, both published at Lausanne in 1758, and republished in an extended and altered form, together with his “Observations on the early condition of the Embryo in Quadrupeds,” made along with Kühlemann, in the *Opera minora* (1762-1768). Though originally educated as a believer in the doctrine of “preformation” by his teacher Boerhaave, Haller was soon led to abandon that view in favour of “epigenesis” or new formation, as may be seen in various parts of his works published before the middle of the century; see especially a long note explanatory of the grounds of his change of opinion in his edition of Boerhaave’s *Praelectiones academicae*, vol. v. part 2, p. 497 (1744), and his *Primae lineae physiologiae* (1747). But some years later, and after having been engaged in observing the phenomena of development in the incubated egg, he again changed his views, and during the remainder of his life was a keen opponent of the system of epigenesis, and a defender and exponent of the theory of “evolution,” as it was then named —a theory very different from that now bearing the name, and which implied belief in the pre-existence of the organs of the embryo in the germ, according to the theory of encasement (*emboîtement*) or inclusion supported by Leibnitz and Bonnet. (See the interesting work of Bonnet, *Considérations sur les corps organisés*, Amsterdam, 1762, for an account of his own views and those of Haller.)

It was reserved for Caspar Frederick Wolff (1733-1794), a German by birth, but naturalized afterwards in Russia, to bring forward observations which, though almost entirely neglected for a long time after their publication, and in some measure discredited under the influence of Haller’s authority, were sixty years later acknowledged to have established the theory of epigenesis upon the secure basis of ascertained facts, and to have laid the first foundation of the morphological science of embryology. Wolff’s work, entitled *Theoria generationis*, first published as an inaugural Dissertation at Berlin in 1759, was republished with additions in German at Berlin in 1764, and again in Latin at Halle in 1774. Wolff also wrote a “Memoir on the Development of the Intestine” in *Nov. comment.* 325 *acad. Petropol.*, 1768 and 1769. But it was not till the latter work was translated into German by J.F. Meckel, and appeared in his *Archiv* for 1812, that Wolff’s peculiar merits as the founder of modern embryology came to be known or fully appreciated.

The special novelty of Wolff’s discoveries consisted mainly in this, that he showed that the germinal part of the bird’s egg forms a layer of united granules or organized particles (cells of the modern histologist), presenting at first no semblance of the form or structure of the future embryo, but gradually converted by various morphological changes in the formative material, which are all capable of being traced by observation, into the several rudimentary organs and systems of the embryo. The earlier form of the embryo he delineated with accuracy; the actual mode of formation he traced in more than one organ, as for example in the alimentary canal, and he was the discoverer of several new and important embryological facts, as in the instance of the primordial kidneys, which have thus been named the Wolffian bodies. Wolff further showed that the growing parts of plants owe their origin to organized particles or cells, so that he was led to the great generalization that the processes of embryonic formation and of adult growth and nutrition are all of a like nature in both plants and animals. No advance, however, was made upon the basis of Wolff’s discoveries till the year 1817, when the researches of C.H. Pander on the development of the chick gave a fuller and more exact view of the phenomena less clearly indicated by Wolff, and laid down with greater precision a plan of the formation of parts in the embryo of birds, which may be regarded as the foundation of the views of all subsequent embryologists.

But although the minuter investigation of the nature and true theory of the process of embryonic development was thus held in abeyance for more than half a century, the interval was not unproductive of observations having an important bearing on the knowledge of the anatomy of the foetus and the function of reproduction. The great work of William Hunter on the human gravid uterus, containing unequalled pictorial illustrations of its subject from the pencil of Rymsdyk and other artists, was published in 1775;[3] and during a large part of the same period numerous communications to the *Memoirs* of the Royal Society testified to the activity and genius of his brother, John Hunter, in the investigation of various parts of comparative embryology. But it is mainly in his rich museum, and in the manuscripts and drawings which he left, and which have been in part described and published in the catalogue of his wonderful collection, that we obtain any adequate idea of the unexampled industry and wide scope of research of that great anatomist and physiologist.

As belonging to a somewhat later period, but still before the time when the more strict investigation of embryological phenomena was resumed by Pander, there fall to be noticed, as indicative of the rapid progress that was making, the experiments of L. Spallanzani, 1789; the researches of J.H. von Autenrieth, 1797, and of Soemmering, 1799, on the human foetus; the observations of Senff on the formation of the skeleton, 1801; those of L. Oken and D.G. Kieser on the intestine and other organs, 1806; Oken’s remarkable work on the bones of the head, 1807 (with the views promulgated in which Goethe’s name is also intimately connected); J.F. Meckel’s numerous and valuable contributions to embryology and comparative anatomy, extending over a long series of years; and F. Tiedemann’s classical work on the development of the brain, 1816.

The observations of the Russian naturalist, Christian Heinrich Pander (1794-1865), were made at the instance and under the immediate supervision of Prof. Döllinger at Würzburg, and we learn from von Baer’s autobiography that he, being an early friend of Pander’s, and knowing his qualifications for the task, had pointed him out to Döllinger as well fitted to carry out the investigation of development which that professor was desirous of having accomplished. Pander’s inaugural dissertation was entitled *Historia metamorphoseos quam ovum incubatum prioribus quinque diebus subit* (Virceburgi, 1817); and it was also published in German under the title of *Beiträge zur Entwickelungsgeschichte des Hühnchens im Eie* (Würzburg, 1817). The beautiful plates illustrating the latter work were executed by the elder E.J. d’Alton, well known for his skill in scientific observation, delineation and engraving.

Pander observed the germinal membrane or *blastoderm*, as he for the first time called it, of the fowl’s egg to acquire three layers of organized substance in the earlier period of incubation. These he named respectively the serous or outer, the vascular or middle, and the mucous or inner layers; and he traced with great skill and care the origin of the principal rudimentary organs and systems from each of these layers, pointing out shortly, but much more distinctly than Wolff had done, the actual nature of the changes occurring in the process of development.

Karl Ernest von Baer (*q.v.*), the greatest of modern embryologists, was, as already remarked, the early friend of Pander, and, at the time when the latter was engaged in his researches at Würzburg, was associated with Döllinger as prosector, and engaged with him in the study of comparative anatomy. He witnessed, therefore, though he did not actually take part in, Pander’s researches; and the latter having afterwards abandoned the inquiry, von Baer took it up for himself in the year 1819, when he had obtained an appointment in the university of Königsberg, where he was the colleague of Burdach and Rathke, both of whom were able coadjutors in the investigation of the subject of his choice. (See v. Baer’s interesting autobiography, published on his retirement from St Petersburg to Dorpat in 1864.)

Von Baer’s observations were carried on at various times from 1819 to 1826 and 1827, when he published the first results in a description of the development of the chick in the first edition of Burdach’s *Physiology*.

It was at this time that von Baer made the important discovery of the ovarian ovum of mammals and of man, totally unknown before his time, and was thus able to prove as matter of exact observation what had only been surmised previously, viz. the entire similarity in the mode of origin of these animals with others lower in the scale. (*Epistola de ovi mammalium et hominis genesi,* Lipsiae, 1827. See also the interesting commentary on or supplement to the *Epistola* in Heusinger’s Journal, and the translation in Breschet’s *Répertoire*, Paris, 1829.)

In 1829 von Baer published the first part of his great work, entitled *Beobachtungen und Reflexionen über die Entwickelungsgeschichte der Thiere*, the second part of which, still leaving the work incomplete, did not appear till 1838. In this work, distinguished by the fulness, richness and extreme accuracy of the observations and descriptions, as well as by the breadth and soundness of the general views on embryology and allied branches of biology which it presents, he gave a detailed account not only of the whole progress of development of the chick as observed day by day during the incubation of the egg, but he also described what was known, and what he himself had investigated by numerous and varied observations, of the whole course of formation of the young in other vertebrate animals. His work is in fact a system of comparative embryology, replete with new discoveries in almost every part.

Von Baer’s account of the layers of the blastoderm differs somewhat from that of Pander, and appears to be more consistent with the further researches which have lately been made than was at one time supposed, in this respect, that he distinguished from a very early period two primitive or

fundamental layers, viz. the animal or upper, and the vegetative or lower, from each of which, in connexion with two intermediate layers derived from them, the fundamental organs and systems of the embryo are derived:—the animal layer, with its derivative, supplying the dermal, neural, osseous and muscular; the vegetative layer, with its derivative, the vascular and mucous (intestinal) systems. He laid down the general morphological principle that the fundamental organs have essentially the 326
shape of tubular cavities, as appears in the first form of the central organ of the nervous system, in the two muscular and osseous tubes which form the walls of the body, and in the intestinal canal; and he followed out with admirable clearness the steps by which from these fundamental systems the other organs arise secondarily, such as the organs of sense, the glands, lungs, heart, vascular glands, Wolffian bodies, kidneys and generative organs.

To complete von Baer's system there was mainly wanting a more minute knowledge of the intimate structure of the elementary tissues, but this had not yet been acquired by biologists, and it remained for Theodor Schwann of Liége in 1839, along with whom should be mentioned those who, like Robert Brown and M.J. Schleiden, prepared the way for his great discovery, to point out the uniformity in histological structure of the simpler forms of plants and animals, the nature of the organized animal and vegetable cell, the cellular constitution of the primitive ovum of animals, and the derivation of the various tissues, complex as well as simple, from the transformation or, as it is now called, differentiation of simple cellular elements,—discoveries which have exercised a powerful and lasting influence on the whole progress of biological knowledge in our time, and have contributed in an eminent degree to promote the advance of embryology itself.

To K.B. Reichert of Berlin more particularly is due the first application of the newer histological views to the explanation of the phenomena of development, 1840. To him and to R.A. von Kölliker and R. Virchow is due the ascertainment of the general principle that there is no free-cell formation in embryonic development and growth, but that all organs are derived from the multiplication, combination and transformation of cells, and that all cells giving rise to organs are the descendants or progeny of previously existing cells, and that these may be traced back to the original cell or cell-substance of the ovum.

It may be that modern research has somewhat modified the views taken by biologists of the statements of Schwann as to the constitution of the organized cell, especially as regards its simplest or most elementary form, and has indicated more exactly the nature of the protoplasmic material which constitutes its living basis; but it has not caused any very wide departure from the general principles enunciated by that physiologist. Schwann's treatise, entitled *Microscopical Researches into the Accordance in the Structure and Growths of Animals and Plants*, was published in German at Berlin in 1839, and was translated into English by Henry Smith, and printed for the Sydenham Society in 1847, along with a translation of Schleiden's memoir, "Contributions to Phytogenesis," which originally appeared in 1838 in Müller's *Archiv* for that year, and which had also been published in English in Taylor and Francis's *Scientific Memoirs*, vol. ii. part vi.

Among the newer observations of the same period which contributed to a more exact knowledge of the structure of the ovum itself may be mentioned—first the discovery of the germinal vesicle, or nucleus, in the germ-disk of birds by J.E. von Purkinje (*Symbolae ad ovi avium historiam ante incubationem*, Vratislaviae, 1825, and republished at Leipzig in 1830); second, von Baer's discovery of the mammiferous ovum in 1827, already referred to; third, the discovery of the germinal vesicle of mammals by J.V. Coste in 1834, and its independent observation by Wharton Jones in 1835; and fourth, the observation in the same year by Rudolph Wagner of the germinal macula or nucleus. Coste's discovery of the germinal vesicle of Mammalia was first communicated to the public in the *Comptes rendus* of the French Academy for 1833, and was more fully described in the *Recherches sur la génération des mammifères*, by Delpech and Coste (Paris, 1834). Thomas Wharton Jones's observations, made in the autumn of 1834, without a knowledge of Coste's communication, were presented to the Royal Society in 1835. This discovery was also confirmed and extended by G.G. Valentin and Bernardt, as recorded by the latter in his work *Symb. ad ovi mammal. hist. ante praegnationem*. Rudolph Wagner's observations first appeared in his *Textbook of Comparative Anatomy*, published at Leipzig in 1834-1835, and in Müller's *Archiv* for the latter year. His more extended researches are described in his work *Prodromus hist. generationis hominis atque animalium* (Leipzig, 1836), and in a memoir inserted in the *Trans. of the Roy. Bavarian Acad. of Sciences* (Munich, 1837).

The two decades of years from 1820 to 1840 were peculiarly fertile in contributions to the anatomy of the foetus and the progress of embryological knowledge. The researches of Prévost and Dumas on the ova and primary stages of development of Batrachia, birds and mammals, made as early as 1824, deserve especial notice as important steps in advance, both in the discovery of the process of yolk segmentation in the batrachian ovum, and in their having shown almost with the force of demonstration, previous to the discovery of the mammiferous ovarian ovum by von Baer, that that body must exist as a minute spherule in the Graafian follicle of the ovary, although they did not actually succeed in bringing the ova clearly under observation.

The works of Pockels (1825), of Seiler (1831), of G. Breschet (1832), of A.A.L.M. Velpeau (1833), of T.L.W. Bischoff (1834)—all bearing upon human embryology; the researches of Coste in comparative embryology in 1834, already referred to, and those published by the same author in 1837; the publication of Johannes Müller's great work on physiology, and Rudolph Wagner's smaller text-book, in both of which the subject of embryology received a very full treatment, together with the excellent

Manual of the Development of the Foetus, by Valentin, in 1835, the first separate and systematic work on the whole subject, now secured to embryology its permanent place among the biological sciences on the Continent; while in this country attention was drawn to the subject by the memoirs of Allen Thomson (1831), Th. Wharton Jones (1835-1838) and Martin Barry (1839-1840).

Among the more remarkable special discoveries which belong to the period now referred to, a few may be mentioned, as, for example, that of the chorda dorsalis by von Baer, a most important one, which may be regarded as the key to the whole of vertebral morphology; the phenomenon of yolk segmentation, now known to be universal among animals, but which was only first carefully observed in Batrachia by Prévost and Dumas (though previously casually noticed by Swammerdam), and was soon afterwards followed out by Rusconi and von Baer in fishes; the discovery of the branchial clefts, plates and vascular arches in the embryos of the higher abranchiate animals by H. Rathke in 1825-1827; the able investigation of the transformations of these arches by Reichert in 1837; and the researches on the origin and development of the urinary and generative organs by Johannes Müller in 1829-1830.

On entering the fifth decade of the 19th century, the number of original contributions and systematic treatises becomes so great as to render the attempt to enumerate even a selection of the more important of them quite unsuitable to the limits of the present article. We must be satisfied, therefore, with a reference to one or two which seem to stand out with greater prominence than the rest as landmarks in the progress of embryological discovery. Among these may first be mentioned the researches of Theodor L.W. von Bischoff, formerly of Giessen and later of Munich, on the development of the ovum in Mammalia, in which a series of the most laborious, minute and accurate observations furnished a greatly novel and very full history of the formative process in several animals of that class. These researches are contained in four memoirs, treating separately of the development of the rabbit, the dog, the guinea-pig and the roe-deer, and appeared in succession in the years 1842, 1845, 1852 and 1854.

Next may be mentioned the great work of Coste, entitled *Histoire gén. et particul. du développement des animaux*, of which, however, only four fasciculi appeared between the years 1847 and 1859, leaving the work incomplete. In this work, in the large folio form, beautiful representations are given of the author's valuable observations on human embryology, and on that of various mammals, birds and fishes, and of the author's discovery in 1847 of the process of partial yolk 327
segmentation in the germinal disk of the fowl's egg during its descent through the oviduct, and his observations on the same phenomenon in fishes and mammals.

The development of reptiles received important elucidation from the researches of Rathke, in his history of the development of serpents, published at Königsberg in 1839, and in a similar work on the turtle in 1848, as well as in a later one on the crocodile in 1866, along with which may be associated the observations of H.J. Clark on the "Embryology of the Turtle," published in Agassiz's *Contributions to Natural History, &c.*, 1857.

The phenomena of yolk segmentation, to which reference has more than once been made, and to which later researches give more and more importance in connexion with the fundamental phenomena of development, received great elucidation during this period, first from the observations of C.T.E. von Siebold and those of Bagge on the complete yolk segmentation of the egg in nematoid worms in 1841, and more fully by the observations of Kölliker in the same animals in 1843. The nature of partial segmentation of the yolk was first made known by Kölliker in his work on the development of the Cephalopoda in 1844, and, as has already been mentioned, the phenomena were observed by Coste in the eggs of birds. The latter observations have since been confirmed by those of Oellacher, Götte and Kölliker. Further researches in a vast number of animals give every reason to believe that the phenomenon of segmentation is in some shape or other the invariable precursor of embryonic formation.

The first considerable work on the development of a division of the invertebrates was that of Maurice Herold of Marburg on spiders, *De generatione aranearum ex ovo*, published at Marburg in 1824, in which the whole phenomena of the formative processes in that animal are described with remarkable clearness and completeness. A few years later an important series of contributions to the history of the development of invertebrate animals appeared in the second volume of Burdach's work on *Physiology*, of which the first edition was published in 1828, and in this the history of the development of the Entozoa was the production of Ch. Theod. von Siebold, and that of most of the other invertebrates was compiled by H. Rathke from the results of his own observations and those of others. These memoirs, together with others subsequently published by Rathke, notably that *Über die Bildung und Entwickelungsgeschichte d. Flusskrebses* (Leipzig, 1829), in which an attempt is made to extend the doctrine of the derivation of the organs from the germinal layers to the invertebrata, entitle him to be regarded as the founder of invertebrate embryology.

A large body of facts having by this time been ascertained with respect to the more obvious processes of development, a further attempt to refer the phenomena of organogenesis to morphological and histological principles became desirable. More especially was the need felt to point out with greater minuteness and accuracy the relation in which the origin of the fundamental organs of the embryo stands to the layers of the blastoderm; and this we find accomplished with signal success in the researches of R. Remak on the development of the chick and frog, published between the years 1850 and 1855.

Starting from Pander’s discovery of the trilaminate blastoderm, Remak worked out the development of the chick in the light of the cell-theory of Schleiden and Schwann. He observed the division of the middle layer into two by a split which subsequently gives rise to the body-cavity (pleuro-peritoneal space) of the adult; and traced the principal organs which came from these two layers (*Hautfaserblatt* and *Darmfaserblatt*) respectively. In this manner the foundations of the germ-layer theory were established in their modern form.

A great step forward was made in 1859 by T.H. Huxley, who compared the serous and mucous layers of Pander with the ectoderm and endoderm of the Coelenterata. But in spite of this comparison it was generally held that germinal layers similar to those of the vertebrata were not found in invertebrate animals, and it was not until the publication in 1871 of Kowalewsky’s researches (see below) that the germinal layer theory was applied to the embryos of all the Metazoa. But the year 1859 will be for ever memorable in the history of science as the year of the publication of the *Origin of Species*. If the enunciation of the cell-theory may be said to have marked a first from a second period in the history of embryology, the publication of Darwin’s great idea ushered in a third. Whereas hitherto the facts of anatomy and development were loosely held together by the theory of types which owed its origin and maintenance to Cuvier, L. Agassiz, J. Müller and R. Owen, they were now combined into one organic whole by the theory of descent and by the hypothesis of recapitulation which was deduced from that theory. First clearly enunciated by Johann Müller in his well-known work *Für Darwin* published in 1864 (rendered in England as *Facts for Darwin*, 1869), the view that a knowledge of embryonic and larval histories would lay bare the secrets of race history and enable the course of evolution to be traced and so lead to the discovery of the natural system of classification, gave a powerful stimulus to embryological research. The first fruits of this impetus were gathered by Alexander Agassiz, A. Kowalewsky and E. Metschnikoff. Agassiz, in his memoir on the *Embryology of the Starfish* published in 1864, showed that the body-cavity in Echinodermata arises as a differentiation of the enteron of the larva and so laid the foundations of our present knowledge of the coelom. This discovery was confirmed in 1869 by Metschnikoff (“Studien üb. d. Entwick. d. Echinodermen u. Nemertinen,” *Mém. Ac. Pétersbourg* (7), 41, 1869), and extended by him to Tornaria, the larva of *Balanoglossus* in 1870 (“Untersuchungen üb. d. Metamorphose einiger Seethiere,” *Zeit. f. wiss. Zoologie*, 20, 1870). In 1871 Kowalewsky in his classical memoir, entitled “Embryologische Studien an Würmern und Arthropoden” (*Mém. Acad. Pétersbourg* (7), 16, 1871), proved the same fact for Sagitta and added immensely to our knowledge of the early stages of development of the Invertebrata. These memoirs formed the basis on which subsequent workers took their stand. Amongst the most important of these was F.M. Balfour (1851-1882). Led to the study of embryology by his teacher, M. Foster, in association with whom he published in 1874 the Elements of Embryology, Balfour was one of the first to take advantage of the facilities for research offered by Dr. A. Dohrn’s Zoological Station at Naples which has since become so celebrated. Here he did the work which was subsequently published in 1878 in his *Monograph of the Development of Elasmobranch Fishes*, and which constituted the most important addition to vertebrate morphology since the days of Johannes Müller. This was followed in 1879 and 1881 by the publication of his *Treatise on Comparative Embryology*, the first work in which the facts of the rapidly growing science were clearly and philosophically put together, and the greatest. The influence of Balfour’s work on embryology was immense and is still felt. He was an active worker in every department of it, and there are few groups of the animal kingdom on which he has not left the impress of his genius.

In the period under consideration the output of embryological work has been enormous. No group of the animal kingdom has escaped exhaustive examination, and no effort has been spared to obtain the embryos of isolated and out of the way forms, the development of which might have a bearing upon important questions of phylogeny and classification. Of this work it is impossible to speak in detail in this summary. It is only possible to call attention to some of its more important features, to mention the more important advances, and to refer to some of the more striking memoirs.

Marine zoological stations have been established, expeditions have been sent to distant countries, and the methods of investigation have been greatly improved. Since Anton Dohrn founded the Stazione Zoologica at Naples in 1872, observatories for the study of marine organisms have been established in most countries. Of journeys which have been made to distant countries and which have resulted in important contributions to embryology, may be mentioned the expedition (1884-1886) of the cousins Sarasin to Ceylon (development of Gymnophiona), of E. Selenka to Brazil and the East 328
Indies (development of Marsupials, Primates and other mammals, 1877, 1889, 1892), of A.A.W. Hubrecht to the East Indies (1890, development of *Tarsius*), of W.H. Caldwell to Australia (1883-1884, discovery of the nature of the ovum and oviposition of *Echidna* and of *Ceratodus*), of A. Sedgwick to the Cape (1883, development of *Peripatus*), of J. Graham Kerr to Paraguay (1896, development of *Lepidosiren*), of R. Semon to Australia and the Malay Archipelago (1891-1893, development of Monotremata, Marsupialia), and of J.S. Budgett to Africa (1898, 1900, 1901, 1903, development of *Polypterus*).

In methods, while great improvements have been made in the processes of hardening and staining embryos, the principal advance has been the introduction in 1883 by W.H. Caldwell in his work on the development of *Phoronis* of the method of making tape-worm like strings of sections as a result of which the process of mounting in order all the sections obtained from an embryo was much facilitated, and the use of an automatic microtome rendered possible. The method of Golgi for the investigation of the nervous system, introduced in 1875, must also be mentioned here.

The word “coelom” (*q.v.*) was introduced into zoology by E. Haeckel in 1872 (*Kalkschwämme*, p. 468) as a convenient term for the body-cavity (pleuro-peritoneal). The word was generally adopted, and was applied alike to the blood-containing body-cavity of Arthropods and to the body-cavity of Vertebrata and segmented worms, in which there is no blood. In 1875 Huxley (*Quarterly Journ. of Mic. Science*, 15, p. 53), relying on the researches of Agassiz, Metschnikoff and Kowalewsky above mentioned, put forward the idea that according to their development three kinds of body-cavity ought to be distinguished: (1) the enterocoelic which arises from enteric diverticula, (2) the schizocoelic which develops as a split in the embryonic mesoblast, and (3) the epicoelic which was enclosed by folds of the skin and lined by ectoderm (*e.g.* atrial cavity of Tunicates, &c.). This suggestion was of great importance, because it led the embryologists of the day (Balfour, the brothers Hertwig, Lankester and others) to discuss the question as to whether there was not more than one kind of body-cavity. The Hertwigs (*Coelomtheorie*, Jena, 1881) distinguished two kinds, the enterocoel and the pseudocoel. The former, to which they limited the use of the word coelom, and which is developed directly or indirectly from the enteron, is found in Annelida, Arthropoda, Echinodermata, Chordata, &c. The latter they regarded as something quite different from the coelom and as arising by a split in what they called for the first time mesenchyme; the mesenchyme being the non-epithelial mesoderm, which they described as consisting of amoeboid cells, but which we now know to consist of a continuous reticulum. The next step was made by E. Ray Lankester, who in 1884 (*Zoologischer Anzeiger*) showed that the pericardium of Mollusca does not contain blood, and therein differs from the rest of the body-cavity which does contain blood, but no suggestion is made that the blood-containing space is not coelomic. In fact it was generally held by the anatomists of the day that the coelom and the vascular system were different parts of the same primitive organ, though separate from it in the adult except in Arthropoda and Mollusca. In the Mollusca, it is true, the pericardial part of the coelom was held to be separate from the vascular, and the Hertwigs had reached the correct conception that the pericardium of these animals was alone true coelom, the vascular part being pseudocoel. This was the state of morphological opinion until 1886, when it was shown (*Proc. Cambridge Phil. Soc.*, 6, 1886, p. 27) (1) that the coelom of *Peripatus* gives rise to the nephridia and generative glands only, and to no other part of the body-cavity of the adult, (2) that the nephridia of the adult do not open as had been supposed into the body-cavity, (3) that the body-cavity is entirely formed of the blood-containing space, the coelom having no perivisceral portion. These results were extended by the same author (*Quart. Journ. Mic. Sci.*, 27, 1887, pp. 486-540) to other Arthropods and to the Mollusca, and the modern theory of the coelom was finally established. An increased precision was given to the conception of coelom by the discovery in 1880 (*Quart. Journ. Mic. Sci.*, 20, p. 164) that the nephridia of Elasmobranchs are a direct differentiation of a portion of it. In 1886 this was extended to *Peripatus* (*Proc. Camb. Phil. Soc.*, 6, p. 27) and doubtless holds universally.

In 1864 it was suggested by V. Hensen (Virchow’s *Archiv*, 31) that the rudiments of nerve-fibres are present from the beginning of development as persistent remains of connexions between the incompletely separated cells of the segmented ovum. This suggestion fell to the ground because it was held by embryologists that the cleavage of the ovum resulted in the formation of completely separate cells, and that the connexions between the adult cells were secondary. In 1886 it was shown (*Quarterly Journ. Mic. Sci.*, 26, p. 182) that in *Peripatus Capensis* the cells of the segmenting ovum do not separate from one another, but remain connected by a loose protoplasmic network. This discovery has since been extended to other ova, even to the small so-called holoblastic ova, and a basis of fact was found for Hensen’s suggestion as to the embryonic origin of nerves (*Quart. Journ. Mic. Sci.*, 33, 1892, pp. 581-584). An extension and further application of the new views as to the cell-theory and the embryonic origin of nerves thus necessitated was made in 1894 (*Quart. Journ. Mic. Sci.*, 37, p. 87), and in 1904 J. Graham Kerr showed that the motor nerves in the dipnoan fish Lepidosiren arise in an essentially similar manner (*Trans. Roy. Society of Edinburgh*, 41, p. 119).

In 1883 Elie Metschnikoff published his researches on the intracellular digestion of invertebrates (*Arbeiten a. d. zoologischen Inst. Wien*, 5; and *Biologisches Centralblatt*, 3, p. 560); these formed the basis of his theory of inflammation and phagocytosis, which has had such an important influence on pathology. As he himself has told us, he was led to make these investigations by his precedent researches on the development of sponges and other invertebrates. To quote his own words: “Having long studied the problem of the germinal layers in the animal series, I sought to give some idea of their origin and significance. The part played by the ectoderm and endoderm appeared quite clear, and the former might reasonably be regarded as the cutaneous investment of primitive multicellular animals, while the latter might be regarded as their organ of digestion. The discovery of intracellular digestion in many of the lower animals led me to regard this phenomenon as characteristic of those ancestral animals from which might be derived all the known types of the animal kingdom (excepting, of course, the Protozoa). The origin and part played by the mesoderm appeared the most obscure. Thus certain embryologists supposed that this layer corresponded to the reproductive organs of primitive animals: others regarded it as the prototype of the organs of locomotion. My embryological and physiological studies on sponges led me to the conclusion that the mesoderm must function in the hypothetically primitive animals as a mass of digestive cells, in all points similar to those of the endoderm. This hypothesis necessarily attracted my attention to the power of seizing foreign corpuscles possessed by the mesodermic cells” (*Immunity in Infective Diseases*, English translation, Cambridge, 1905).

The branch of embryology which concerns itself with the study of the origin, history and conjugation of the individuals (gametes) which are concerned in the reproduction of the species has made great

advances. These began in 1875 and following years with a careful examination of the behaviour of the germinal vesicle in the maturation and fertilization of the ovum. The history of the polar bodies, the origin of the female pronucleus, the presence in the ovum of a second nucleus, the male pronucleus, which gave rise to the first segmentation nucleus by fusion with the female pronucleus, were discovered (E. van Beneden, O. Bütschli, O. Hertwig, H. Fol), and in 1876 O. Hertwig (*Morphologisches Jahrbuch*, 3, 1876) for the first time observed the entrance of a spermatozoon into the egg and the formation of the male pronucleus from it. The centrosome was discovered by W. Flemming in 1875 in the egg of the fresh-water mussel, and independently in 1876 by E. van Beneden in Dicyemids. In 1883 came E. van Beneden's celebrated discovery (*Arch. Biologie*, 4) of the reduction 329
of the number of chromosomes in the nucleus of both male and female gametes, and of the fact that the male and female pronuclei contribute the same number of chromosomes to the zygote-nucleus. He also showed that the gametogenesis in the male is a similar process to that in the female, and paved the way for the acceptation of the view (due to Bütschli) that polar bodies are aborted female gametes. These discoveries were extended and completed by subsequent workers, among whom may be mentioned E. van Beneden, J.B. Carnoy, G. Platner, T. Boveri, O. Hertwig, A. Brauer. The subject is still being actively pursued, and hopes are entertained that some relation may be found between the behaviour of the chromosomes and the facts of heredity.

Since 1874 (W. His, *Unsere Körperform und das physiologische Problem ihrer Entstehung*) a new branch of embryology, which concerns itself with the physiology of development, has arisen (experimental embryology). The principal workers in this field have been W. Roux, who in 1894 founded the *Archiv für Entwickelungsmechanik der Organismen*, T. Boveri and Y. Delage who discovered and elucidated the phenomenon of merogony, J. Loeb who discovered artificial parthenogenesis, O. and R. Hertwig, H. Driesch, C. Herbst, E. Maupas, A. Weismann, T.H. Morgan, C.B. Davenport (*Experimental Morphology*, 2 vols., 1899) and many others.

In the elucidation of remarkable life-histories we may point in the first place to the work of A. Kowalewsky on the development of the Tunicata ("Entwickelungsgeschichte d. einfachen Ascidien," *Mém. Acad. Pétersbourg* (7), 10, 1866, and *Arch. f. Mic. Anatomie*, 7, 1871), in which was demonstrated for the first time the vertebrate relationship of the Tunicata (possession of a notochord, method of development of the central nervous system) and which led to the establishment of the group Chordata. We may also mention the work of Y. Delage in the metamorphosis of *Sacculina* (*Arch. zool. exp.* (2) 2, 1884), A. Giard (*Comptes rendus*, 123, 1896, p. 836) and of A. Malaquin on *Monstrilla* (*Arch. zool. exp.* (3), 9, p. 81, 1901), of Delage (*Comptes rendus*, 103, 1886, p. 698) and Grassi and Calandruccio (*Rend. Acc. Lincei* (5), 6, 1897, p. 43), on the development of the eels, and of P. Pergande on the life-history of the Aphidae (*Bull. U.S. Dep. Agric. Ent.*, technical series, 9, 1901). The work of C. Grobben (*Arbeiten zool. Inst. Wien*, 4, 1882) and of B. Uljanin ("Die Arten der Gattung Doliolum," *Fauna u. Flora des Golfes von Neapel*, 1884) on the extraordinary life-history and migration of the buds in *Doliolum* must also be mentioned. In pure embryological morphology we have had Heymons' elucidation of the Arthropod head, the work of Hatschek on Annelid and other larvae, the works of H. Bury and of E.W. MacBride which have marked a distinct advance in our knowledge of the development of Echinodermata, of K. Mitsukuri, who has founded since 1882 an important school of embryology in Japan, on the early development of Chelonia and Aves, of A. Brauer and G.C. Price on the development of vertebrate excretory organs, of Th. W. Bischoff, E. van Beneden, E. Selenka, A.A.W. Hubrecht, R. Bonnet, F. Keibel and R. Assheton on the development of mammals, of A.A.W. Hubrecht and E. Selenka on the early development and placentation of the Primates, of J. Graham Kerr and of J.S. Budgett on the development of Dipnoan and Ganoid fishes, of A. Kowalewsky, B. Hatschek, A. Willey and E.W. MacBride on the development of Amphioxus, of B. Dean on the development of Bdellostoma, of A. Götte on the development of Amphibia, of H. Strahl and L. Will on the early development of reptiles, of T.H. Huxley, C. Gegenbaur and W.K. Parker on the development of the vertebrate skeleton, of van Wijhe on the segmentation of the vertebrate head, by which the modern theory of head-segmentation, previously adumbrated by Balfour, was first established, of Leche and Röse on the development of mammalian dentitions. We may also specially notice W. Bateson's work on the development of *Balanoglossus* and his inclusion of this genus among the Chordata (1884), the discovery by J.P. Hill of a placenta in the marsupial genus *Perameles* (1895), the work of P. Marchal (1904) on the asexual increase by fission of the early embryos of certain parasitic Hymenoptera (so called germinogony), a phenomenon which had been long ago shown to occur in *Lumbricus trapezoides* by N. Kleinenberg (1879) and by S.F. Harmer in Polyzoa (1893). The work on cell-lineage which has been so actively pursued in America may be mentioned here. It has consisted mainly of an extension of the early work of A. Kowalewsky and B. Hatschek on the formation of the layers, being a more minute and detailed examination of the origin of the embryonic tissues.

The most important text-books and summaries which have appeared in this period have been Korschelt and Heider's *Lehrbuch der vergleichenden Entwickelungsgeschichte der wirbellosen Tiere* (1890-1902), C.S. Minot's *Human Embryology* (1892), and the *Handbuch der vergleichenden und experimentellen Entwickelungslehre der Wirbeltiere*, edited by O. Hertwig (1901, et seq.). See also K.E. von Baer, *Über Entwicklungsgeschichte der Tiere* (Königsberg, 1828, 1837); F.M. Balfour, *A Monograph on the Development of Elasmobranch Fishes* (London, 1878); *A Treatise on Comparative Embryology*, vols. i. and ii. (London, 1885) (still the most important work on Vertebrate Embryology); M. Duval, *Atlas d'Embryologie* (Paris, 1889); M. Foster and F.M. Balfour, *Elements of Embryology* (London, 1883); O. Hertwig, *Lehrbuch der Entwicklungsgeschichte des Menschen u. der Wirbeltiere* (6th ed., Jena, 1898); A. Kölliker, *Entwicklungsgeschichte des Menschen u. der höheren Tiere* (Leipzig, 1879); A.M. Marshall, *Vertebrate Embryology* (London, 1893).

(A. Se.*)

Physiology of Development

Physiology of Development [in German, *Entwicklungsmechanik* (W. Roux), *Entwicklungsphysiologie* (H. Driesch), *physiologische Morphologie* (J. Loeb)] is, in the broadest meaning of the word, the experimental science of morphogenesis, *i.e.* of the laws that govern morphological differentiation. In this sense it embraces the study of regeneration and variation, and would, as a whole, best be called rational morphology. Here we shall treat of the Physiology of Development in a narrower sense, as the study of the laws that govern the development of the adult organism from the egg, Regeneration and Variation and Selection forming the subjects of special articles.

After the work done by W. His, A. Goette and E.F.W. Pflüger, who gave a sort of general outline and orientation of the subject, the first to study developmental problems properly in a systematical way, and with full conviction of their great importance, was Wilhelm Roux. This observer, having found by a full analysis of the facts of "development" that the first special problem to be worked out was the question when and where the first differentiation appeared, got as his main result that, when one of the two first blastomeres (cleavage cells) of the frog's egg was killed, the living one developed into a typical half-embryo, *i.e.* an embryo that was either the right or the left part of a whole one. From that Roux concluded that the first cleavage plane determined already the median plane of the adult; and that the basis of all differentiation was given by an unequal division of the nuclear substances during karyokinesis, a result that was also attained on a purely theoretical basis by A. Weismann. Hans Driesch repeated Roux's fundamental experiment with a different method on the sea-urchin's egg, with a result that was absolutely contrary to that of Roux: the isolated blastomere cleaved like half the egg, but it resulted in a whole blastula and a whole embryo, which differed from a normal one only in its small size. Driesch's result was obtained in somewhat the same manner by E.B. Wilson with the egg of Amphioxus, by Zoja with the egg of Medusae, &c. It thus became very probable that an inequality of nuclear division could not be the basis of differentiation. The following experiments were still more fatal to the theories of Roux and of Weismann. Driesch found that even when the first eight or sixteen cells of the cleaving egg of the sea-urchin were brought into quite abnormal positions with regard to one another, still a quite normal embryo was developed; Driesch and T.H. Morgan discovered jointly that in the Ctenophore egg one isolated blastomere developed into a half-embryo, but that the same was the case if a portion of protoplasm was cut off from the fertilized egg not yet in cleavage; last, but not of least importance, in the case of the frog's egg which had been Roux's actual subject of experiment, conditions were discovered by O. Schultze and O. Hertwig under which one of 330
the two first blastomeres of this egg developed into a whole embryo of half size. This result was made still more decisive by Morgan, who showed that it was quite in the power of the experimenter to get either a half-embryo or a whole one of half size, the latter dependent only upon giving to the blastomere the opportunity for a rearrangement of its matter by turning it over.

Thus we may say that the general result of the introductory series of experiments in the physiology of development is the following:—In many forms, *e.g.* Echinoderms, Amphioxus, Ascidians, Fishes and Medusae, the potentiality (*prospective Potenz*—Driesch) of all the blastomeres of the segmented egg is the same, *i.e.* each of them may play any or every part in the future development; the prospective value (*prosp. Bedeutung*—D.) of each blastomere depends upon, or is a function of, its position in the whole of the segmented egg; we can term the "whole" of the egg after cleavage an "aequipotential system" (Driesch). But though aequipotential, the whole of the segmented egg is nevertheless not devoid of orientation or direction; the general law of causality compels us to assume a general orientation of the smallest parts of the egg, even in cases where we are not able to see it. It has been experimentally proved that external stimuli (light, heat, pressure, &c.) are not responsible for the first differentiation of organs in the embryo; thus, should the segmented egg be absolutely equal in itself, it would be incomprehensible that the first organs should be formed at one special point of it and not at another. Besides this general argument, we see a sort of orientation in the typical forms of the polar or bilateral cleavage stages.

Differentiation, therefore, depends on a primary, *i.e.* innate, orientation of the egg's plasma in those forms, the segmented eggs of which represent aequipotential systems; this orientation is capable of a sort of regulation or restoration after disturbances of any sort; in the egg of the Ctenophora such a regulation is not possible, and in the frog's egg it is facultative, *i.e.* possible under certain conditions, but impossible under others. Should this interpretation be right, the difference between the eggs of different animals would not be so great as it seemed at first: differences with regard to the potentialities of the blastomeres would only be differences with regard to the capability of regulation or restoration of the egg's protoplasm.

The foundation of physiological embryology being laid, we now can shortly deal with the whole series of special problems offered to us by a general analysis of that science, but at present worked out only to a very small extent.

We may ask the following questions:—What are the general conditions of development? On what general factors does it depend? How do the different organs of the partly developed embryo stand with regard to their future fate? What are the stimuli (*Reize*) effecting differentiation? What is to be said about the specific character of the different formative effects? And as the most important question of all: Are all the problems offered to us in the physiology of development to be solved with the aid of the laws known hitherto in science, or do we want specifically new "vitalistic" factors?

Energy in different forms is required for development, and is provided by the surrounding medium. Light, though of no influence on the cleavage (Driesch), has a great effect on later stages of development, and is also necessary for the formation of polyps in Eudendrium (J. Loeb). That a certain temperature is necessary for ontogeny has long been known; this was carefully studied by O. Hertwig, as was also the influence of heat on the rate of development. Oxygen is also wanted, either from a certain stage of development or from the very beginning of it, though very nearly related forms differ in this respect (Loeb). The great influence of osmotic pressure on growth was studied by J. Loeb, C. Herbst and C.H. Davenport. In all these cases energy may be necessary for development in general, or a specific form of energy may be necessary for the formation of a specific organ; it is clear that, especially in the latter case, energy is shown to be a proper factor for morphogenesis. Besides energy, a certain chemical condition of the medium, whether offered by the water in which the egg lives or (especially in later stages) by the food, is of great importance for normal ontogeny; the only careful study in this respect was carried out by Herbst for the development of the egg of Echinids. This investigator has shown that all salts of the sea water are of great importance for development, and most of them specifically and typically; for instance, calcium is absolutely necessary for holding together the embryonic cells, and without calcium all cells will fall apart, though they do not die, but live to develop further.

Conditions of differentiation.

What we have dealt with may be called external factors of development; as to their complement, the internal factors, it is clear that every elementary factor of general physiology may be regarded as one of them. Chemical metamorphosis plays, of course, a great part in differentiation, especially in the form of secretions; but very little has been carefully studied in this respect. Movement of living matter, whether of cells or of intracellular substance, is another important factor (O. Bütschli, F. Dreyer, L. Rhumbler.) Cell-division is another, its differences in direction, rate and quantity being of great importance for differentiation. We know very little about it; a so-called law of O. Hertwig, that a cell would divide at right angles to its longest diameter, though experimentally stated in some cases, does not hold for all, and the only thing we can say is, that the unknown primary organization of the egg is here responsible. (Compare the papers on "cell-lineage" of E.B. Wilson, F.R. Lillie, H.S. Jennings, O. Zurstrassen and others.) Of the inner factors of ontogeny there is another category that may be called physical, that already spoken of being physiological. The most important of these is the capillarity of the cell surfaces. Berthold was the first to call attention to its role in the arrangement of cell composites, and afterwards the matter was more carefully studied by Dreyer, Driesch, and especially W. Roux, with the result that the arrangement of cells follows the principle of surfaces *minimae areae* (Plateau) as much as is reconcilable with the conditions of the system.

It has already been shown that in many cases the embryo after cleavage, *i.e.* the blastula, is an "aequipotential system." It was shown that in the egg of Echinids there existed such an absolute lack of determination of the cleavage cells that (*a*) the cells may be put in quite abnormal positions with reference to one another without disturbing development; (*b*) a quarter blastomere gives a quite normal little pluteus, even a sixteenth yields a gastrula; (*c*) two eggs may fuse in the early blastula stage, giving one single normal embryo of double size. Our next question concerns the distribution of potentiality, when the embryo is developed further than the blastula stage. In this case it has been shown that the potentialities of the different embryonic organs are different: that, for instance, in Echinoderms or Amphibians the ectoderm, when isolated, is not able to form endoderm, and so on (Driesch, D. Barfurth); but it has been shown at the same time that the ectoderm in itself, the intestine in itself of Echinoderms (Driesch), the medullary plate in itself of Triton (H. Spemann), is as aequipotential as was the blastula: that any part whatever of these organs may be taken away without disturbing the development of the rest into a normal and proportional embryonic part, except for its smaller size.

Potentialities of embryonic cells.

If the single phases of differentiation are to be regarded as effects, we must ask for the causes, or stimuli, of these effects. For a full account of the subject we refer to Herbst, by whom also the whole botanical literature, much more important than the zoological, is critically reviewed. We have already seen that when the blastula represents an aequipotential system, there must be some sort of primary organization of the egg, recoverable after disturbances, that directs and localizes the formation of the first embryonic organs; we do not know much about this organization. Directive stimuli (*Richtungsreize*) play a great role in ontogeny; Herbst has analysed many cases where their existence is probable. They have been experimentally proved in two cases. The chromatic cells of the yolk sac of Fundulus are attracted by the oxygen of the arteriae (Loeb); the mesenchyme cells of Echinus are attracted by some specific parts of the ectoderm, for they move towards them also when removed from their original positions to any point of the blastocoel by shaking (Driesch). Many directive stimuli might be discovered by a careful study of grafting experiments, such as have been made by Born, Joest, Harrison and others, but at present these experiments have not been carried out far enough to get exact results.

Formative stimuli.

Formative stimuli in a narrower meaning of the word, *i.e.* stimuli affecting the origin of embryonic organs, have long been known in botany; in zoology we know (especially from Loeb) a good deal about the influence of light, gravitation, contact, &c., on the formation of organs in hydroids, but these forms are very plant-like in many respects; as to free-living animals, Herbst proved that the formation of the arms of the pluteus larva depends on the existence of the calcareous tetrahedra, and made in other cases (lens of vertebrate eye, nerves and muscles, &c.) the existence of formative stimuli very probable. Many of the facts generally known as functional adaptation (*functionelle Anpassung*—Roux) in botany and zoology may also belong to this category, *i.e.* be the effects of some external stimulus, but they are far from having been analysed in a satisfactory manner. That the structure of parts of the vertebrate skeleton is always in relation to their function, even under abnormal conditions, is well known; what is the real "cause" of differentiation in this case is difficult to say.

Specific characters.

It is obvious that we cannot answer the question why the different ontogenetic effects are just what they are. Developmental physiology takes the specific nature of form for granted, and it may be left for a really rational theory of the evolution of species in the future to answer the problem of species, as far as it is answerable at all. What we intend to do here is only to say in a few words wherein consists the specific character of embryonic organs. That embryonic parts are specific or typical in regard to their protoplasm is obvious, and is well proved by the fact that the different parts of the embryo react differently to the same chemical or other reagents (Herbst, Loeb). That they may be typical also in regard to their nuclei was shown by Boveri for the generative cells of Ascaris; we are not able at present to say anything definite about the importance of this fact. The specific nature of an embryonic organ consists to a high degree in the number of cells composing it; it was shown for many cases that this number, and also the size of cells, is constant under constant conditions, and that under inconstant conditions the number is variable, the size constant; for instance, embryos which have developed from one of the two first blastomeres show only half the normal number of cells in their organs (Morgan, Driesch).

Self-differentiation.

We have learnt that the successive steps of embryonic development are to be regarded as effects, caused by stimuli, which partly exist in the embryo itself. But it must be noted that not every part of the embryo is dependent on every other one, but that there exists a great independence of the parts, to a varying degree in every case. This partial independence has been called self-differentiation (*Selbstdifferenzierung*) by Roux, and is certainly a characteristic feature of ontogeny. At the same time it must not be forgotten that the word is only relative, and that it only expresses our recognition of a negation.

For instance, we know that the ectoderm of Echinus may develop further if the endoderm is taken away; in other words, that it develops by self-differentiation in regard to the endoderm, that its differentiation is not dependent on the endoderm; but it would be obviously more important to know the factors on which this differentiation is actually dependent than to know one factor on which it is not. The same is true for all other experiments on "self-differentiation," whether analytical (Loeb, Schaper, Driesch) or not (grafting experiments, Born, Joest, &c.).

Vitalism.

Can we understand differentiation by means of the laws of natural phenomena offered to us by physics and chemistry? Most people would say yes, though not yet. Driesch has tried to show that we are absolutely not able to understand development, at any rate one part of it, *i.e.* the localization of the various successive steps of differentiation. But it is impossible to give any idea of this argument in a few words, and we can only say here that it is based on the experiments upon isolated blastomeres, &c., and on an analysis of the character of aequipotential systems. In this way physiology of development would lead us straight on into vitalism.

References.—An account of the subject, with full literature, is given by H. Driesch, *Resultate und Probleme der Entwicklungsphysiologie der Tiere in Ergebnissen der Anat. u. Entw.-Gesch.* (1899). Other works are: C.H. Davenport, *Experimental Morphology* (New York, 1897-1899); Y. Delage, *La Structure du protoplasma*, &c. (1895); Driesch, *Mathem. mech. Betrachtung morpholog. Probleme* (Jena, 1891); *Entwicklungsmechan. Studien* (1891-1893); *Analytische Theorie d. organ. Entw.* (Leipzig, 1894); *Studien über d. Regulationsvermögen* (1897-1900), &c.; C. Herbst, "Über die Bedeutung d. Reizphysiologie für die kausale Auffassung von Vorgängen i. d. tier. Ontogenese," *Biolog. Centralblatt*, vols. xiv. u. xv. (Leipzig, 1894). Many papers on influence of salts on development in *Arch. f. Entw.-Mech.*; O. Hertwig, Papers in *Arch. f. mikr. Anat.*, "Die Zelle und die Gewebe," ii. (Jena, 1897); W. His, *Unsere Körperform* (Leipzig, 1875); J. Loeb, *Untersuch. z. physiol. Morph.* (Würzburg, 1891-1892). Papers in *Arch. f. Entw.-Mech.* and Pflüger's *Archiv*; T.H. Morgan, *The Development of the Frog's Egg* (New York, 1897); Papers in *Arch. f. Entw.-Mech.*; Roux, *Gesammelte Abhandlungen* (Leipzig, 1895); Papers in *Arch. f. Entw.-Mech.*; A. Weismann, *Das Keimplasma* (Jena, 1892); E.B. Wilson, papers in *Journ. Morph.*, "The Cell in Development and Inheritance" (New York, 1896).

(H. A. E. D.)

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1 In the mammalia the word *foetus* is often employed in the same signification as embryo; it is especially applied to the embryo in the later stages of uterine development.

2 It may be proper to mention, as authors of this period who made special researches on the development of the embryo—(1) Volcher Coiter of Groningen, who, along with Aldrovandus of Bologna, made a series of observations on the formation of the chick, day by day, in the incubated egg, which were described in a work published in 1573, and (2) Hieronymus Fabricius (ab Aquapendente), who, in his work *De formato foetu*, first published at Padua in 1600, gave an interesting account, illustrated by many fine engravings, of uterogestation and the foetus of a number of quadrupeds and other animals, and in a posthumous work entitled *De formatione ovi et pulli*, edited by J. Prevost and published at Padua in 1621, described and illustrated by engravings the daily changes of the egg in incubation. It is enough, however, to say that Fabricius was entirely ignorant of the earlier phenomena of development which occur in the first two or three days, and even of the source of the embryonic rudiments, which he conceived to spring, not from the yolk or true ovum, but from the chalazae or twisted, deepest part of the white. The cicatricula he looked upon as merely the vestige of the pedicle by which the yolk had previously been attached to the ovary.

3 Along with the work of W. Hunter must be mentioned a large collection of unpublished observations by Dr James Douglas, which are preserved in the Hunterian Museum of Glasgow University.

EMDEN, a maritime town of Germany, in the Prussian province of Hanover, near the mouth of the Ems, 49 m. N.W. from Oldenburg by rail. Pop. (1885) 14,019; (1905) 20,754. The Ems once flowed beneath its walls, but is now 2 m. distant, and connected with the town by a broad and deep canal, divided into the inner (or dock) harbour and the outer (or "free port") harbour. The latter is ¾ m. in length, has a breadth of nearly 400 ft., and since the construction of the Ems-Jade and Dortmund-Ems canals, has been deepened to 38 ft., thus allowing the largest sea-going vessels to approach its wharves. The town is intersected by canals (crossed by numerous bridges), which bring it into communication with most of the towns in East Friesland, of which it is the commercial capital. The waterways which traverse and surround it and the character of its numerous gabled medieval houses give it the appearance of an old Dutch, rather than of a German, town. Of its churches the most noteworthy are the Reformed "Great Church" (Grosse Kirche), a large Gothic building completed in 1455, containing the tomb of Enno II. (d. 1540), count of East Friesland; the Gasthauskirche, formerly the church of a Franciscan friary founded in 1317; and the Neue Kirche (1643-1647). Of its secular buildings, the Rathaus (town-hall), built in 1574-1576, on the model of that of Antwerp, with a lofty tower, and containing an interesting collection of arms and armour, is particularly remarkable. There are numerous educational institutions, including classical and modern schools, and schools of commerce, navigation and telegraphy. The town has two interesting museums. Emden is the seat of an active trade in agricultural produce and live-stock, horses, timber, coal, tea and wine. The deep-sea fishing industry of the town is important, the fishing fleet in 1902 numbering 67 vessels. Machinery, cement, cordage, wire ropes, tobacco, leather, &c. are manufactured. Emden is also of importance as the station of the submarine cables connecting Germany with England, North America and Spain. It has a regular steamboat service with Borkum and Norderney.

Emden (Emuden, Emetha) is first mentioned in the 12th century, when it was the capital of the Eemsgo (Emsgau, or county of the Ems), one of the three hereditary countships into which East Friesland had been divided by the emperor. In 1252 the countship was sold to the bishops of Münster; but their rule soon became little more than nominal, and in Emden itself the family of Abdena, the episcopal provosts and castellans, established their practical independence. Towards the end of the 14th century the town gained a considerable trade owing to the permission given by the provost to the pirates known as "Viktualienbrüder" to make it their market, after they had been driven out of Gothland by the Teutonic Order. In 1402, after the defeat of the pirates off Heligoland by the fleet of Hamburg, Emden was besieged, but it was not reduced by Hamburg, with the aid of Edzard Cirksena of Greetsyl, until 1431. The town was held jointly by its captors till 1453, when Hamburg sold its 332
rights to Ulrich Cirksena, created count of East Friesland by the emperor Frederick III. in 1454. In 1544 the Reformation was introduced, and in the following years numerous Protestant refugees from the Low Countries found their way to the town. In 1595 Emden became a free imperial city under the protection of Holland, and was occupied by a Dutch garrison until 1744 when, with East Friesland, it was transferred to Prussia. In 1810 Emden became the chief town of the French department of Ems Oriental; in 1815 it was assigned to Hanover, and in 1866 was annexed with that kingdom by Prussia.

See Fürbringer, *Die Stadt Emden in Gegenwart und Vergangenheit* (Emden, 1892).

EMERALD, a bright green variety of beryl, much valued as a gem-stone. The word comes indirectly from the Gr. σμάραγδος (Arabic *zumurrud*), but this seems to have been a name vaguely given to a number of stones having little in common except a green colour. Pliny's "smaragdus" undoubtedly included several distinct species. Much confusion has arisen with respect to the "emerald" of the Scriptures. The Hebrew word *nōphek*, rendered emerald in the Authorized Version, probably meant the carbuncle: it is indeed translated ἄνθραξ in the Septuagint, and a marginal reading in the Revised Version gives carbuncle. On the other hand, the word *bāreqath*, rendered σμάραγδος in the LXX., appears in the A.V. as carbuncle, with the alternative reading of emerald in the R.V. It may have referred to the true emerald, but Flinders Petrie suggests that it meant rock-crystal.

The properties of emerald are mostly the same as those described under Beryl. The crystals often show simply the hexagonal prism and basal plane. The prisms cleave, though imperfectly, at right angles to the geometrical axis; and hexagonal slices were formerly worn in the East. Compared with most gems, the emerald is rather soft, its hardness (7.5) being but slightly above that of quartz. The specific gravity is low, varying slightly in stones from different localities, but being for the Muzo emerald about 2.67. The refractive and dispersive powers are not high, so that the cut stones display little brilliancy or "fire." The emerald is dichroic, giving in the dichroscope a bluish-green and a yellowish-green image. The magnificent colour which gives extraordinary value to this gem, is probably due to chromium. F. Wöhler found 0.186% of Cr_2O_3 in the emerald of Muzo,—a proportion which, though small, is sufficient to impart an emerald-green colour to glass. The stone loses colour when strongly heated, and M. Lewy suggested that the colour was due to an organic pigment. Greville

Williams showed that emeralds lost about 9% of their weight on fusion, the specific gravity being reduced to about 2.4.

The ancients appear to have obtained the emerald from Upper Egypt, where it is said to have been worked as early as 1650 B.C. It is known that Greek miners were at work in the time of Alexander the Great, and in later times the mines yielded their gems to Cleopatra. Remains of extensive workings were discovered in the northern Etbai by the French traveller, F. Cailliaud, in 1817, and the mines were re-opened for a short time under Mehemet Ali. “Cleopatra’s Mines” are situated in Jebel Sikait and Jebel Zabara near the Red Sea coast east of Assuan. They were visited in 1891 by E.A. Floyer, and the Sikait workings were explored in 1900 by D.A. MacAlister and others. The Egyptian emeralds occur in mica-schist and talc-schist.

On the Spanish conquest of South America vast quantities of emeralds were taken from the Peruvians, but the exact locality which yielded the stones was never discovered. The only South American emeralds now known occur near Bogotà, the capital of Colombia. The most famous mine is at Muzo, but workings are known also at Coscuez and Somondoco. The emerald occurs in nests of calcite in a black bituminous limestone containing ammonites of Lower Cretaceous age. The mineral is associated with quartz, dolomite, pyrites, and the rare mineral called “parisite”—a fluo-carbonate of the cerium metals, occurring in brownish-yellow hexagonal crystals, and named after J.J. Paris, who worked the emeralds. It has been suggested that the Colombian emerald is not in its original matrix. The fine stones are called *cañutillos* and the inferior ones *morallion*.

In 1830 emeralds were accidentally discovered in the Ural Mountains. At the present time they are worked on the river Takovaya, about 60 m. N.E. of Ekaterinburg, where they occur in mica-schist, associated with aquamarine, alexandrite, phenacite, &c. Emerald is found also in mica-schist in the Habachthal, in the Salzburg Alps, and in granite at Eidsvold in Norway. Emerald has been worked in a vein of pegmatite, piercing slaty rocks, near Emmaville, in New South Wales. The crystals occurred in association with topaz, fluorspar and cassiterite; but they were mostly of rather pale colour. In the United States, emerald has occasionally been found, and fine crystals have been obtained from the workings for hiddenite at Stonypoint, Alexander county, N.C.

Many virtues were formerly ascribed to the emerald. When worn, it was held to be a preservative against epilepsy, it cured dysentery, it assisted women in childbirth, it drove away evil spirits, and preserved the chastity of the wearer. Administered internally it was reputed to have great medicinal value. In consequence of its refreshing green colour it was naturally said to be good for the eyesight.

The stone known as “Oriental emerald” is a green corundum. Lithia emerald is the mineral called hiddenite; Uralian emerald is a name given to demantoid; Brazilian emerald is merely green tourmaline; evening emerald is the peridot; pyro-emerald is fluorspar which phosphoresces with a green glow when heated; and “mother of emerald” is generally a green quartz or perhaps in some cases a green felspar.

See AQUAMARINE, BERYL.

(F. W. R.*)

ÉMERIC-DAVID, TOUSSAINT-BERNARD (1755-1839), French archaeologist and writer on art, was born at Aix, in Provence, on the 20th of August 1755. He was destined for the legal profession, and having gone in 1775 to Paris to complete his legal education, he acquired there a taste for art which influenced his whole future career, and he went to Italy, where he continued his art studies. He soon returned, however, to his native village, and followed for some time the profession of an advocate; but in 1787 he succeeded his uncle Antoine David as printer to the parlement. He was elected mayor of Aix in 1791; and although he speedily resigned his office, he was in 1793 threatened with arrest, and had for some time to adopt a vagrant life. When danger was past he returned to Aix, sold his printing business, and engaged in general commercial pursuits; but he was not long in renouncing these also, in order to devote himself exclusively to literature and art. From 1809 to 1814, under the Empire, he represented his department in the Lower House (*Corps législatif*); in 1814 he voted for the downfall of Napoleon; in 1815 he retired into private life, and in 1816 he was elected a member of the Institute. He died in Paris on the 2nd of April 1839. Émeric-David was placed in 1825 on the commission appointed to continue *L’Histoire littéraire de la France.* His principal works are *Recherches sur l’art statuaire, considéré chez les anciens et les modernes* (Paris, 1805), a work which obtained the prize of the Institute; *Suite d’études calquées et dessinées d’après cinq tableaux de Raphaël* (Paris, 1818-1821), in 6 vols. fol.; *Jupiter, ou recherches sur ce dieu, sur son culte*, &c. (Paris, 1833), 2 vols. 8vo, illustrated; and *Vulcain* (Paris, 1837).

EMERITUS (Lat. from *emereri*, to serve out one's time, to earn thoroughly), a term used of Roman soldiers and public officials who had earned their discharge from the service, a veteran, and hence applied, in modern times, to a university professor (*professor emeritus*) who has vacated his chair, on account of long service, age or infirmity, and, in the Presbyterian church, to a minister who has for like reason given up his charge.

EMERSON, RALPH WALDO (1803-1882), American poet and essayist, was born in Boston, Massachusetts, on the 25th of May 1803. Seven of his ancestors were ministers of New England churches. Among them were some of those men of mark who made the backbone of the American character: the sturdy Puritan, Peter Bulkeley, sometime rector of Odell in Bedfordshire, and afterward pastor of the church in the wilderness at Concord, New Hampshire; the zealous evangelist, Father Samuel Moody of Agamenticus in Maine, who pursued graceless sinners even into the alehouse; 333
Joseph Emerson of Malden, "a heroic scholar," who prayed every night that no descendant of his might ever be rich; and William Emerson of Concord, Mass., the patriot preacher, who died while serving in the army of the Revolution. Sprung from such stock, Emerson inherited qualities of self-reliance, love of liberty, strenuous virtue, sincerity, sobriety and fearless loyalty to ideals. The form of his ideals was modified by the metamorphic glow of Transcendentalism which passed through the region of Boston in the second quarter of the 19th century. But the spirit in which Emerson conceived the laws of life, reverenced them and lived them out, was the Puritan spirit, elevated, enlarged and beautified by the poetic temperament.

His father was the Rev. William Emerson, minister of the First Church (Unitarian) in Boston. Ralph Waldo was the fourth child in a family of eight, of whom at least three gave evidence of extraordinary mental powers. He was brought up in an atmosphere of hard work, of moral discipline, and (after his father's death in 1811) of that wholesome self-sacrifice which is a condition of life for those who are poor in money and rich in spirit. His aunt, Miss Mary Moody Emerson, a brilliant old maid, an eccentric saint, was a potent factor in his education. Loving him, believing in his powers, passionately desiring for him a successful career, but clinging with both hands to the old forms of faith from which he floated away, this solitary, intense woman did as much as any one to form, by action and reaction, the mind and character of the young Emerson. In 1817 he entered Harvard College, and graduated in 1821. In scholarship he ranked about the middle of his class. In literature and oratory he was more distinguished, receiving a Boylston prize for declamation, and two Bowdoin prizes for dissertations, the first essay being on "The Character of Socrates" and the second on "The Present State of Ethical Philosophy"—both rather dull, formal, didactic productions. He was fond of reading and of writing verse, and was chosen as the poet for class-day. His cheerful serenity of manner, his tranquil mirthfulness, and the steady charm of his personality made him a favourite with his fellows, in spite of a certain reserve. His literary taste was conventional, including the standard British writers, with a preference for Shakespeare among the poets, Berkeley among the philosophers, and Montaigne (in Cotton's translation) among the essayists. His particular admiration among the college professors was the stately rhetorician, Edward Everett; and this predilection had much to do with his early ambition to be a professor of rhetoric and elocution.

Immediately after graduation he became an assistant in his brother William's school for young ladies in Boston, and continued teaching, with much inward reluctance and discomfort, for three years. The routine was distasteful; he despised the superficial details which claimed so much of his time. The bonds of conventionalism were silently dissolving in the rising glow of his poetic nature. Independence, sincerity, reality, grew more and more necessary to him. His aunt urged him to seek retirement, self-reliance, friendship with nature; to be no longer "the nursling of surrounding circumstances," but to prepare a celestial abode for the muse. The passion for spiritual leadership stirred within him. The ministry seemed to offer the fairest field for its satisfaction. In 1825 he entered the divinity school at Cambridge, to prepare himself for the Unitarian pulpit. His course was much interrupted by ill-health. His studies were irregular, and far more philosophical and literary than theological.

In October 1826 he was "approbated to preach" by the Middlesex Association of Ministers. The same year a threatened consumption compelled him to take a long journey in the south. Returning in 1827, he continued his studies, preached as a candidate in various churches, and improved in health. In 1829 he married a beautiful but delicate young woman, Miss Ellen Tucker of Concord, and was installed as associate minister of the Second Church (Unitarian) in Boston. The retirement of his senior colleague soon left him the sole pastor. Emerson's early sermons were simple, direct, unconventional. He dealt freely with the things of the spirit. There was a homely elevation in his discourses, a natural freshness in his piety, a quiet enthusiasm in his manner, that charmed thoughtful hearers. Early in 1832 he lost his wife, a sorrow that deeply depressed him in health and spirits. Following his passion for independence and sincerity, he arrived at the conviction that the Lord's Supper was not intended by Christ to be a permanent sacrament. To him, at least, it had become an outgrown form. He was willing to continue the service only if the use of the elements should be dropped and the rite made simply an act of spiritual remembrance. Setting forth these views, candidly and calmly, in a sermon, he found his congregation, not unnaturally, reluctant to agree with him, and therefore retired, not without some disappointment, from the pastoral office. He never again took charge of a parish; but he continued to preach, as opportunity offered, until 1847. In fact, he was always a preacher, though of a singular order. His supreme task was to befriend and guide the inner life of man.

The strongest influences in his development about this time were the liberating philosophy of Coleridge, the mystical visions of Swedenborg, the intimate poetry of Wordsworth, and the stimulating essays of Carlyle. On Christmas Day 1832 he took passage in a sailing vessel for the Mediterranean. He travelled through Italy, visited Paris, spent two months in Scotland and England, and saw the four men whom he most desired to see—Landor, Coleridge, Carlyle and Wordsworth. “The comfort of meeting such men of genius as these,” he wrote, “is that they talk sincerely.” But he adds that he found all four of them, in different degrees, deficient in insight into religious truth. His visit to Carlyle, in the lonely farm-house at Craigenputtock, was the memorable beginning of a lifelong friendship. Emerson published Carlyle’s first books in America. Carlyle introduced Emerson’s Essays into England. The two men were bound together by a mutual respect deeper than a sympathy of tastes, and a community of spirit stronger than a similarity of opinions. Emerson was a sweet-tempered Carlyle, living in the sunshine. Carlyle was a militant Emerson, moving amid thunderclouds. The things that each most admired in the other were self-reliance, directness, moral courage. A passage in Emerson’s Diary, written on his homeward voyage, strikes the keynote of his remaining life. “A man contains all that is needful to his government within himself.... All real good or evil that can befall him must be from himself.... There is a correspondence between the human soul and everything that exists in the world; more properly, everything that is known to man. Instead of studying things without, the principles of them all may be penetrated into within him.... The purpose of life seems to be to acquaint man with himself.... The highest revelation is that God is in every man.” Here is the essence of that intuitional philosophy, commonly called Transcendentalism. Emerson disclaimed allegiance to that philosophy. He called it “the saturnalia, or excess of faith.” His practical common sense recoiled from the amazing conclusions which were drawn from it by many of its more eccentric advocates. His independence revolted against being bound to any scheme or system of doctrine, however nebulous. He said: “I wish to say what I feel and think to-day, with the proviso that to-morrow perhaps I shall contradict it all.” But this very wish commits him to the doctrine of the inner light. All through his life he navigated the Transcendental sea, piloted by a clear moral sense, warned off the rocks by the saving grace of humour, and kept from capsizing by a good ballast of New England prudence.

After his return from England in 1833 he went to live with his mother at the old manse in Concord, Mass., and began his career as a lecturer in Boston. His first discourses were delivered before the Society of Natural History and the Mechanics’ Institute. They were chiefly on scientific subjects, approached in a poetic spirit. In the autumn of 1835 he married Miss Lydia Jackson of Plymouth, having previously purchased a spacious old house and garden at Concord. There he spent the remainder of his life, a devoted husband, a wise and tender father, a careful house-holder, a virtuous villager, a friendly neighbour, and, spite of all his disclaimers, the central and luminous figure among the Transcendentalists. The doctrine which in others seemed to produce all sorts of extravagances— 334
communistic experiments at Brook Farm and Fruitlands, weird schemes of political reform, long hair on men and short hair on women—in his sane, well-balanced nature served only to lend an ideal charm to the familiar outline of a plain, orderly New England life. Some mild departures from established routine he tranquilly tested and as tranquilly abandoned. He tried vegetarianism for a while, but gave it up when he found that it did him no particular good. An attempt to illustrate household equality by having the servants sit at table with the rest of the family was frustrated by the dislike of his two sensible domestics for such an inconvenient arrangement. His theory that manual labour should form part of the scholar’s life was checked by the personal discovery that hard labour in the fields meant poor work in the study. “The writer shall not dig,” was his practical conclusion. Intellectual independence was what he chiefly desired; and this, he found, could be attained in a manner of living not outwardly different from that of the average college professor or country minister. And yet it was to this property-holding, debt-paying, law-abiding, well-dressed, courteous-mannered citizen of Concord that the ardent and enthusiastic turned as the prophet of the new idealism. The influence of other Transcendental teachers, Dr Hedge, Dr Ripley, Bronson Alcott, Orestes Brownson, Theodore Parker, Margaret Fuller, Henry Thoreau, Jones Very, was narrow and parochial compared with that of Emerson. Something in his imperturbable, kindly presence, his angelic look, his musical voice, his commanding style of thought and speech, announced him as the possessor of the great secret which many were seeking—the secret of a freer, deeper, more harmonious life. More and more, as his fame spread, those who “would live in the spirit” came to listen to the voice, and to sit at the feet, of the Sage of Concord.

It was on the lecture-platform that he found his power and won his fame. The courses of lectures that he delivered at the Masonic Temple in Boston, during the winters of 1835 and 1836, on “Great Men,” “English Literature,” and “The Philosophy of History,” were well attended and admired. They were followed by two discourses which commanded for him immediate recognition, part friendly and part hostile, as a new and potent personality. His Phi Beta Kappa oration at Harvard College in August 1837, on “The American Scholar,” was an eloquent appeal for independence, sincerity, realism, in the intellectual life of America. His address before the graduating class of the divinity school at Cambridge, in 1838, was an impassioned protest against what he called “the defects of historical Christianity” (its undue reliance upon the personal authority of Jesus, and its failure to explore the moral nature of man as the fountain of established teaching), and a daring plea for absolute self-reliance and a new inspiration of religion. “In the soul,” he said, “let redemption be sought. Wherever a man comes, there comes revolution. The old is for slaves. Go alone. Refuse the good models, even those which are sacred in the imagination of men. Cast conformity behind you, and acquaint men at first hand with Deity.” In this address Emerson laid his hand on the sensitive point of Unitarianism, which rejected the divinity of Jesus, but held fast to his supreme authority. A blaze of controversy sprang up at once. Conservatives attacked him; Radicals defended him. Emerson made no reply. But amid this somewhat fierce illumination he went forward steadily as a public lecturer. It was not his negations that made him popular; it was the eloquence with which he presented the positive side of his doctrine. Whatever the titles of his discourses, “Literary Ethics,” “Man the Reformer,” “The Present Age,” “The Method of Nature,” “Representative Men,” “The Conduct of Life,” their theme was always the same, namely, “the infinitude of the private man.” Those who thought him astray on the subject of religion listened to him with delight when he poetized the commonplaces of art, politics, literature or the household. His utterance was Delphic, inspirational. There was magic in his elocution. The simplicity and symmetry of his sentences, the modulations of his thrilling voice, the radiance of his fine face, even his slight hesitations and pauses over his manuscript, lent a strange charm to his speech. For more than a generation he went about the country lecturing in cities, towns and villages, before learned societies, rustic lyceums and colleges; and there was no man on the platform in America who excelled him in distinction, in authority, or in stimulating eloquence.

In 1847 Emerson visited Great Britain for the second time, was welcomed by Carlyle, lectured to appreciative audiences in Manchester, Liverpool, Edinburgh and London, made many new friends among the best English people, paid a brief visit to Paris, and returned home in July 1848. “I leave England,” he wrote, “with increased respect for the Englishman. His stuff or substance seems to be the best in the world. I forgive him all his pride. My respect is the more generous that I have no sympathy with him, only an admiration.” The impressions of this journey were embodied in a book called *English Traits*, published in 1856. It might be called “English Traits and American Confessions,” for nowhere does Emerson’s Americanism come out more strongly. But the America that he loved and admired was the ideal, the potential America. For the actual conditions of social and political life in his own time he had a fine scorn. He was an intellectual Brahmin. His principles were democratic, his tastes aristocratic. He did not like crowds, streets, hotels—“the people who fill them oppress me with their excessive civility.” Humanity was his hero. He loved man, but be was not fond of men. He had grave doubts about universal suffrage. He took a sincere interest in social and political reform, but towards specific “reforms” his attitude was somewhat remote and visionary. On the subject of temperance he held aloof from the intemperate methods of the violent prohibitionists. He was a believer in woman’s rights, but he was lukewarm towards conventions in favour of woman suffrage. Even in regard to slavery he had serious hesitations about the ways of the abolitionists, and for a long time refused to be identified with them. But as the irrepressible conflict drew to a head Emerson’s hesitation vanished. He said in 1856, “I think we must get rid of slavery, or we must get rid of freedom.” With the outbreak of the Civil War he became an ardent and powerful advocate of the cause of the Union. James Russell Lowell said, “To him more than to all other causes did the young martyrs of our Civil War owe the sustaining strength of thoughtful heroism that is so touching in every record of their lives.”

Emerson the essayist was a condensation of Emerson the lecturer. His prose works, with the exception of the slender volume entitled *Nature* (1836), were collected and arranged from the manuscripts of his lectures. His method of writing was characteristic. He planted a subject in his mind, and waited for thoughts and illustrations to come to it, as birds or insects to a plant or flower. When an idea appeared, he followed it, “as a boy might hunt a butterfly”; when it was captured he pinned it in his “Thought-book”. The writings of other men he used more for stimulus than for guidance. He said that books were for the scholar’s idle times. “I value them,” he said, “to make my top spin.” His favourite reading was poetry and mystical philosophy: Shakespeare, Dante, George Herbert, Goethe, Berkeley, Coleridge, Swedenborg, Jakob Boehme, Plato, the new Platonists, and the religious books of the East (in translation). Next to these he valued books of biography and anecdote: Plutarch, Grimm, St Simon, Varnhagen von Ense. He had some odd dislikes, and could find nothing in Aristophanes, Cervantes, Shelley, Scott, Miss Austen, Dickens. Novels he seldom read. He was a follower of none, an original borrower from all. His illustrations were drawn from near and far. The zodiac of Denderah; the Savoyards who carved their pine-forests into toys; the naked Derar, horsed on an idea, charging a troop of Roman cavalry; the long, austere Pythagorean lustrum of silence; Napoleon on the deck of the “Bellerophon,” observing the drill of the English soldiers; the Egyptian doctrine that every man has two pairs of eyes; Empedocles and his shoe; the horizontal stratification of the earth; a soft mushroom pushing its way through the hard ground,—all these allusions and a 335
thousand more are found in the same volume. On his pages, close beside the Parthenon, the Sphinx, St Paul’s, Etna and Vesuvius, you will find the White Mountains, Monadnock, Agiocochook, Katahdin, the pickerel-weed in bloom, the wild geese honking through the sky, the chick-a-dee braving the snow, Wall Street and State Street, cotton-mills, railroads and Quincy granite. For an abstract thinker he was strangely in love with the concrete facts of life. Idealism in him assumed the form of a vivid illumination of the real. From the pages of his teeming note-books he took the material for his lectures, arranging and rearranging it under such titles as Nature, School, Home, Genius, Beauty and Manners, Self-Possession, Duty, The Superlative, Truth, The Anglo-Saxon, The Young American. When the lectures had served their purpose he rearranged the material in essays and published them. Thus appeared in succession the following volumes: *Essays* (First Series) (1841); *Essays* (Second Series)

(1844); *Representative Men* (1850); *English Traits* (1856); *The Conduct of Life* (1860); *Society and Solitude* (1870); *Letters and Social Aims* (1876). Besides these, many other lectures were printed in separate form and in various combinations.

Emerson's style is brilliant, epigrammatic, gem-like; clear in sentences, obscure in paragraphs. He was a sporadic observer. He saw by flashes. He said, "I do not know what arguments mean in reference to any expression of a thought." The coherence of his writing lies in his personality. His work is fused by a steady glow of optimism. Yet he states this optimism moderately. "The genius which preserves and guides the human race indicates itself by a small excess of good, a small balance in brute facts always favourable to the side of reason."

His verse, though in form inferior to his prose, was perhaps a truer expression of his genius. He said, "I am born a poet"; and again, writing to Carlyle, he called himself "half a bard." He had "the vision," but not "the faculty divine" which translates the vision into music. In his two volumes of verse (*Poems*, 1846; *May Day and other Pieces*, 1867) there are many passages of beautiful insight and profound feeling, some lines of surprising splendour, and a few poems, like "The Rhodora," "The Snowstorm," "Ode to Beauty," "Terminus," "The Concord Ode," and the marvellous "Threnody" on the death of his first-born boy, of beauty unmarred and penetrating truth. But the total value of his poetical work is discounted by the imperfection of metrical form, the presence of incongruous images, the predominance of the intellectual over the emotional element, and the lack of flow. It is the material of poetry not thoroughly worked out. But the genius from which it came—the swift faculty of perception, the lofty imagination, the idealizing spirit enamoured of reality—was the secret source of all Emerson's greatness as a speaker and as a writer. Whatever verdict time may pass upon the bulk of his poetry, Emerson himself must be recognized as an original and true poet of a high order.

His latter years were passed in peaceful honour at Concord. In 1866 Harvard College conferred upon him the degree of LL.D., and in 1867 he was elected an overseer. In 1870 he delivered a course of lectures before the university on "The Natural History of the Intellect." In 1872 his house was burned down, and was rebuilt by popular subscription. In the same year he went on his third foreign journey, going as far as Egypt. About this time began a failure in his powers, especially in his memory. But his character remained serene and unshaken in dignity. Steadily, tranquilly, cheerfully, he finished the voyage of life.

"I trim myself to the storm of time,
I man the rudder, reef the sail,
Obey the voice at eve obeyed at prime:
'Lowly faithful, banish fear,
Right onward drive unharmed;
The port, well worth the cruise, is near.
And every wave is charmed.'"

Emerson died on the 27th of April 1882, and his body was laid to rest in the peaceful cemetery of Sleepy Hollow, in a grove on the edge of the village of Concord.

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(H. van D.)

EMERSON, WILLIAM (1701-1782), English mathematician, was born on the 14th of May 1701 at Hurworth, near Darlington, where his father, Dudley Emerson, also a mathematician, taught a school. Unsuccessful as a teacher he devoted himself entirely to studious retirement, and published many works which are singularly free from errata. In mechanics he never advanced a proposition which he had not previously tested in practice, nor published an invention without first proving its effects by a model. He was skilled in the science of music, the theory of sounds, and the ancient and modern scales; but he never attained any excellence as a performer. He died on the 20th of May 1782 at his native village. Emerson was eccentric and indeed clownish, but he possessed remarkable independence of character and intellectual energy. The boldness with which he expressed his opinions on religious subjects led to his being charged with scepticism, but for this there was no foundation.

Emerson’s works include *The Doctrine of Fluxions* (1748); *The Projection of the Sphere, Orthographic, Stereographic and Gnomical* (1749); *The Elements of Trigonometry* (1749); *The Principles of Mechanics* (1754); *A Treatise of Navigation* (1755); *A Treatise of Algebra*, in two books (1765); *The Arithmetic of Infinites, and the Differential Method, illustrated by Examples* (1767); *Mechanics, or the Doctrine of Motion* (1769); *The Elements of Optics*, in four books (1768); *A System of Astronomy* (1769); *The Laws of Centripetal and Centrifugal Force* (1769); *The Mathematical Principles of Geography* (1770); *Tracts* (1770); *Cyclomathesis, or an Easy Introduction to the several branches of the Mathematics* (1770), in ten vols.; *A Short Comment on Sir Isaac Newton’s Principia*; to which is added, *A Defence of Sir Isaac against the objections that have been made to several parts of his works* (1770); *A Miscellaneous Treatise containing several Mathematical Subjects* (1776).

EMERY (Ger. *Smirgel*), an impure variety of corundum, much used as an abrasive agent. It was known to the Greeks under the name of σμύρις or σμίρις, which is defined by Dioscorides as a stone used in gem-engraving. The Hebrew word *shamir* (related to the Egyptian *asmir*), where translated in our versions of the Old Testament “adamant” and “diamond,” probably signified the emery-stone or corundum.

Emery occurs as a granular or massive, dark-coloured, dense substance, having much the appearance of an iron-ore. Its specific gravity varies with its composition from 3.7 to 4.3. Under the microscope, it is seen to be a mechanical aggregate of corundum, usually in grains or minute crystals of a bluish colour, with magnetite, which also is granular and crystalline. Other iron oxides, like haematite and limonite, may be present as alteration-products of the magnetite. Some of the alumina and iron oxide may occasionally be chemically combined, so as to form an iron spinel, or hercynite. In addition to these minerals emery sometimes contains quartz, mica, tourmaline, cassiterite, &c. Indeed emery may be regarded as a rock rather than a definite mineral species.

The hardness of emery is about 8, whereas that of pure corundum is 9. The “abrasive power,” or “effective hardness,” of emery is by no means proportional to the amount of alumina which it contains, but seems rather to depend on its physical condition. Thus, taking the effective hardness of sapphire 336
as 100, Dr J. Lawrence Smith found that the emery of Samos with 70.10% of alumina had a corresponding hardness of 56; that of Naxos, with 68.53 of Al_2O_3, a hardness of 46; and that of Gumach with 77.82 of Al_2O_3, a hardness of 47.

Emery has been worked from a very remote period in the Isle of Naxos, one of the Cyclades, whence the stone was called *naxium* by Pliny and other Roman writers. The mineral occurs as loose blocks and as lenticular masses or irregular beds in granular limestone, associated with crystalline schists. The Naxos emery has been described by Professor G. Tschermak. From a chemical analysis of a sample it has been calculated that the emery contained 52.4% of corundum, 32.1 of magnetite, 11.5 of tourmaline, 2 of muscovite and 2 of margarite.

Important deposits of corundum were discovered in Asia Minor by J. Lawrence Smith, when investigating Turkish mineral resources about 1847. The chief sources of emery there are Gumach Dagh, a mountain about 12 m. E. of Ephesus; Kula, near Ala-shehr; and the mines in the hills between Thyra and Cosbonnar, south of Smyrna. The occurrence is similar to that in Naxos. The emery is found as detached blocks in a reddish soil, and as rounded masses embedded in a crystalline limestone associated with mica-schist, gneiss and granite. The proportion of corundum in this emery is said to vary from 37 to 57%. Emery is worked at several localities in the United States, especially near Chester, in Hampden county, Mass., where it is associated with peridotites. The corundum and magnetite are regarded by Dr J.H. Pratt as basic segregations from an igneous magma. The deposits were discovered by H.S. Lucas in 1864.

The hardness and toughness of emery render it difficult to work, but it may be extracted from the rock by blasting in holes bored with diamond drills. In the East fire-setting is employed. The emery after being broken up is carefully picked by hand, and then ground or stamped, and separated into grades by wire sieves. The higher grades are prepared by washing and eleutriation, the finest being known as “flour of emery.” A very fine emery dust is collected in the stamping room, where it is deposited after floating in the air. The fine powder is used by lapidaries and plate-glass manufacturers. Emery-wheels are made by consolidating the powdered mineral with an agglutinating medium like shellac or silicate of soda or vulcanized india-rubber. Such wheels are not only used by dentists and lapidaries but are employed on a large scale in mechanical workshops for grinding, shaping and polishing steel. Emery-sticks, emery-cloth and emery-paper are made by coating the several materials with powdered emery mixed with glue, or other adhesive media. (See Corundum.)

(F. W. R.*)

EMETICS (from Gr. ἐμετικός, causing vomit), the term given to substances which are administered for the purpose of producing vomiting. It is customary to divide emetics into two classes, those which produce their effect by acting on the vomiting centre in the medulla, and those which act directly on the stomach itself. There is considerable confusion in the nomenclature of these two divisions, but all are agreed in calling the former class central emetics, and the latter gastric. The gastric emetics in common use are alum, ammonium carbonate, zinc sulphate, sodium chloride (common salt), mustard and warm water. Copper sulphate has been purposely omitted from this list, since unless it produces vomiting very shortly after administration, being itself a violent gastro-intestinal irritant, some other emetic must promptly be administered. The central emetics are apomorphine, tartar emetic, ipecacuanha, senega and squill. Of these tartar emetic and ipecacuanha come under both heads: when taken by the mouth they act as gastric emetics before absorption into the blood, and later produce a further and more vigorous effect by stimulation of the medullary centre. It must be remembered, however, that, valuable though these drugs are, their action is accompanied by so much depression, they should never be administered except under medical advice.

Emetics have two main uses: that of emptying the stomach, especially in cases of poisoning, and that of expelling the contents of the air passages, more especially in children before they have learnt or have the strength to expectorate. Where a physician is in attendance, the first of these uses is nearly always replaced by lavage of the stomach, whereby any subsequent depression is avoided. Emetics still have their place, however, in the treatment of bronchitis, laryngitis and diphtheria in children, as they aid in the expulsion of the morbid products. Occasionally also they are administered when a foreign body has got into the larynx. Their use is contra-indicated in the case of anyone suffering from aneurism, hernia or arterio-sclerosis, or where there is any tendency to haemorrhage.

EMEU, evidently from the Port. *Ema*,[1] a name which has in turn been applied to each of the earlier-known forms of Ratite birds, but has finally settled upon that which inhabits Australia, though, up to the close of the 18th century, it was given by most authors to the bird now commonly called cassowary—this last word being a corrupted form of the Malayan *Suwari* (see Crawfurd, *Gramm. and Dict. Malay Language*, ii. pp. 178 and 25), apparently first printed as *Casoaris* by Bontius in 1658 (*Hist. nat. et med. Ind. Orient.* p. 71).

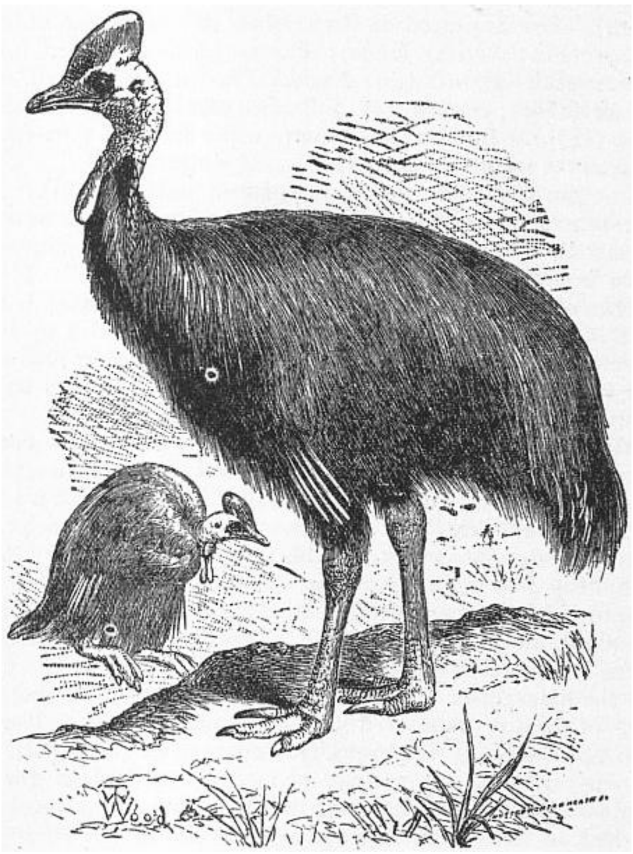

Fig. 1.—Ceram Cassowary.[2]

The cassowaries (*Casuariidae*) and emeus (*Dromaeidae*)—as the latter name is now used—have much structural resemblance, and form the order *Megistanes*,[3] which is peculiar to the Australian Region. Huxley showed (*Proc. Zool. Soc.*, 1867, pp. 422, 423,) that they agree in differing from the other *Ratitae* in many important characters; one of the most obvious of them is that each contour-feather appears to be double, its *hyporachis*, or aftershaft, being as long as the main shaft—a feature noticed in the case of either form so soon as examples were brought to Europe. The external distinctions of the two families are, however, equally plain. The cassowaries, when adult, bear a horny helmet on their head; they have some part of the neck bare, generally more or less ornamented with caruncles, and the claw of the inner toe is remarkably elongated. The emeus have no helmet, their head is feathered, their neck has no caruncles, and their inner toes bear a claw of no singular character.

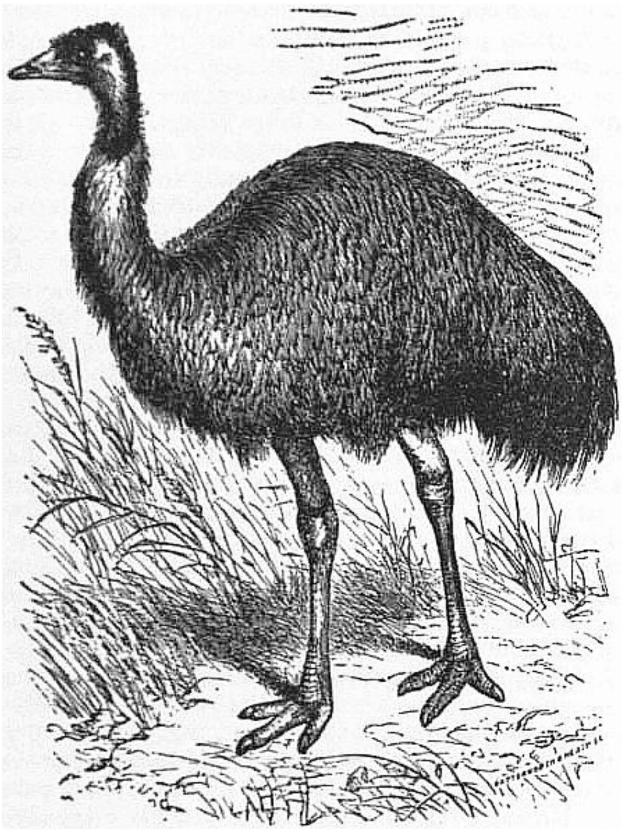

FIG. 2.—Emeu.

The type of the *Casuariidae* is the species named by Linnaeus *Struthio casuarius* and by John Latham *Casuarius emeu*. Vieillot subsequently called it *C. galeatus*, and his epithet has been very commonly adopted by writers, to the exclusion of the older specific appellation. It seems to be peculiar to the island of Ceram, and was made known to naturalists, as we learn from Clusius, in 1597, by the first Dutch expedition to the East Indies, when an example was brought from Banda, whither it had doubtless been conveyed from its native island. It was said to have been called by the inhabitants "Emeu," or "Ema," but this name they must have had from the earlier Portuguese navigators.[4] Since that time examples have been continually imported into Europe, so that it has become one of the best-known members of the subclass *Ratitae*. For a long time its glossy, but coarse and hair-like, black plumage, its lofty helmet, the gaudily-coloured caruncles of its neck, and the four or five barbless quills which represent its wing-feathers, made it appear unique among birds. But in 1857 Dr George Bennett certified the existence of a second and perfectly distinct species of cassowary, an inhabitant of New Britain, where it was known to the natives as the *Mooruk*, and in his honour it was named by John Gould *C. bennetti*. Several examples were soon after received in England, and these confirmed the view of it already taken. A considerable number of other species of the genus have since been described from various localities in the same subregion. Conspicuous among them from its large size and lofty helmet is the *C. australis*, from the northern parts of Australia. Its existence indeed had been ascertained, by T.S. Wall, in 1854, but the specimen obtained by that unfortunate explorer was lost, and it was not until 1867 that an example was submitted to competent naturalists.

Not much seems to be known of the habits of any of the cassowaries in a state of nature. Though the old species occurs rather plentifully over the whole of the interior of Ceram, A.R. Wallace was unable to obtain or even to see an example. They all appear to bear captivity well, and the hens in confinement frequently lay their dark-green and rough-shelled eggs, which, according to the custom of the *Ratitae*, are incubated by the cocks. The nestling plumage is mottled (*Proc. Zool. Soc.*, 1863, pl. xlii.), and when about half-grown they are clothed in dishevelled feathers of a deep tawny colour.

Of the emeus (as the word is now restricted) the best known is the *Casuarius novae-hollandiae* of John Latham, made by Vieillot the type of his genus *Dromaeus*,[5] whence the name of the family (*Dromaeidae*) is taken. This bird immediately after the colonization of New South Wales (in 1788) was found to inhabit the south-eastern portion of Australia, where, according to John Hunter (*Hist. Journ.*, &c., pp. 409, 413), the natives call it *Maracry*, *Marryang* or *Maroang*; but it has now been so hunted down that not an example remains at large in the districts that have been fully settled. It is said to have existed also on the islands of Bass Straits and in Tasmania, but it has been exterminated in both, without, so far as is known, any ornithologist having had the opportunity of determining whether the race inhabiting those localities was specifically identical with that of the mainland or distinct. Next to the ostrich the largest of existing birds, the common emeu is an inhabitant of the more open country, feeding on fruits, roots and herbage, and generally keeping in small companies. The nest is a shallow pit scraped in the ground, and from nine to thirteen eggs, in colour varying from a bluish-green to a dark bottle-green, are laid therein. These are hatched by the cock-bird, the period of incubation lasting from 70 to 80 days. The young at birth are striped longitudinally with dark markings on a light ground. A remarkable structure in *Dromaeus* is a singular opening in the front of the windpipe, communicating with a tracheal pouch. This has attracted the attention of several anatomists, and has been well described by Dr Murie (*Proc. Zool. Soc.*, 1867, pp. 405-415). Various conjectures have been made as to its function, the most probable of which seems to be that it is an organ of sound in the breeding-season, at which time the hen-bird has long been known to utter a remarkably loud booming note. Due convenience being afforded to it, the emeu thrives well, and readily propagates its kind in Europe. Like other Ratite birds it will take to the water, and examples have been seen voluntarily swimming a wide river.

(A. N.)

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1 By Moraes (1796) and Sousa (1830) the word is said to be from the Arabic *Na'āma* or *Na'ēma*, an ostrich (*Struthio camelus*); but no additional evidence in support of the assertion is given by Dozy in 1869 (*Glossaire des mots espagnols et portugais dérivés de l'arabe*, 2nd ed., p. 260). According to Gesner in 1555 (lib. iii. p. 709), it was the Portuguese name of the crane (*Grus communis*), and had been transferred with the qualifying addition of "*di Geï*" (*i.e.* ground-crane) to the ostrich. This statement is confirmed by Aldrovandus (lib. ix. cap. 2). Subsequently, but in what order can scarcely now be determined, the name was naturally enough used for the ostrich-like birds inhabiting the lands discovered by the Portuguese, both in the Old and in the New World. The last of these are now known as rheas, and the preceding as cassowaries.

2 The figures are taken, by permission, from Messrs Mosenthal and Harting's *Ostriches and Ostrich Farming* (Trübner & Co., 1877).

3 *Ann. and Mag. Nat. Hist.* ser. 4, xx. p. 500.

4 It is known that the Portuguese preceded the Dutch in their voyages to the East, and it is almost certain that the latter were assisted by pilots of the former nation, whose names for places and various natural objects would be imparted to their employers (see Dodo).

5 The obvious misprint of *Dromeicus* in this author's work (*Analyse*, &c., p. 54) was foolishly followed by many naturalists, forgetful that he corrected it a few pages farther on (p. 70) to *Dromaius*—the properly latinized form of which is *Dromaeus*.

EMIGRATION (from Lat. *emigrare*; *e*, *ex*, out of, and *migrare*, to depart), the movement of population out of one country into another (see Migration).

EMILIA, a territorial division (*compartimento*) of Italy, bounded by Venetia and Lombardy on the N., Liguria on the W., Tuscany on the S., the Marches on the S.E., and the Adriatic Sea on the E. It has an area of 7967 sq. m., and a population of 2,477,690 (1901), embracing eight provinces, as follows:—(1) Bologna (pop. 529,612; 61 communes); (2) Ferrara (270,558; 16 communes); (3) Forlì (283,996; 41 communes); (4) Modena (323,598; 45 communes); (5) Parma (303,694; 50 communes); (6) Piacenza (250,491; 47 communes); (7) Ravenna (234,656; 18 communes); (8) Reggio nell' Emilia (281,085; 43 communes). In these provinces the chief towns, with communal populations, are as follows:—

(1) Bologna (147,898), Imola (33,144), Budrio (17,077), S. Giovanni in Persiceto (15,978), Castelfranco (13,484), Castel S. Pietro (13,426), Medicina (12,575), Molinella (12,081), Crevalcore (11,408). 338

(2) Ferrara (86,675), Copparo (39,222), Argenta (20,474), Portomaggiore (20,141), Cento (19,078), Bondeno (15,682), Comacchio (10,745).

(3) Forlì (43,321), Rimini (43,595). Cesena (42,509).

(4) Modena (63,012), Carpi (22,876), Mirandola (13,721), Finale nell' Emilia (12,896), Pavullo nel Frignano (12,034).

(5) Parma (48,523), Borgo S. Donnino (12,019).

(6) Piacenza (35,647).·

(7) Ravenna (63,364), Faenza (39,757), Lugo (27,244), Bagnacavallo (15,176), Brisighella (13,815), Alfonsine (10,369).

(8) Reggio nell’ Emilia (58,993), Correggio (14,445), Guastalla (11,091).

The northern portion of Emilia is entirely formed by a great plain stretching from the Via Aemilia to the Po; its highest point is not more than 200 ft. above sea-level, while along the E. coast are the lagoons at the mouth of the Po and those called the Valli di Comacchio to the S. of them, and to the S. again the plain round Ravenna (10 ft.), which continues as far as Rimini, where the mountains come down to the coast.

Immediately to the S.E. of the Via Aemilia the mountains begin to rise, culminating in the central chain of the Ligurian and Tuscan Apennines. The boundary of Emilia follows the highest summits of the chain in the provinces of Parma, Reggio and Modena, passing over the Monte Bue (5915 ft.) and the Monte Cimone (7103 ft.), while in the provinces of Bologna and Forlì it keeps somewhat lower along the N.E. slopes of the chain. With the exception of the Po, the main rivers of Emilia descend from this portion of the Apennines, the majority of them being tributaries of the Po; the Trebbia (which rises in the province of Genoa), Taro, Secchia and Panaro are the most important. Even the Reno, Ronco and Montone, which now flow directly into the Adriatic, were, in Roman times, tributaries of the Po, and the Savio and Rubicone seem to be the only streams of any importance from these slopes of the Tuscan Apennines which ran directly into the sea in Roman times (see Apennines).

Railway communication in the plain of Emilia is unattended by engineering difficulties (except for the bridging of rivers) and is mainly afforded by the line from Piacenza to Rimini. This, as far as Bologna, forms part of the main route from Milan to Florence and Rome, while beyond Rimini it follows the S.E. coast of Italy past Ancona as far as Brindisi and Lecce. The description follows this main line in a S.E. direction. Piacenza, being immediately S. of a bridge over the Po, is an important centre; a line runs to the W. to Voghera, through which it communicates with the lines of W. Lombardy and Piedmont, and immediately N. of the Po a line goes off to Cremona. A new bridge over the Po carries a direct line from Cremona to Borgo S. Donnino. From Parma starts a main line, followed by expresses from Milan to Rome, which crosses the Apennines to Spezia (and Sarzana, for Pisa and Rome), tunnelling under the pass of La Cisa, while in a N. and N.E. direction lines run to Brescia and Suzzara. From Reggio branch lines run to Guastalla, Carpi and Sassuolo, there being also a line from Sassuolo to Modena. At Modena the main line to Verona through Suzzara and Mantua diverges to the N.; there is also a branch N.N.E. to Mirandola, and another S. to Vignola. Bologna is, however, the most important railway centre; besides the line S. to Pistoia and Florence over the Apennines and the line S.E. to Rimini, Ancona and Brindisi, there is the main line N.N.E. to Ferrara, Padua and Venice, and there are branches to Budrio and Portomaggiore to the N.E., and to S. Felice sul Panaro and Poggio Rusco to the N., which connect the main lines of the district.

At Castel Bolognese, 5 m. N.W. of Faenza, a branch goes off to Lugo, whence there are connexions with Budrio, Lavezzola (on the line between Ravenna and Ferrara) and Ravenna, and at Faenza a line, not traversed by express trains, goes across the Apennines to Florence. Rimini is connected by a direct line with Ravenna and Ferrara; and Ferrara, besides the main line S.S.W. to Bologna and N. by E. to Padua, has a branch to Poggio Rusco, which goes on to Suzzara, a station on the main line between Modena and Verona. There are also many steam tramways in the flatter part of the province, the fertility and agricultural activity of which are considerable. The main products of the plain are cereals, wine, and, in the marshy districts near the Po, rice; the system prevailing is that of the mezzadria—half the produce to the owner and half to the cultivator. The ancient Roman divisions of the fields are still preserved in some places. There are also considerable pastures, and cheese is produced, especially Parmesan. Flax, hemp and silkworms are also cultivated, and a considerable quantity of poultry kept. The hill districts produce cereals, vines, olives and fruit; while on the mountains are considerable chestnut and other forests, and extensive summer pastures, the flocks going in part to the Maremma in summer, and in part to the pastures of the plain of the Emilia.

The name Emilia comes from the Via Aemilia (*q.v.*), the Roman road from Ariminum to Placentia, which traversed the entire district from S.E. to N.W., its line being closely followed by the modern railway. The name was transferred to the district (which formed the eighth Augustan region of Italy) as early as the time of Martial, in popular usage (*Epigr.* vi. 85. 5), and in the 2nd and 3rd centuries it is frequently named as a district under imperial judges (*iuridici*), generally in combination with Flaminia or Liguria and Tuscia. The district of Ravenna was, as a rule, from the 3rd to the 5th century, not treated as part of Aemilia, the chief town of the latter being Placentia. In the 4th century Aemilia and Liguria were joined to form a consular province; after that Aemilia stood alone, Ravenna being sometimes temporarily added to it. The boundaries of the ancient district correspond approximately with those of the modern.

In the Byzantine period Ravenna became the seat of an exarch; and after the Lombards had for two centuries attempted to subdue the Pentapolis (Ravenna, Bologna, Forlì, Faenza, Rimini), Pippin took these cities from Aistulf and gave them, with the March of Ancona, to the papacy in 755, to which, under the name of Romagna, they continued to belong. At first, however, the archbishop of Ravenna was in reality supreme. The other chief cities of Emilia—Ferrara, Modena, Reggio, Parma, Piacenza—were, on the other hand, independent, and in the period of the communal independence of the individual towns of Italy each of the chief cities of Emilia, whether belonging to Romagna or not, had a history of its own; and, notwithstanding the feuds of Guelphs and Ghibellines, prospered considerably. The study of Roman law, especially at Bologna, acquired great importance. The imperial influence kept the papal power in check. Nicholas III. obtained control of the Romagna in 1278, but the papal dominion almost fell during the Avignon period, and was only maintained by the efforts of Cardinal

Albornoz, a Spaniard sent to Italy by Innocent VI. in 1353. Even so, however, the papal supremacy was little more than a name; and this state of things only ceased when Caesar Borgia, the natural son of Alexander VI., crushed most of the petty princes of Romagna, intending to found there a dynasty of his own; but on the death of Alexander VI. it was his successors in the papacy who carried on and profited by what Caesar Borgia had begun. The towns were thenceforth subject to the church and administered by cardinal legates. Ferrara and Comacchio remained under the house of Este until the death of Alphonso II. in 1597, when they were claimed by Pope Clement VIII. as vacant fiefs. Modena and Reggio, which had formed part of the Ferrara duchy, were thenceforth a separate duchy under a branch of the house of Este, which was descended from a natural son of Alphonso I. Carpi and Mirandola were small principalities, the former of which passed to the house of Este in 1525, in which year Charles V. expelled the Pio family, while the last of the Pico dynasty of Mirandola, Francesco Maria, having sided with the French in the war of Spanish Succession, was deprived of his duchy in 1709 by the emperor Joseph I., who sold it to the house of Este in 1710. Parma and Piacenza were at first under the Farnese, Pope Paul III. having placed his natural son Pier Luigi therein 1545, and then, after the extinction of the family in 1731, under a secondary branch of the Bourbons of Spain. In 1796-1814, Emilia was first incorporated in the Italian republic and then in the Napoleonic Italian kingdom; after 1815 there was a return to the *status quo ante*, Romagna returning to the papacy and its ecclesiastical government, the duchy of Parma being given to Marie Louise, wife of the deposed Napoleon, and Modena to the archduke Francis of Austria, the heir of the last Este. In Romagna and Modena the government was oppressive, arbitrary, corrupt and unprogressive, while in Parma things were better. In 1821 and 1831 there were unsuccessful attempts at revolt in Emilia, which were sternly and cruelly repressed; chronic discontent continued and the people joined again in the movement of 1848-1849, which was crushed by Austrian troops. In 1859 the struggle for independence was finally successful, Emilia passing to the Italian kingdom almost without resistance. 339

EMINENCE (Lat. *eminentia*), a title of honour now confined to the cardinals of the Church of Rome. It was originally given as a complimentary title to emperors, kings, and then to less conspicuous persons. The Roman empire of the 4th century adopted from the "vanity of the East the forms and ceremonies of ostentatious greatness." Gibbon includes in the "profusion of epithets" by which "the purity of the Latin language was debased," and which were lavished on "the principal officers of the empire," "your Sincerity, your Gravity, your Excellency, your Eminence, your sublime and wonderful Magnitude, your illustrious and magnificent Highness." From the *notitia dignitatum* it passed into the Latin of the middle ages as a flattering epithet, and was applied in the church and by the popes to the dignified clergy at large, and sometimes as a pure form of civility to churchmen of modest rank. On the 10th of June 1630, Urban VIII. confined the use of the titles *Eminentiae* and *Eminentissimi* to the cardinals, to imperial electors, and to the master of the Hospital of St John of Jerusalem (order of the Knights of Malta). Since the dissolution of the Holy Roman Empire, and the entire change, if not actual destruction, of the order of St John, the title "eminence" has become strictly confined to the cardinals. Before 1630 the members of the Sacred College were "Illustrissimi" and "Reverendissimi." It is, therefore, not correct to speak of a cardinal who lived before that time as "his Eminence."

See du Cange, *Glossarium mediae et infimae latinitatis* (Niort and London, 1884), s.v. "Eminentia."

EMINENT DOMAIN (Lat. *eminens*, rising high above surrounding objects: and *dominium*, domain), a term applied in law to the sovereign right of a state to appropriate private property to public uses, whether the owner consents or not. It is repeatedly employed by Grotius (*e.g. De jure belli*, bk. iii. c. 20, s. 7), Bynkershoek (*Quaest. jur. pub.* bk. 2, c. 15), and Puffendorf (*De jure naturae et gentium*, bk. i. c. 1, s. 19),—the two latter, however, preferring the word *imperium* to *dominium*; and by other Dutch jurists. But in modern times it is chiefly in the United States of America that the doctrine of eminent domain has received its application, and it is chiefly to American law that the following remarks refer (see also the article COMPENSATION). Eminent domain is distinguishable alike from the *police power*, by which restrictions are imposed on private property in the public interest, *e.g.* in connexion with the liquor traffic or public health (see *re Haff* (1904), 197 U.S. 488); from the *power of taxation*, by which the owner of private property is compelled to contribute a portion of it for public purposes; and from the *war-power*, involving the destruction of private property in the course of military operations. The police power fetters rights of property; eminent domain takes them away. The power of taxation is analogous to eminent domain as regards the purposes to which the contribution of the tax-payer is to be applied. But, unlike eminent domain, it does not necessarily involve a taking of specific property for those purposes. The destruction of property in military operations—or in the discharge by Government of other duties in cases of necessity, *e.g.* in order to check the progress of a fire in a city—clearly cannot be said to be an exercise of the power of eminent domain. The question whether the element of compensation is necessarily involved in the idea of eminent domain has in modern times aroused much controversy. According to one school of thought (see Lewis, *Eminent Domain*, s. 10), this question must be answered in the negative. According to a second, whose view has the support of the civilians (see Randolph, *Eminent Domain*, s. 227; Mills, *Eminent Domain*, s. 1) compensation is an inherent attribute of the power. An intermediate view is advocated by Professor Thayer (*Cases on Constitutional Law*, vol. 1, 953), according to which eminent domain springs from the necessities of government, while the obligation to reimburse rests upon the natural right of individuals. The right to compensation is thus not a component part of the power to take, but arises at the same time and the latter cannot exist without it. The relation between the two is that of substance and shadow. The matter is not, however, of great practical importance, for the Federal Constitution prohibits the exercise of the power "without just compensation" (5th Amendment), while in most of the states the State constitution or other legislation has imposed upon it a similar limitation: and the tendency of modern judicial decisions is in favour of the view that the absence of such a limitation will make an enactment so far unconstitutional and invalid.

In order to justify the exercise of the power of eminent domain, the purposes to which the property taken is to be applied must be "public," *i.e.* primarily public, and not primarily of private interest and merely incidentally beneficial to the public (*Madisonville Traction Co.* v. *Mining Co.*, 1904, 196 U.S. 239). Subject to this definition, the term "public" receives a wide interpretation. All kinds of property may be taken; and the procedure indicated by the different legislatures must be followed. Any contravention of this rule would involve a breach of the 5th Amendment of the Federal Constitution, which provides that "no person ... shall be ... deprived of ... property, without due process of law." It may be added that if the performance of a covenant is rendered impossible by an act of eminent domain the covenantor is excused.

In *English law*, the only exact analogue to the doctrine of eminent domain is to be found in the prerogative right of the crown to enter upon the lands of subjects or to interfere with their enjoyment for the defence of the realm (see *A.G.* v. *Tomline*; 1879; 12 Ch. D. 214). No attempt is made to exercise this prerogative, and lands are acquired for state purposes by statute usually framed on or incorporating the Lands Clauses Acts (see Compensation). The French *Code Civil* secures compensation to the owner of property in cases of *expropriation pour cause d'utilité publique* (art. 545), and there is similar provision in Belgium (Const. Law, art. II.), Holland (Fundamental Law, art. 147), Spain (Civil Code, art. 349, and Law of 3rd May, 1841), and most other European states. It has been held in France that the right to compensation does not arise under art. 545 of the Code Civil where only a *servitude d'utilité publique* is created on a private individual's land.

In addition to the authorities cited in the text, see Lewis, *Eminent Domain* (2nd ed., Chicago, 1900); Mills, *Eminent Domain* (2nd ed., St Louis, 1888); Randolph, *Eminent Domain in the United States* (Boston, 1894).

(A. W. R.)

EMINESCU, MICHAIL (1849-1889), the greatest Rumanian poet of the 19th century, was born on the 20th of December in Ipateshti near Botoshani, in the north of Moldavia. He was of Turco-Tatar origin, and his surname was originally Emin; this was changed to Eminovich and finally to the Rumanian form Eminescu. He was educated for a time in Czernowitz, and then entered the civil service. In 1864 he resumed his studies in Transylvania, but soon joined a roving theatrical company where he played in turn the rôles of actor, prompter and stage-manager. After a few years he went to Vienna, Jena and Berlin, where he attended lectures, especially on philosophy. In 1874 he was appointed school inspector and librarian at the university of Jassy, but was soon turned out through the change of government, and took charge, as editor in chief, of the Conservative paper *Timpul* (Times). In 1883 he had the first attack of the insanity hereditary in his family, and in 1889 he died in 340
a private institution in Bucharest. In 1870 his great poetical talent was revealed by two contributions to the *Convorbiri literare*, the organ of the Junimist party in Jassy; these were the poems "Venera şi Madona" and "Epigonii." Other poems followed and soon established his claim to be the first among the modern poets of his country. He was thoroughly acquainted with the chronicles of the past, had a complete mastery of the Rumanian language, and was a lover and admirer of Rumanian popular poetry. Influenced by these studies and by the philosophy of Schopenhauer, he introduced a new spirit into Rumanian poetry. Mystically inclined and himself of a melancholy disposition, he lived in the glory of the medieval Rumanian past; stifled by the artificiality of the world around him, he rebelled against the conventionality of society and his surroundings. In inimitable language he denounced the vileness of the present and painted in glowing pictures the heroism of the past; he also surprised nature in its primitive beauty, and he gave expression to stirring emotions in lyrics couched in the language and metre of popular poetry. He further proved himself an unsurpassed master in satire. Over all his poetry hangs a cloud of sadness, the sense of coming doom. Simplicity of language, masterly handling of rhyme and verse, deep thought and plastic expression made Eminescu the creator of a school of poetry which dominated the thought of Rumania and the expression of Rumanian writers and poets at the end of the 19th century and the beginning of the 20th.

Five editions of his collected poems appeared after 1890. Some of them were translated into German by “Carmen Sylva” and Mite Kremnitz, and others have also been translated into several other languages. Eminescu also wrote two short novels, real poems in prose (Jassy, 1890).

(M. G.)

EMIN PASHA [Eduard Schnitzer] (1840-1892), German traveller, administrator and naturalist, was the son of Ludwig Schnitzer, a merchant of Oppeln in Silesia, and was born in Oppeln on the 28th of March 1840. He was educated at the universities of Breslau, Berlin and Königsberg, and took the degree of M.D. at Berlin. He displayed an early predilection for zoology and ornithology, and in later life became a skilled and enthusiastic collector, particularly of African plants and birds. When he was four-and-twenty he determined to seek his fortunes abroad, and made his way to Turkey, where, after practising medicine on his own account for a short time, he was appointed (in 1865) quarantine medical officer at Antivari. The duties of the post were not heavy, and allowed him leisure for a diligent study of Turkish, Arabic and Persian. From 1870 to 1874 he was in the service of the governor of northern Albania, had adopted a Turkish name (though not that by which he afterwards became so widely known), and was practically naturalized as a Turk.

After a visit home in 1875 he went to Cairo, and then to Khartum, in the hope of an opportunity for travelling in the interior of Africa. This came to him in the following year, when General Charles George Gordon, who had recently succeeded Sir Samuel Baker as governor of the equatorial provinces of Egypt, invited Schnitzer, who was now known as “Emin Effendi,” to join him at Lado on the upper Nile. Although nominally Gordon’s medical officer, Emin was soon entrusted with political missions of some importance to Uganda and Unyoro. In these he acquitted himself so well that when, in 1878, Gordon’s successor at Lado was deprived of his office on account of malpractices (Gordon himself having been made governor-general of the Sudan), Emin was chosen to fill the post of governor of the Equatorial Province (*i.e.* the old equatorial provinces minus the Bahr-el-Ghazal) and given the title of “bey.” He proved an energetic and enterprising governor; indeed, his enterprise on more than one occasion brought him into conflict with Gordon, who eventually decided to remove Emin to Suakin. Before the change could be effected, however, Gordon resigned his post in the Sudan, and his successor revoked the order.

The next three or four years were employed by Emin in various journeys through his province, and in the initiation of schemes for its development, until in 1882, on his return from a visit to Khartum, he became aware that the Mahdist rising, which had originated in Kordofan, was spreading southward. The effect of the rising was, of course, more markedly felt in Emin’s province after the abandonment of the Sudan by the Egyptian government in 1884. He was obliged to give up several of his stations in face of the Mahdist advance, and ultimately to retire from Lado, which had been his capital, to Wadelai. This last step followed upon his receipt of a letter from Nubar Pasha, informing him that it was impossible for the Egyptian government to send him help, and that he must stay in his province or retire towards the coast as best he could. Emin (who about this time was raised to the rank of pasha) had some thoughts of a retreat to Zanzibar, but decided to remain where he was and endeavour to hold his own. To this end he carried on protracted negotiations with neighbouring native potentates. When, in 1887, (Sir) H.M. Stanley’s expedition was on its way to relieve him, it is clear from Emin’s diary that he had no wish to leave his province, even if relieved. He had done good work there, and established a position which he believed himself able to maintain. He hoped, however, that the presence of Stanley’s force, when it came, would strengthen his position; but the condition of the relieving party, when it arrived in April 1888, did not seem to Emin to promise this. Stanley’s proposal to Emin, as stated in the latter’s diary, was that Emin should either remain as governor-general on behalf of the king of the Belgians, or establish himself on Victoria Nyanza on behalf of a group of English merchants who wished to start an enterprise in Africa on the model of the East India Company. After much hesitation, and prompted by a growing disaffection amongst the natives (owing, as he maintained, to his loss of prestige after the arrival of Stanley’s force), Emin decided to accompany Stanley to the coast, where the expedition arrived in December 1889. Unfortunately, on the evening of a reception dinner given in his honour, Emin met with an accident which resulted in fracture of the skull. Careful nursing gradually restored him to health, and on his convalescence he resolutely maintained his decision to remain in Africa, and, if possible, to work there in future on behalf of the German government. The seal was definitely set upon this decision by his formal engagement on behalf of his native country, early in 1890. Preparations for a new expedition into the interior were set on foot, and meanwhile Emin was honoured in various ways by learned societies in Germany and elsewhere.

The object of the new expedition was (to quote Emin’s instructions) “to secure on behalf of Germany the territories situated south of and along Victoria Nyanza up to Albert Nyanza,” and to “make known to the population there that they were placed under German supremacy and protection, and to break or undermine Arab influence as far as possible.” The force, which was well equipped, started at the end of April 1890. But before it had penetrated far inland the political reasons for sending the expedition vanished with the signature, on the 1st of July 1890, of the Anglo-German agreement defining the spheres of influence of the two nations, an agreement which excluded the Albert Nyanza

region from the German sphere. For a time things went well enough with the expedition; Emin occupied the important town of Tabora on the route from the coast to Tanganyika and established the post of Bukoba on Victoria Nyanza, but by degrees ill-fortune clouded its prospects. Difficulties on the route; dissensions between Emin and the authorities in German East Africa, and misunderstandings on the part of both; epidemics of disease in Emin's force, followed by a growing spirit of mutiny among his native followers; an illness of a painful nature which attacked him—all these gradually undermined Emin's courage, and his diaries at the close of 1891 reflect a gloomy and almost hopeless spirit. In May that year he had crossed into the Congo State by the south shore of Albert Edward Nyanza, and many months were spent on the borders of the great Congo Forest and in the Undusuma country south-west of Albert Nyanza, breaking ground new to Europeans. In December 1891 he sent 341
off his companion, Dr Stuhlmann, with the bulk of the caravan, on the way back to the east coast. Emin remained behind with the sick, and with a very reduced following left the lake district in March 1892 for the Congo river. On reaching Ipoto on the Ituri he came within the region of the Arab slave raiders and ivory hunters, in whose company he at times travelled. These gentry were incensed against Emin for the energetic way in which he had dealt with their comrades while in German territory, and against Europeans generally by the campaign for their suppression begun by the Congo State. At the instigation of one of these Arabs Emin was murdered on the 23rd or 24th of October 1892 at Kinena, a place about 80 m. E.S.E. of Stanley Falls.

See *Emin Pasha, his Life and Work*, by Georg Schweitzer, with introduction by R.W. Felkin (2 vols., London, 1898); *Emin Pasha in Central Africa* (London, 1888), a collection of Emin's papers contributed to scientific journals; and *Mit Emin Pascha ins Herz von Afrika* (Berlin, 1894), by Dr Franz Stuhlmann. Major G. Casati (1838-1902), an Italian officer who spent several years with Emin, and accompanied him and Stanley to the coast, narrated his experiences in *Dieci anni in Equatoria* (English edition, *Ten Years in Equatoria and the Return with Emin Pasha*, London, 1891).

EMLYN, THOMAS (1663-1741), English nonconformist divine, was born at Stamford, Lincolnshire. He served as chaplain to the presbyterian Letitia, countess of Donegal, and then to Sir Robert Rich, afterwards (1691) becoming colleague to Joseph Boyse, presbyterian minister in Dublin. From this office he was virtually dismissed on his own confession of unitarianism, and for publishing *An Humble Inquiry into the Scripture Account of Jesus Christ* (1702) was sentenced to a year's imprisonment and a fine of £1000. Thanks to the intervention of Boyse he was released in 1705 on payment of £90. He is said to have been the first English preacher definitely to describe himself as "unitarian," and writes in his diary, "I thank God that He did not call me to this lot of suffering till I had arrived at maturity of judgment and firmness of resolution, and that He did not desert me when my friends did. He never let me be so cast down as to renounce the truth or to waver in my faith." Of Christ he writes, "We may regard with fervent gratitude so great a benefactor, but our esteem and rational love must ascend higher and not rest till it centre in his God and ours." Emlyn preached a good deal in Paul's Alley, Barbican, in his later years, and died in London in 1741.

EMMANUEL, or Immanuel, a Hebrew symbolical proper name, meaning "God (is) with us." When in 734-733 B.C. Ahaz, king of Judah, alarmed at the preparations made against him by the Syro-Ephraimitish alliance, was inclined to seek aid from Tiglath-pileser of Assyria, the prophet Isaiah endeavoured to allay his fear by telling him that the danger would pass away, and as a sign from Yahweh that this should be so, any young woman who should within the year bear a son, might call his name Immanuel in token of the divine protection accorded to Judah. For before the infant should come to even the immature intelligence of childhood the lands of the foe would be laid waste (Isaiah vii. 14-16). For other interpretations, especially as regards the mother, see *Ency. Bib.* col. 2162-3, and the commentaries. In the post-exilic period the historical meaning of the passage was forgotten, and a new significance was given to it in accordance with the gradually developing eschatological doctrine. This new interpretation finds expression in Matt. i. 23, where the name is applied to Jesus as the Messiah. At the close of Isaiah viii. 8 for "of thy land, O Immanuel," we should probably read "of the land, for God is with us." The three passages quoted are the only instances where this word occurs in Scripture; it is frequent in hymns and devotional literature as a title of Jesus Christ.

EMMANUEL PHILIBERT (1528-1580), duke of Savoy, son of Charles III. and Beatrice of Portugal, one of the most renowned princes of the later Renaissance, was born on the 8th of July 1528. Charles, after trying in vain to remain neutral in the wars between France and the emperor Charles V., had been forced to side with the latter, whereupon his duchy was overrun with foreign soldiery and became the battlefield of the rival armies. Prince Emmanuel took service with the emperor in 1545 and distinguished himself in Germany, France and the Low Countries. On the death of his father in 1553 he succeeded to the title, little more than an empty one, and continued in the emperor's service. Having been refused the command of the imperial troops in Piedmont, he tried in vain to negotiate a separate peace with France; but in 1556 France and Spain concluded a five years' truce, by which each was to retain what it then occupied. This would have been the end of Savoy, but within a year the two powers were again at war. The chief events of the campaign were the successful resistance of Cuneo, held for the duke by Count Luserna, and the victory of St Quentin (1557), won by Emmanuel Philibert himself against the French. At last in 1558 the powers agreed to an armistice, and in 1559 the peace of Cateau-Cambrésis was made, by which Emmanuel regained his duchy, but on onerous terms, for France was to occupy several Piedmontese fortresses, including Turin and Pinerolo, for not more than three years, and a marriage was arranged between the duke and Margaret, duchess of Berry, sister of the French king; while Spain was to garrison Asti and Vercelli (afterwards exchanged for Santhià) until France evacuated the above-mentioned fortresses. The duke's marriage took place in Paris a few months later; and after the French evacuation he re-entered his dominions amidst the rejoicings of the people. The condition of Piedmont at that time was deplorable; for wars, the exactions and devastations of the foreign soldiery, and religious antagonism between Catholics and Protestants had wrought terrible havoc. "Uncultivated," wrote the Venetian ambassador, quoted by E. Ricotti, "no citizens in the cities, neither man nor beast in the fields, all the land forest-clad and wild; one sees no houses, for most of them are burnt, and of nearly all the castles only the walls are visible; of the inhabitants, once so numerous, some have died of the plague or of hunger, some by the sword, and some have fled elsewhere preferring to beg their bread abroad rather than support misery at home which is worse than death." There was no army, the administration was chaotic, and the finances were in a hopeless state. The duke set to work to put his house in order, and inaugurated a series of useful reforms, ably assisted by his minister, Niccolò Balbo. But progress was slow, and was accompanied by measures which abolished the states general, the last survival of feudal liberties. Savoy, following the tendency of the other states of Europe at that time, became thenceforth an absolute monarchy, but without that transformation the achievement of complete independence from foreign powers would have been impossible.

One of the first questions with which he had to deal was the religious difficulty. The inhabitants of the Pellice and Chisone valleys had long professed a primitive form of Christianity which the orthodox regarded as heretical, and had been subject to numerous persecutions in consequence (see Waldenses). At the time of the Reformation they had gone over to Protestantism, and during the wars of the 16th century the new religion made great progress in Piedmont. The duke as a devout Catholic desired to purge the state of heresy, and initiated repressive measures against the Waldenses, but after some severe and not very successful fighting he ended by allowing them a measure of religious liberty in those valleys (1561). At the pope's instigation he recommenced persecution some years later, but his duchess and some German princes pleaded successfully in favour of the Protestants. He next turned his attention to getting rid of the French garrisons; the negotiations proved long and troublesome, but in December 1562 the French departed on payment of 100,000 scudi, retaining only Pinerolo and Savigliano, and Turin became the capital once more. There remained the Bernese, who had occupied some of the duke's territories in Savoy and Vaud, and in Geneva, over which he claimed certain rights. With Bern he made a compromise, regaining Gex, the Chablais, and the Genevois, on condition that Protestantism should be tolerated there, but he renounced Vaud and some other districts (1566). Disagreements with the Valais were settled in a similar way in 1569; but the Genevans refused to recognize Savoyard suzerainty. Emmanuel reformed the currency, reorganized 342
justice, prepared the way for the emancipation of the serfs, raised the standing army to 25,000 men, and fortified the frontiers, ostensibly against Huguenot raids, but in reality from fear of France. On the death of Charles IX. of France in 1574 the new king, Henry III., passed through Piedmont on his way from Poland; Emmanuel gave him a magnificent reception, and obtained from him a promise that Pinerolo and Savigliano should be evacuated, which was carried out at the end of the year. Philip of Spain was likewise induced to evacuate Asti and Santhià in 1575. Thus, after being more or less under foreign occupation for 39 years, the duchy was at last free. The duke rounded off his dominions by the purchase of Tenda and Oneglia, which increased his seaboard, and the last years of his life were spent in fruitless negotiations to obtain Monferrato, held by the Gonzagas under Spanish protection, and Saluzzo, which was a French fief. He died on the 30th of August 1580, and was succeeded by his son Charles Emmanuel I. As a statesman Emmanuel Philibert was able, business-like and energetic; but he has been criticized for his duplicity, although in this respect he was no worse than most other European princes, whose ends were far more questionable. He was autocratic, but just and very patriotic. During his reign the duchy, which had been more than half French, became predominantly Italian. By diplomacy, which, although he was a capable and brave soldier, he preferred to war, he succeeded in freeing his country, and converting it from a ruined and divided land into a respectable independent power of the second rank, and, after Venice, the best-governed state in Italy.

The most accurate biography of Emmanuel Philibert is contained in E. Ricotti's *Storia della monarchia Piemontese*, vol. ii. (Florence, 1861), which is well done and based on documents; cf. Claretta's *La Successione di Emanuele Filiberto* (Turin, 1884).

EMMAUS, the name of two places in Palestine.

1. A village mentioned by Luke (xxiv. 13), without any indication of direction, as being 60 stadia (almost 7 m.), or according to some MSS.[1] 160 stadia, from Jerusalem. Its identification is a matter of mere guesswork: it has been sought at (*a*) Emmaus-Nicopolis (see 2 below), distant 176 stadia from Jerusalem; (*b*) Kuryet el-‘Enab, distant 66 stadia, on the carriage road to Jaffa; (*c*) Kulonieh, distant 36 stadia, on the same road; (*d*) el-Kubeibeh, distant 63 stadia, on the Roman road to Lydda; (*e*) ’Urtas, distant 60 stadia; and (*f*) Khurbet el-Khamasa, distant 86 stadia, on the Roman road to Eleutheropolis. Of these, el-Kubeibeh or ‘Urtas seems the most probable, though many favour Kulonieh because of its nearness to Bet Mizza, in which name there is similarity with Emmaus, and because of a reading (30 stadia) in Josephus.

2. Emmaus-Nicopolis, now ‘Amwās, a town on the maritime plain, and a place of importance during the Maccabaean and Jewish wars. Near it Judas Maccabaeus defeated Gorgias in 164 B.C., and Vespasian established a fortified camp in A.D. 69. It was afterwards rebuilt and named Nicopolis, and became an episcopal see. It was also noted for a healing spring.

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1 Including Codex א. But this distance is too great for the conditions of Luke’s narrative and the reading (160) is evidently an attempt to harmonize with the traditional identification of Emmaus-Nicopolis held by Eusebius and Jerome. For a curious reading in three old Latin MSS, which makes Emmaus the name of the second traveller on the journey, see *Expos. Times*, xiii. 429, 477, 561.

EMMENDINGEN, a town of Germany, in the grand-duchy of Baden, close to the Black Forest, on the Elz and the main line of railway Mannheim-Constance. Pop. 6200. It has a Protestant church with a fine spire, a Roman Catholic church, a handsome town-hall, an old castle (now a hospital), once the residence of the counts of Hochberg, spinning mills, tanneries and manufactures of photographic instruments, paper, machinery and cigars. There is also a considerable trade in timber and cattle. Here the author Johann Georg Schlosser (1739-1799), the husband of Goethe’s sister Cornelia (who died in 1777 and is interred in the old graveyard), was *Oberamtmann* (bailiff) for a few years.

Emmendingen was formerly the seat of the counts of Hochberg, a cadet branch of the margraves of Baden. In 1418 it received market rights from the emperor, and in 1590 was raised to the status of a town, and walled, by Margrave Jacob III.

EMMERICH (the ancient *Embrica*), a town of Germany, in the Prussian Rhine province, on the right bank of the Rhine and the railway from Cologne to Amsterdam, 5 m. N.E. of Cleves. Pop. (1905) 12,578. It has a considerable shipping trade, and manufactories of tobacco and cigars, chocolate, margarine, oil, chemicals, brushes, vinegar, soap, guano and perfumery. There are also iron foundries and machine factories. The old minster church, built in the middle of the 11th century, contains some fine choir stalls.

Emmerich, formerly called Embrika and Emrik, originally a Roman colony, is mentioned in records so early as the 7th century. St Willibrord founded a monastery and church here. In 1233 the place came into the possession of the dukes of Gelderland and received the status of a town in 1247. In 1371 it fell to the duchy of Cleves, and passed with it in 1609 to Brandenburg. The town joined the Hanseatic League in 1407. In 1794 it was bombarded by the French under General Vandamme, and in 1806 it was assigned to the grand-duchy of Berg. It passed into the possession of Prussia in 1815.

See A. Dederich, *Annalen der Stadt Emmerich* (Emmerich, 1867).

EMMET, ROBERT (1778-1803), Irish rebel, youngest son of Robert Emmet, physician to the lord-lieutenant of Ireland, was born in Dublin in 1778, and entered Trinity College in October 1793, where he had a distinguished academic career, showing special aptitude for mathematics and chemistry, and acquiring a reputation as an orator. Without taking a degree he removed his name from the college books in April 1798, as a protest against the inquisitorial examination of the political views of the students conducted by Lord Clare as chancellor of the university. Thus cut off from entering a learned profession, he turned towards political intrigue, being already to some extent in the secrets of the United Irishmen, of whom his elder brother Thomas Addis Emmet (see below) was one of the most prominent. In April 1799 a warrant was issued for his arrest, but was not executed; and in 1800 and the following year he travelled on the continent of Europe, where he entered into relations with the leaders of the United Irishmen, exiled since the rebellion of 1798, who were planning a fresh outbreak in Ireland in expectation of support from France. Emmet went to Paris in October 1802, where he had an interview with Bonaparte which convinced him that the peace of Amiens would be of short duration and that a French invasion of England might be looked for in August 1803. The councils of the conspirators were weakened by divided opinions as to the ultimate aim of their policy; and no clearly thought-out scheme of operations appears to have been arrived at when Emmet left Paris for Ireland in October 1802. Those in his confidence afterwards denied that Emmet was himself the originator of the plan on which he acted; and several of the ablest of the United Irishmen held aloof, believing the project to be impracticable. Among the latter was Lord Cloncurry, at one time on the executive of the United Irishmen, with whom Emmet dined the night before he left Paris, and to whom he spoke of his plans with intense enthusiasm and excitement. Emmet’s lack of discretion was shown by his revealing his intentions in detail to an Englishman named Lawrence, resident near Honfleur, with whom he sought shelter when travelling on foot on his way to Ireland. Arriving in Dublin at the end of October he received information to the effect that seventeen counties were ready to take up arms if a successful effort were made in Dublin. For some time he remained concealed in his father’s house near Miltown, making his preparations. A large number of pikes were collected and stored in Dublin during the spring of 1803, but fire-arms and ammunition were not plentiful.

The probability of a French invasion in August was increased by the renewal of the war in May, Emmet’s brother Thomas being then in Paris in communication with Talleyrand and Bonaparte. But a discovery by the government of concealed arms, and an explosion at one of Emmet’s depôts in Patrick 343
Street on the 16th of July, necessitated immediate action, and the 23rd of that month was accordingly fixed for the projected rising. An elaborate plan of operations, which he described in detail in a letter to his brother after his arrest, had been prepared by Emmet, the leading feature of which was a simultaneous attack on the castle, the Pigeon House and the artillery barracks at Island bridge; while bodies of insurgents from the neighbouring counties were to march on the capital. But the whole scheme miscarried. Some of Emmet’s bolder proposals, such as a plan for capturing the commander-in-chief, were vetoed by the timidity of his associates, none of whom were men of any ability. On the 23rd of July all was confusion at the depôts, and the leaders were divided as to the course to be pursued; orders were not obeyed; a trusted messenger despatched for arms absconded with the money committed to him to pay for them; treachery, quite unsuspected by Emmet, honeycombed the conspiracy; the Wicklow contingent failed to appear; the Kildare men turned back on hearing that the rising had been postponed; a signal expected by a contingent at the Broadstone was never given. In this hopeless state of affairs a false report reached Emmet at one of his depôts at nine o’clock in the evening that the military were approaching. Without taking any step to verify it, Emmet put on a green and white uniform and placed himself at the head of some eighty men, who marched towards the castle, being joined in the streets by a second body of about equal strength. None of these insurgents had any discipline, and many of them were drunk. Lord Kilwarden, proceeding to a hastily summoned meeting of the privy council, was dragged from his carriage by this rabble and murdered, together with his nephew Richard Wolfe; his daughter who accompanied him being conveyed to safety by Emmet himself. Emmet, now seeing that the rising had become a mere street brawl, made his escape; a detachment of soldiers quickly dispersed his followers.

After hiding for some days in the Wicklow mountains Emmet repaired to the house of a Mrs Palmer at Harold’s Cross, in order to be near the residence of John Philpot Curran (*q.v.*), to whose daughter Sarah he had for some time been secretly attached, and with whom he had carried on a voluminous correspondence, afterwards seized by the authorities at her father’s house. Attempting without success to persuade this lady to fly with him to America, Emmet lingered in the neighbourhood till the 25th of August, when he was apprehended by Major H.C. Sirr, the same officer who had captured Lord Edward Fitzgerald in 1798. At his trial he was defended and betrayed by the infamous Leonard MacNally (*q.v.*), and was convicted of treason; and after delivering an eloquent speech from the dock, was hanged on the 20th of September 1803.

By the universal testimony of his friends, Robert Emmet was a youth of modest character, pure motives and winning personality. But he was entirely lacking in practical statesmanship. Brought up in a revolutionary atmosphere, his enthusiasm was uncontrolled by judgment. Thomas Moore, who warmly eulogizes Emmet, with whom he was a student at Trinity College, records that one day when he was playing on the piano the melody “Let Erin remember,” Emmet started up exclaiming passionately, “Oh, that I were at the head of 20,000 men marching to that air!” He had no knowledge of the world or of men; he trusted every one with child-like simplicity; except personal courage he had none of the qualities essential to leadership in such an enterprise as armed rebellion. The romance of his love affair with Sarah Curran—who afterwards married Robert Henry Sturgeon, an officer distinguished in the Peninsular War—has cast a glamour over the memory of Robert Emmet; and it inspired Thomas Moore’s well-known songs, “She is far from the land where her young hero sleeps,” and “Oh, breathe not his name”; it is also the subject of Washington Irving’s “The Broken Heart.” Emmet was short and slight in figure; his face was marked by smallpox, and he was described in 1803 for the purpose of identification as being “of an ugly, sour countenance and dirty brown complexion.” A few poems by Emmet of little merit are appended to Madden’s biography.

See R.R. Madden, *The United Irishmen, their Lives and Times* (2nd ed. 4 vols., Dublin, 1858-1860); Charles Phillips, *Recollections of Curran and Some of his Contemporaries* (2nd ed., London, 1822);

Henry Grattan, *Memoirs of the Life and Times of the Right Hon. H. Grattan* (5 vols., London, 1839-1846); W.H. Maxwell, *History of the Irish Rebellion in 1798; with Memoirs of the Union and Emmet's Insurrection in 1803* (London, 1845); W.H. Curran, *Life of J.P. Curran* (2 vols., Edinburgh, 1822); Thomas Moore, *Life and Death of Lord Edward Fitzgerald* (2 vols. 3rd ed., London, 1832); and *Memoirs, Journals and Correspondence of Thomas Moore*, edited by Lord John Russell (8 vols., London, 1853-1856).

(R. J. M.)

EMMET, THOMAS ADDIS (1764-1827), Irish lawyer and politician, second son of Robert Emmet, physician to the lord-lieutenant of Ireland, and elder brother of Robert Emmet (*q.v.*), the rebel, was born at Cork on the 24th of April 1764, and was educated at Trinity College, Dublin, and at Edinburgh University, where he studied medicine and was a pupil of Dugald Stewart in philosophy. After visiting the chief medical schools on the continent, he returned to Ireland in 1788; but the sudden death of his elder brother, Christopher Temple Emmet (1761-1788), a barrister of some distinction, induced him to follow the advice of Sir James Mackintosh to forsake medicine for the law as a profession. He was called to the Irish bar in 1790, and quickly obtained a practice, principally as counsel for prisoners charged with political offences, and became the legal adviser of the leading United Irishmen. When the Dublin corporation issued a declaration of Protestant ascendancy in 1792, the counter-manifesto of the United Irishmen was drawn up by Emmet; and in 1795 he took the oath of the society in open court, becoming secretary in the same year and a member of the executive in 1797. Although Grattan had a profound contempt for Emmet's political understanding, describing him as a quack in politics who set up his own crude notions as settled rules, Emmet was among the more prudent of the United Irishmen on the eve of the rebellion. It was only when convinced that parliamentary reform and Catholic emancipation were not to be obtained by constitutional methods, that he reluctantly engaged in treasonable conspiracy; and in opposition to bolder spirits like Lord Edward Fitzgerald, he discountenanced the taking up of arms until help should be obtained from France. Though not among those taken at the house of Oliver Bond on the 12th of March 1798 (see Fitzgerald, Lord Edward), he was arrested about the same time, and he was one of the leaders who after the rebellion were imprisoned at Fort George till 1802. Being then released, he went to Brussels, where he was visited by his brother Robert in October of that year; and he was in the secrets of those who were preparing for a fresh rising in Ireland in conjunction with French aid. After the failure of Robert Emmet's rising in July 1803, the news of which reached him in Paris, where he was in communication with Bonaparte, he emigrated to the United States. Joining the New York bar he obtained a lucrative practice and in 1812-13 was attorney-general of New York; his abilities and success being such that Judge Story declared him to be "by universal consent in the first rank of American advocates." He died while conducting a case in court on the 14th of November 1827. Thomas Emmet married, in 1791, Jane, daughter of the Rev. John Patten, of Clonmel.

See authorities under Emmet, Robert; also Alfred Webb, *Compendium of Irish Biography* (Dublin, 1878); C.S. Haynes, *Memoirs of Thomas Addis Emmet* (London, 1829); Theobald Wolfe Tone, *Memoirs*, edited by W.T.W. Tone (2 vols., London, 1827); W.E.H. Lecky, *Hist. of Ireland in the Eighteenth Century*, vol. iv. (Cabinet edition, 5 vols., London, 1892).

(R. J. M.)

EMMETT, DANIEL DECATUR (1815-1904), American songwriter, was born at Mount Vernon, Ohio. He started the "negro minstrel" performances, which from 1842 onwards became so popular in America and England, and he composed a number of songs which had a great temporary vogue. He is remembered particularly as the writer of the famous Southern war-song "Dixie," which he composed in 1859.

EMMITSBURG, a town in Frederick county, Maryland, U.S.A., 61 m. by rail W. by N. of Baltimore, and 1½ m. S. of the northern boundary of the state. Pop. (1900) 849; (1910) 1054. It is served by the
Emmitsburg railway (7 m. long) to Rocky Ridge on the Western Maryland railway. The town is in a 344
picturesque region on the eastern slope of the Blue Ridge Mountains. Two miles S.W. is Mount St. Mary's College (Roman Catholic), founded in 1808 by the Rev. John du Bois (1764-1842)—its president until 1826, when he became bishop of New York—and chartered by the state in 1830. The Ecclesiastical Seminary of the college has been a great training school, and has been called the

“Nursery of Bishops”; among its graduates have been Bishop Hughes, Cardinal McCloskey and Archbishop Corrigan. In 1908 the college had 25 instructors and 350 students, of whom 57 were in the Ecclesiastical Seminary, and 61 in the Minim Department. Half a mile S. of the town is St Joseph’s College and Academy (incorporated in 1816), for young women, which is conducted by the Sisters of Charity—this order was introduced into the United States at Emmitsburg by Mrs Elizabeth Ann Seton in 1809. The first settlement at Emmitsburg was made about 1773. It was at first called “Silver Fancy,” and then for a time was known as “Poplar Fields”; but in 1786 the present name was adopted in honour of William Emmitt, one of the original settlers. The town was incorporated in 1824.

EMMIUS, UBBO (1547-1625), Dutch historian and geographer, was born at Gretha in East Friesland on the 5th of December 1547. After studying at Rostock, he spent two years in Geneva, where he became intimate with Theodore Beza; and returning to the Netherlands was appointed the principal of a college at Norden, a position which he lost in 1587 because, as a Calvinist, he would not subscribe to the confession of Augsburg. Subsequently he was head of a college at Leer, and in 1594 became rector of the college at Groningen, and when in 1614 this college became a university he was chosen principal and professor of history and Greek, and by his wise guidance and his learning speedily raised the new university to a position of eminence. He was on friendly terms with Louis, count of Nassau; corresponded with many of the learned men of his time; and died at Groningen on the 9th of December 1625. He was twice married, and left a son and a daughter. The chief works of Emmius are: *Rerum Frisicarum historiae decades*, in six parts, a complete edition of which was published at Leiden in 1616; *Opus chronologicum* (Groningen, 1619); *Vetus Graecia illustrata* (Leiden, 1626); and *Historia temporis nostri*, which was first published at Groningen in 1732. An account of his life, written by Nicholas Mulerius, was published, with the lives of other professors of Groningen, at Groningen in 1638.

See N.G. van Kampen, *Geschiedenis der letteren en wetenschappen in de Nederlanden* (The Hague, 1821-1826).

EMMONS, EBENEZER (1800-1863), American geologist, was born at Middlefield, Massachusetts, on the 16th of May 1800. He studied medicine at Albany, and after taking his degree practised for some years in Berkshire county. His interest in geology was kindled in early life, and in 1824 he had assisted Prof. Chester Dewey (1784-1867) in preparing a geological map of Berkshire county, in which the first attempt was made to classify the rocks of the Taconic area. While thus giving much of his time to natural science, undertaking professional work in natural history and geology in Williams College, he also accepted the professorship of chemistry and afterwards of obstetrics in the Albany Medical College. The chief work of his life was, however, in geology, and he has been designated by Jules Marcou as “the founder of American palaeozoic stratigraphy, and the first discoverer of the primordial fauna in any country.” In 1836 he became attached to the Geological Survey of the State of New York, and after lengthened study he grouped the local strata (1842) into the Taconic and overlying New York systems. The latter system was subdivided into several groups that were by no means well defined. Emmons had previously described the Potsdam sandstone (1838), and this was placed at the base of the New York system. It is now regarded as Upper Cambrian. In 1844 Emmons for the first time obtained fossils in his Taconic system: a notable discovery because the species obtained were found to differ from all then-known Palaeozoic fossils, and they were regarded as representing the primordial group. Marcou was thus led to advocate that the term Taconic be generally adopted in place of Cambrian. Nevertheless the Taconic fauna of Emmons has proved to include only the lower part of Sedgwick’s Cambrian. Considerable discussion has taken place on the question of the Taconic system, and whether the term should be adopted; and the general opinion has been adverse. Emmons made contributions on agriculture and geology to a series of volumes on the natural history of New York. He also issued a work entitled *American Geology; containing a statement of the principles of the Science, with full illustrations of the characteristic American Fossils* (1855-1857). From 1851 to 1860 he was state geologist of North Carolina. He died at Brunswick, North Carolina, on the 1st of October 1863.

See the *Biographical Notice of Ebenezer Emmons*, by J. Marcou; *Amer. Geologist*, vol. vii. (Jan., 1891), p. 1 (with portrait and list of publications).

EMMONS, NATHANAEL (1745-1840), American theologian, was born at East Haddam, Connecticut, on the 20th of April 1745. He graduated at Yale in 1767, studied theology under the Rev. John Smalley (1734-1820) at Berlin, Connecticut, and was licensed to preach in 1769. After preaching four years in New York and New Hampshire, he became, in April 1773, pastor of the Second church at Franklin (until 1778 a part of Wrentham, Massachusetts), of which he remained in charge until May 1827, when failing health compelled his relinquishment of active ministerial cares. He lived, however, for many years thereafter, dying of old age at Franklin on the 23rd of September 1840. It was as a theologian that Dr Emmons was best known, and for half a century probably no clergyman in New England exerted so wide an influence. He developed an original system of divinity, somewhat on the structural plan of that of Samuel Hopkins, and, in Emmons's own belief, contained in and evolved from Hopkinsianism. While by no means abandoning the tenets of the old Calvinistic faith, he came to be looked upon as the chief representative of what was then known as the "new school" of theologians. His system declared that holiness and sin are free voluntary exercises; that men act freely under the divine agency; that the slightest transgression deserves eternal punishment; that it is through God's mere grace that the penitent believer is pardoned and justified; that, in spite of total depravity, sinners ought to repent; and that regeneration is active, not passive, with the believer. Emmonsism was spread and perpetuated by more than a hundred clergymen, whom he personally trained. Politically, he was an ardent patriot during the War of Independence, and a strong Federalist afterwards, several of his political discourses attracting wide attention. He was a founder and the first president of the Massachusetts Missionary Society, and was influential in the establishment of Andover Theological Seminary. More than two hundred of his sermons and addresses were published during his lifetime. His *Works* were published in 6 vols. (Boston, 1842; new edition, 1861).

See also the *Memoir*, by Dr E.A. Park (Andover, 1861).

EMPEDOCLES (*c.* 490-430 B.C.), Greek philosopher and statesman, was Born at Agrigentum (Acragas, Girgenti) in Sicily of a distinguished family, then at the height of its glory. His grandfather Empedocles was victorious in the Olympian chariot race in 496; in 470 his father Meto was largely instrumental in the overthrow of the tyrant Thrasydaeus. We know almost nothing of his life. The numerous legends which have grown up round his name yield very little that can fairly be regarded as authentic. It seems that he carried on the democratic tradition of his house by helping to overthrow an oligarchic government which succeeded the tyranny in Agrigentum, and was invited by the citizens to become their king. That he refused the honour may have been due to a real enthusiasm for free institutions or to the prudential recognition of the peril which in those turbulent times surrounded the royal dignity. Ultimately a change in the balance of parties compelled him to leave the city, and he died in the Peloponnese of the results of an accident in 430.

Of his poem on nature (φύσις) there are left about 400 lines in unequal fragments out of the original 5000; of the hymns of purification (καθαρμοί) less than 100 verses remain; of the other works, 345
improbably assigned to him, nothing is known. His grand but obscure hexameters, after the example of Parmenides, delighted Lucretius. Aristotle, it is said, called him the father of rhetoric. But it was as at once statesman, prophet, physicist, physician and reformer that he most impressed the popular imagination. To his contemporaries, as to himself, he seemed more than a mere man. The Sicilians honoured his august aspect as he moved amongst them with purple robes and golden girdle, with long hair bound by a Delphic garland, and brazen sandals on his feet, and with a retinue of slaves behind him. Stories were told of the ingenuity and generosity by which he had made the marshes round Selinus salubrious, of the grotesque device by which he laid the winds that ruined the harvests of Agrigentum, and of the almost miraculous restoration to life of a woman who had long lain in a death-like trance. Legends stranger still told of his disappearance from among men. Empedocles, according to one story, was one midnight, after a feast held in his honour, called away in a blaze of glory to the gods; according to another, he had only thrown himself into the crater of Etna, in the hope that men, finding no traces of his end, would suppose him translated to heaven. But his hopes were cheated by the volcano, which cast forth his brazen sandals and betrayed his secret (Diog. Laërt. viii. 67). The people of Agrigentum have never ceased to honour his name, and even in modern times he has been celebrated by followers of Mazzini as the democrat of antiquity *par excellence*.

As his history is uncertain, so his doctrines are hard to put together. He does not belong to any one definite school. While, on one hand, he combines much that had been suggested by Parmenides, Pythagoras and the Ionic schools, he has germs of truth that Plato and Aristotle afterwards developed; he is at once a firm believer in Orphic mysteries, and a scientific thinker, precursor of the physical scientists. There are, according to Empedocles, four ultimate elements, four primal divinities, of which are made all structures in the world—fire, air, water, earth. These four elements are eternally brought into union, and eternally parted from each other, by two divine beings or powers, love and hatred—an attractive and a repulsive force which the ordinary eye can see working amongst men, but which really pervade the whole world. According to the different proportions in which these four indestructible and unchangeable matters are combined with each other is the difference of the organic structure produced; *e.g.* flesh and blood are made of equal (in weight but not in volume) parts of all four elements, whereas bones are one-half fire, one-fourth earth, and one-fourth water. It is in the aggregation and segregation of elements thus arising that Empedocles, like the atomists, finds the real process which corresponds to what is popularly termed growth, increase or decrease. Nothing new comes or can come into being; the only change that can occur is a change in the juxtaposition of element with element.

Empedocles apparently regarded love (φιλότης) and discord (νεῖκος) as alternately holding the empire over things,—neither, however, being ever quite absent. As the best and original state, he seems to have conceived a period when love was predominant, and all the elements formed one great sphere or globe. Since that period discord had gained more sway; and the actual world was full of contrasts and oppositions, due to the combined action of both principles. His theory attempted to explain the separation of elements, the formation of earth and sea, of sun and moon, of atmosphere. But the most interesting and most matured part of his views dealt with the first origin of plants and animals, and with the physiology of man. As the elements (his deities) entered into combinations, there appeared quaint results—heads without necks, arms without shoulders. Then as these fragmentary structures met, there were seen horned heads on human bodies, bodies of oxen with men’s heads, and figures of double sex. But most of these products of natural forces disappeared as suddenly as they arose; only in those rare cases where the several parts were found adapted to each other, and casual member fitted into casual member, did the complex structures thus formed last. Thus from spontaneous aggregations of casual aggregates, which suited each other as if this had been intended, did the organic universe originally spring. Soon various influences reduced the creatures of double sex to a male and a female, and the world was replenished with organic life. It is impossible not to see in this theory a crude anticipation of the “survival of the fittest” theory of modern evolutionists.

As man, animal and plant are composed of the same elements in different proportions, there is an identity of nature in them all. They all have sense and understanding; in man, however, and especially in the blood at his heart, mind has its peculiar seat. But mind is always dependent upon the body, and varies with its changing constitution. Hence the precepts of morality are with Empedocles largely dietetic.

Knowledge is explained by the principle that the several elements in the things outside us are perceived by the corresponding elements in ourselves. We know only in so far as we have within us a nature cognate to the object of knowledge. Like is known by like. The whole body is full of pores, and hence respiration takes place over the whole frame. But in the organs of sense these pores are specially adapted to receive the effluxes which are continually rising from bodies around us; and in this way perception is somewhat obscurely explained. The theory, however unsatisfactory as an explanation, has one great merit, that it recognizes between the eye, for instance, and the object seen an intermediate something. Certain particles go forth from the eye to meet similar particles given forth from the object, and the resultant contact constitutes vision. This idea contains within it the germ of the modern idea of the subjectivity of sense-given data; perception is not merely a passive reflection of external objects.

It is not easy to harmonize these quasi-scientific theories with the theory of transmigration of souls which Empedocles seems to expound. Probably the doctrine that the divinity (δαίμων) passes from element to element, nowhere finding a home, is a mystical way of teaching the continued identity of the principles which are at the bottom of every phase of development from inorganic nature to man. At the top of the scale are the prophet and the physician, those who have best learned the secret of life; they are next to the divine. One law, an identity of elements, pervades all nature; existence is one from end to end; the plant and the animal are links in a chain where man is a link too; and even the distinction between male and female is transcended. The beasts are kindred with man; he who eats their flesh is not much better than a cannibal.

Looking at the opposition between these and the ordinary opinions, we are not surprised that Empedocles notes the limitation and narrowness of human perceptions. We see, he says, but a part, and fancy that we have grasped the whole. But the senses cannot lead to truth; thought and reflection must look at the thing on every side. It is the business of a philosopher, while he lays bare the fundamental difference of elements, to display the identity that subsists between what seem unconnected parts of the universe.

See Diog. Laërt. viii. 51-77; Sext. Empiric. *Adv. math.* vii. 123; Simplicius, *Phys.* f. 24, f. 76. For text Simon Karsten, “Empedoclis Agrigenti carminum reliquiae,” in *Reliq. phil. vet.* (Amsterdam, 1838); F.W.A. Mullach, *Fragmenta philosophorum Graecorum*, vol. i.; H. Stein, *Empedoclis Agrigenti fragmenta* (Bonn, 1882); H. Ritter and L. Preller, *Historia philosophiae* (4th ed., Gotha, 1869), chap. iii. ad fin.; A. Fairbanks, *The First Philosophers of Greece* (1898). Verse translation, W.E. Leonard (1908). For criticism E. Zeller, *Phil. der Griechen* (Eng. trans. S.F. Alleyne, 2 vols., London, 1881); A.W. Benn, *Greek Philosophers* (1882); J.A. Symonds, *Studies of the Greek Poets* (3rd ed., 1893), vol. i. chap. 7; C.B. Renouvier, *Manuel de philosophie ancienne* (Paris, 1844); T. Gomperz, *Greek Thinkers*, vol. i. (Eng. trans. L. Magnus, 1901); W. Windelband, *Hist. of Phil.* (Eng. trans. 1895); many articles in periodicals (see Baldwin’s *Dict. of Philos.* vol. iii. p. 190).

(W. W.; X.)

EMPEROR (Fr. *empereur*, from the Lat. *imperator*), a title formerly borne by the sovereigns of the Roman empire (see Empire), and since their time, partly by derivation, partly by imitation, used by a variety of other sovereigns. Under the Republic, the term *imperator* applied in theory to any magistrate vested with *imperium*; but in practice it was only used of a magistrate who was acting abroad (*militiae*) and was thus in command of troops. The term *imperator* was the natural and regular designation employed by his troops in addressing such a magistrate; but it was more particularly and specially employed by them to salute him after a victory; and when he had been thus saluted he could use the title of imperator in public till the day of his triumph at Rome, after which it would lapse along with his *imperium*. The senate itself might, in the later Republic, invite a victorious general to assume the title; and in these two customs—the salutation of the troops, and the invitation of the senate—we see in the germ the two methods by which under the Empire the *princeps* was designated; while in the military connotation attaching to the name even under the Republic we can detect in advance the military character by which the emperor and the Empire were afterwards distinguished. Julius Caesar was the first who used the title continuously (from 58 B.C. to his death in 44 B.C.), as well *domi* as *militiae*; and his nephew Augustus took a further step when he made the term imperator a *praenomen*, a practice which after the time of Nero becomes regular. But apart from this amalgamation of the term with his regular name, and the private right to its use which that bestowed, every emperor had an additional and double right to the title on public grounds, possessed as he was of an *imperium infinitum majus*, and commanding as he did all the troops of the Empire. From the latter point of view—as *generalissimo* of the forces of Rome, he had the right to the insignia of the commander (the laurel wreath and the fasces), and to the protection of a bodyguard, the *praetoriani*. This public title of imperator was normally conferred by the senate; and an emperor normally dates his reign from the day of his salutation by the senate. But the troops were also regarded as still retaining the right of saluting an *imperator*; and there were emperors who regarded themselves as created by such salutation and dated their reigns accordingly. The military associations of the term thus resulted, only too often, in making the emperor the nominee of a turbulent soldiery.

Augustus had been designated (not indeed officially, but none the less regularly) as *princeps*—the first citizen or foremost man of the state. The designation suited the early years of the Empire, in which a dyarchy of *princeps* and senate had been maintained. But by the 2nd century the dyarchy is passing into a monarchy: the title of princeps recedes, and the title of imperator comes into prominence to designate not merely the possessor of a certain *imperium*, or the general of troops, but the simple monarch in the fulness of his power as head of the state. From the days of Diocletian one finds occasionally two emperors, but not, at any rate in theory, two Empires; the two emperors are the dual sovereigns of a single realm. But from the time of Arcadius and Honorius (A.D. 395) there are in reality (though not in theory) two Empires as well as two emperors, one of the East and one of the West. When Greek became the sole language of the East Roman Empire, *imperator* was rendered sometimes by βασιλεύς and sometimes by αὐτοκράτωρ, the former word being the usual designation of a sovereign, the latter specially denoting that despotic power which the *imperator* held, and being in fact the official translation of *imperator*. Justinian uses αὐτοκράτωρ as his formal title, and βασιλεύς as the popular term.

On the revival of the Roman empire in the West by Charlemagne in 800, the title (at first in the form *imperator*, or *imperator Augustus*, afterwards *Romanorum imperator Augustus*) was taken by him and by his Frankish, Italian and German successors, heads of the Holy Roman Empire, down to the abdication of the emperor Francis II. in 1806. The doctrine had, however, grown up in the earlier middle ages (about the time of the emperor Henry II., 1002-1024) that although the emperor was chosen in Germany (at first by the nation, afterwards by a small body of electors), and entitled from the moment of his election to be crowned in Rome by the pope, he could not use the title of emperor until that coronation had actually taken place. The German sovereign, therefore, though he exercised, as soon as chosen, full imperial powers both in Germany and Italy, called himself merely “king of the Romans” (*Romanorum rex semper Augustus*) until he had received the sacred crown in the sacred city. In 1508 Maximilian I., being refused a passage to Rome by the Venetians, obtained from Pope Julius II. a bull permitting him to style himself emperor elect (*imperator electus*, erwählter Kaiser). This title was taken by Ferdinand I. (1558) and all succeeding emperors, immediately upon their coronation in Germany; and it was until 1806 their strict legal designation, and was always employed by them in proclamations and other official documents. The term “elect” was, however, omitted even in formal documents when the sovereign was addressed or was spoken of in the third person.

In medieval times the emperor, conceived as vicegerent of God and co-regent with the pope in government of the Christian people committed to his charge, might almost be regarded as an ecclesiastical officer. Not only was his function regarded as consisting in the defence and extension of true religion; he was himself arrayed in ecclesiastical vestments at his coronation; he was ordained a subdeacon; and assisting the pope in the celebration of the Eucharist, he communicated in both kinds as a clerk. The same sort of ecclesiastical character came also to be attached to the tsars[1] of Russia, who—especially in their relations with the Orthodox Eastern Church—may vindicate for themselves (though the sultans of Turkey have disputed the claim) the succession to the East Roman emperors (see Empire). But the title of emperor was also used in the middle ages, and is still used, in a loose and vague sense, without any ecclesiastical connotation or hint of connexion with Rome (the two attributes which should properly distinguish an emperor), and merely in order to designate a non-European ruler with a large extent of territory. It was thus applied, and is still applied, to the rulers of China and Japan; it was attributed to the Mogul sovereigns of India; and since 1876 it has been used by British monarchs in their capacity of sovereigns of India (*Kaiser-i-Hind*).[2]

Since the French Revolution and during the course of the 19th century the term emperor has had an eventful history. In 1804 Napoleon took the title of "Emperor of the French," and posed as the reviver of the Empire of Charlemagne. Afraid that Napoleon would next proceed to deprive him of his title of Holy Roman Emperor, Francis II. first took the step, in 1804, of investing himself with a new title, that of "Hereditary Emperor of Austria," and then, in 1806, proceeded to the further step of abdicating his old historical title and dissolving the Holy Roman Empire. Thus the old and true sense of the term emperor—the sense in which it was connected with the church in the present and with Rome in the past—finally perished; and the term became partly an apanage of Bonapartism (Louis Napoleon resuscitated it as Napoleon III. in 1853), and partly a personal title of the Habsburgs as rulers of their various family territories. In 1870, however, a new and most important use of the title was begun, when the union of Germany was achieved, and the Prussian king, who became the head of united Germany, received in that capacity the title of German Emperor. Here the title of emperor designates the president of a federal state; and here the Holy Roman emperor of the 17th and 18th centuries, the president of a loose confederation of German states, may be said to have found his successor. But the term has been widely and loosely used in the course of the 19th century. It was the style from 1821 to 1889 of the princes of the house of Braganza who ruled in Brazil; it has been assumed by usurpers in Haiti, and in Mexico it was borne by Augustin Iturbide in 1822 and 1823, and by the ill-fated Archduke Maximilian of Austria from 1864 to 1867. It can hardly, therefore, be said to have any definite descriptive force at the present time, such as it had in the middle ages. So far as it has any such force in Europe, it may be said partly to be connected with Bonapartism, and to denote a popular but military dictatorship, partly to be connected with the federal idea, and to denote a precedence over other kings possessed by a ruler standing at the head of a composite state which may embrace kings among its members. It is in this latter sense that it is used of Germany, and of Britain in respect of India; it is in something approaching this latter sense that it may be said to be used of Austria. 347

See J. Selden, *Titles of Honour* (1672); J. Bryce, *Holy Roman Empire* (London, 1904); and Sir E. Colebrooke, "On Imperial and Other Titles" in the *Journal of the Royal Asiatic Society* (1877). See also the articles on "Imperator" and "Princeps" in Smith's *Dictionary of Greek and Roman Antiquities* (1890).

(E. Br.)

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1 The word *Tsar*, like the German *Kaiser*, is derived from Caesar (see Tsar). Peter the Great introduced the use of the style "Imperator," and the official designation is now "Emperor of all the Russias, Tsar of Poland, and Grand Duke of Finland," though the term tsar is still popularly used in Russia.

2 For the titles of βασιλεύς, *imperator Augustus*, &c., applied in the 10th century to the Anglo-Saxon kings, see Empire (note). The claim to the style of emperor, as a badge of equal rank, played a considerable part in the diplomatic relations between the Sultan and certain European sovereigns. Thus, at a time when this style (*Padishah*) was refused by the Sultan to the tsars of Russia, and even to the Holy Roman Emperor himself, it was allowed to the French kings, who in diplomatic correspondence and treaties with Turkey called themselves "emperor of France" (*empereur de France*).—[Ed.].

EMPHYSEMA (Gr. ἐμφυσᾶν to inflate) is a word vaguely meaning the abnormal presence of air in certain parts of the body. At the present day, however, there are two conditions to which it refers, "pulmonary emphysema" (and the word pulmonary is often omitted) and "surgical emphysema." Of pulmonary emphysema there are two forms, true vesicular and interstitial (or interlobular). Vesicular emphysema signifies that there is an enlargement of air-vesicles, resulting either from their excessive distension, from destruction of the septa, or from both causes combined (see Respiratory System). In interstitial emphysema the air is infiltrated into the connective tissue beneath the pleura and between the pulmonary air-cells.

The former variety is by far the more common, and appears to be capable of being produced by various causes, the chief of which are the following:—

1. Where a portion of the lung has become wasted, or its vesicular structure permanently obliterated by disease, without corresponding falling in of the chest wall, the neighbouring air-vesicles or some of them undergo dilatation to fill the vacuum (vicarious emphysema).

2. In some cases of bronchitis, where numbers of the smaller bronchial tubes become obstructed, the air in the pulmonary vesicles remains imprisoned, the force of expiration being insufficient to expel it; while, on the other hand, the stronger force of inspiration being adequate to overcome the resistance, the air-cells tend to become more and more distended, and permanent alterations in their structure, including emphysema, are the result (inspiratory theory).

3. Emphysema also arises from exertion involving violent expiratory efforts, during which the glottis is constricted, as in paroxysms of coughing, in straining, and in lifting heavy weights (expiratory theory). Whooping-cough is well known as the exciting cause of emphysema in many persons.

4. Another view, known as the nutritive theory, maintains that emphysema depends essentially on a

primary nutritive change in the walls of the air-vesicles. Thus these are impaired in their resisting power, and are far more likely to become distended by any force acting on them from within.

5. Again in certain cases the cartilages of the chest become hypertrophied and rigid, thus causing a primary chronic enlargement, and the lungs become emphysematous in order to fill up the increased space (Freund’s theory).

In whatever manner produced, this disease gives rise to important morbid changes in the affected portions of the lungs, especially the loss of the natural elasticity of the air-cells, and likewise the destruction of many of the pulmonary capillary blood-vessels, and the diminution of aerating surface for the blood. As a consequence an increased strain is thrown on the right ventricle with a consequent dilatation leading on to heart failure and all its attendant troubles. The chief symptom in this complaint is shortness of breath, more or less constant but greatly aggravated by exertion, and by attacks of bronchitis, to which persons suffering from emphysema appear to be specially liable. The respiration is of similar character to that already described in the case of asthma. In severe forms of the disease the patient comes to acquire a peculiar puffy or bloated appearance, and the configuration of the chest is altered, assuming the character known as the *barrel-shaped* or *emphysematous* chest.

The main element in the treatment of emphysema consists in attention to the general condition of the health, and in the avoidance of all causes likely to aggravate the disease or induce its complications. Compressed air baths and expiration into rarefied air may be useful. During attacks of urgent dyspnoea and lividity, with engorgement of veins, the patient should be repeatedly bled until relief is obtained. Interstitial emphysema arising from the rupture of air-cells in the immediate neighbourhood of the pleura may occur as a complication of the vesicular form, or separately as the result of some sudden expulsive effort, such as a fit of coughing, or, as has frequently happened, in parturition. Gangrene or post-mortem decomposition may lead to the presence of air in the interstitial tissue of the lung. Occasionally the air infiltrates the cellular tissue of the posterior mediastinum, and thence comes to distend the integument of the whole surface of the body (surgical emphysema). Surgical emphysema signifies the effusion of air into the general connective tissues of the body. The commonest causes are a wound of some air-passage, or a penetrating wound of the chest wall without injury to the lung. It may, however, occur in any situation of the body and in many other ways. Its severity varies from very slight cases where only a little crepitation may be felt under the skin, to extreme cases where the whole body is blown up and death is imminent from impeded respiration and failure of the action of the heart. In the milder cases no treatment is necessary as the air gradually becomes absorbed, but in the more severe cases incisions must be made in the swollen cellular tissues to allow the air to escape.

EMPIRE, a term now used to denote a state of large size and also (as a rule) of composite character, often, but not necessarily, ruled by an emperor—a state which may be a federation, like the German empire, or a unitary state, like the Russian, or even, like the British empire, a loose commonwealth of free states united to a number of subordinate dependencies. For many centuries the writers of the Church, basing themselves on the Apocalyptic writings, conceived of a cycle of four empires, generally explained—though there was no absolute unanimity with regard to the members of the cycle—as the Assyrian, the Persian, the Macedonian and the Roman. But in reality the conception of Empire, like the term itself (Lat. *imperium*), is of Roman origin. The empire of Alexander had indeed in some ways anticipated the empire of Rome. “In his later years,” Professor Bury writes, “Alexander formed the notion of an empire, both European and Asiatic, in which the Asiatics should not be dominated by the European invaders, but Europeans and Asiatics alike should be ruled on an equality by a monarch, indifferent to the distinction of Greek and barbarian, and looked upon as their own king by Persians as well as by Macedonians.” The contemporary Cynic philosophy of cosmopolitanism harmonized with this notion, as Stoicism did later with the practice of the Roman empire; and Alexander, like Diocletian and Constantine, accustomed a Western people to the forms of an Oriental court, while, like the earlier Caesars, he claimed and received the recognition of his own divinity. But when he died in 323, his empire, which had barely lasted ten years, died with him; and it was divided among Diadochi who, if in some other respects (for instance, the Hellenization of the East) they were heirs of their master’s policy, were destitute of the imperial conception. The work of Alexander was rather that of the forerunner than the founder. He prepared the way for the world-empire of Rome; he made possible the rise of a universal religion. And these are the two factors which, throughout the middle ages, went together to make the thing which men called Empire.

The Roman empire.

At Rome the term *imperium* signified generally, in its earlier use, the sovereignty of the state over the individual, a sovereignty which the Romans had disengaged with singular clearness from all other kinds of authority. Each of the higher magistrates of the Roman people was vested, by a *lex curiata* (for power was distinctly conceived as resident in, and delegated by, the community), with an *imperium* both civil and military, which varied in degree with the magnitude of his office. In the later days of the Republic such imperium was enjoyed, partly in Rome by the resident consuls and praetors, partly in the provinces by the various proconsuls or propraetors. There was thus a certain *morcellement* of *imperium*, delegated as it was by 348 the people to a number of magistrates: the coming of the Empire meant the reintegration of this *imperium*, and its unification, by a gradual process, in the hands of the *princeps*, or emperor. The means by which this process was achieved had already been anticipated under the Republic. Already in the days of Pompey it had been found convenient to grant to an extraordinary officer an *imperium aequum* or *majus* over a large area, and that officer thus received powers, within that area, equal to, or greater than, the powers of the provincial governors. This precedent was followed by Augustus in the year 27 B.C., when he acquired for himself sole *imperium* in a certain number of provinces (the imperial provinces), and an *infinitum imperium majus* in the remaining provinces (which were termed senatorial). As a result, Augustus enjoyed an *imperium* coextensive indeed with the whole of the Roman world, but concurrent, in part of that world, with the *imperium* of the senatorial proconsuls; and the early Empire may thus be described as a dyarchy. But the distinction between imperial and senatorial provinces finally disappeared; by the time of Constantine the emperor enjoyed sole *imperium*, and an absolute monarchy had been established. We shall not, however, fully understand the significance of the Roman empire, unless we realize the importance of its military aspect. All the soldiers of Rome had from the first to swear *in verba Caesaris Augusti*; and thus the whole of the Roman army was his army, regiments of which he might indeed lend, but of which he was sole *Imperator* (see under Emperor). Thus regarded as a permanent commander-in-chief, the emperor enjoyed the privileges, and suffered from the weaknesses, of his position. He had the power of the sword behind him; but he became more and more liable to be deposed, and to be replaced by a new commander, at the will of those who bore the sword in his service.

Development under Diocletian and Constantine.

The period which is marked by the reigns of Diocletian and Constantine (A.D. 284-337) marks a great transformation in the character of the Empire. The old dyarchy, under which the emperor might still be regarded as an official of the respublica Romana, passed into a new monarchy, in which all political power became, as it were, the private property of the monarch. There was now no distinction of provinces; and the old public *aerarium* became merely a municipal treasury, while the *fiscus* of the emperor became the exchequer of the Empire. The officers of the imperial praetorium, or bodyguard, are now the great officers of state; his private council becomes the public consistory, or supreme court of appeal; and the *comites* of his court are the administrators of his empire. “All is in him, and all comes from him,” as our own year-books say of the medieval king; his household, for instance, is not only a household, but also an administration. On the other hand, this unification seems to be accompanied by a new bifurcation. The exigencies of frontier defence had long been drawing the Empire towards the troubled East; and this tendency reached its culmination when a new Rome arose by the Bosporus, and Constantinople became the centre of what seemed a second Empire in the East (A.D. 324). Particularly after the division of the Empire between Arcadius and Honorius in 395 does this bifurcation appear to be marked; and one naturally speaks of the two Empires of the West and the East. Yet it cannot be too much emphasized that in reality such language is utterly inexact. The Roman empire was, and always continued to be, ideally one and indivisible. There were two emperors, but one Empire—two persons, but one power. The point is of great importance for the understanding of the whole of the middle ages: there only is, and can be, one Empire, which may indeed, for convenience, be ruled conjointly by two emperors, resident, again for convenience, in two separate capitals. And, as a matter of fact, not only did the residence of an emperor in the East not spell bifurcation, it actually fostered the tendency towards unification. It helped forward the transformation of the Empire into an absolute and quasi-Asiatic monarchy, under which all its subjects fell into a single level of loyal submission: it helped to give the emperor a gorgeous court, marked by all the ceremony and the servility of the East.[1] The deification of the emperor himself dates from the days of Augustus; by the time of Constantine it has infected the court and the government. Each emperor, again, had from the first enjoyed the sacrosanct position which was attached to the tribunate; but now his palace, his chamber, his charities, his letters, are all “sacred,” and one might almost speak in advance of a “Holy Roman Empire.”

Division of the Empire.

Influence of Christianity.

But there is one factor, the greatest of all, which still remains to be added, before we have counted the sum of the forces that made the world think in terms of empire for centuries to come; and that is the reception of Christianity into the Roman empire by Constantine. That reception added a new sanction to the existence of the Empire and the position of the emperor. The Empire, already one and indivisible in its aspect of a political society, was welded still more firmly together when it was informed and permeated by a common Christianity, and unified by the force of a spiritual bond. The Empire was now the Church; it was now indeed indestructible, for, if it perished as an empire, it would live as a church. But the Church made it certain that it would not perish, even as an empire, for many centuries to come. On the one hand the Church thought in terms of empire and taught the millions of its disciples (including the barbarians themselves) to think in the same terms. No other political conception—no conception of a πόλις or of a nation—was any longer possible. When the Church gained its hold of the Roman world, the Empire, as it has been well said, was already “not only a government, but a fashion of conceiving the world”: it had stood for three centuries, and no man could think of any other form of political association. Moreover, the gospel of St Paul—that there is *one* Church, whereof Christ is the Head, and we are all members—could not but reinforce for the Christian the conception of a necessary political unity of all the world under a single head. *Una Chiesa in uno Stato*—such, then, was the theory of the Church. But not only did the Church perpetuate the conception of empire by making it a part of its own theory of the world: it perpetuated that conception equally by materializing it in its own organization of itself. Growing up under the shadow of the Empire, the Church too became an empire, as the Empire had become a church. As it took over something of the old pagan ceremonial, so it took over much of the old secular organization. The pope borrowed his title of *pontifex maximus* from the emperor: what is far more, he made himself gradually, and in the course of centuries, the Caesar and Imperator of the Church. The offices and the dioceses of the Church are parallel to the offices and dioceses of the Diocletian empire: the whole spirit of orderly hierarchy and regular organization, which breathes in the Roman Church, is the heritage of ancient Rome. The Donation of Constantine is a forgery; but it expresses a great truth when it represents Constantine as giving to the pope the imperial palace and insignia, and to the clergy the ornaments of the imperial army (see Donation of Constantine).

Barbarian invasions.

Upon this world, informed by these ideas, there finally descended, in the 5th century, the avalanche 349
of barbaric invasion. Its impact seemed to split the Empire into fragmentary kingdoms; yet it left the universal Church intact, and with it the conception of empire. With that conception, indeed, the barbarians had already been for centuries familiar: service in Roman armies, and settlement in Roman territories, had made the Roman empire for them, as much as for the civilized provincial, part of the order of the world. One of the barbarian invaders, Odoacer (Odovakar), might seem, in 476, to have swept away the Empire from the West, when he commanded the abdication of Romulus Augustulus; and the date 476 has indeed been generally emphasized as marking "the fall of the Western empire." Other invaders, again, men like the Frank Clovis or the great Ostrogoth Theodoric, might seem, in succeeding years, to have completed the work of Odoacer, and to have shattered the sorry scheme of the later Empire, by remoulding it into national kingdoms. *De facto*, there is some truth in such a view: *de jure*, there is none.[2] All that Odoacer did was to abolish one of the two joint rulers of the indivisible Empire, and to make the remaining ruler at Constantinople sole emperor from the Bosporus to the pillars of Hercules. He abolished the dual sovereignty which had been inaugurated by Diocletian, and returned to the unity of the Empire in the days of Marcus Aurelius. He did not abolish the Roman empire in the West: he only abolished its separate ruler, and, leaving the Empire itself subsisting, under the sway (nominal, it is true, but none the less acknowledged) of the emperor resident at Constantinople, he claimed to act as his vicar, under the name of patrician, in the administration of the Italian provinces.[3] As Odoacer thus fitted himself into the scheme of empire, so did both Clovis and Theodoric. They do not claim to be emperors (that was reserved for Charlemagne): they claim to be the vicars and lieutenants of the Empire. Theodoric spoke of himself to Zeno as *imperio vestro famulans*; he left justice and administration in Roman hands, and maintained two annual consuls in Rome. Clovis received the title of consul from Anastasius; the Visigothic kings of Spain (like the kings of the savage Lombards) styled themselves Flavii, and permitted the cities of their eastern coast to send tribute to Constantinople. Yet it must be admitted that, as a matter of fact, this adhesion of the new barbaric kings to the Empire was little more than a form. The Empire maintained its ideal unity by treating them as its vicars; but they themselves were forming separate and independent kingdoms within its borders. The Italy of the Ostrogoths cannot have belonged, in any real sense, to the Empire; otherwise Justinian would never have needed to attempt its reconquest. And in the 7th and 8th centuries the form of adhesion itself decayed: the emperor was retiring upon the Greek world of the East, and the German conquerors, settled within their kingdoms, lost the width of outlook of their old migratory days.

The Church and the Empire.

It is here that the action of the Church becomes of supreme importance. The Church had not ceased to believe in the continuous life of the Empire. The Fathers had taught that when the cycle of empires was finally ended by the disappearance of the empire of Rome, the days of Antichrist would dawn; and, since Antichrist was not yet come, the Church believed that the Empire still lived, and would continue to live till his coming. Meanwhile the Eastern emperor, ever since Justinian's reconquest of Italy, had been able to maintain his hold on the centre of Italy; and Rome itself, the seat of the head of the Church, still ranked as one of the cities under his sway. The imperialist theory of the Church found its satisfaction in this connexion of its head with Constantinople; and as long as this connexion continued to satisfy the Church, there was little prospect of any change. For many years after their invasion of 568, the pressure which the Lombards maintained on central Italy, from their kingdom in the valley of the Po, kept the popes steadily faithful to the emperor of the East and his representative in Italy, the exarch of Ravenna. But it was not in the nature of things that such fidelity should continue unimpaired. The development of the East and the West could not but proceed along constantly diverging lines, until the point was reached when their connexion must snap. On the one hand, the development of the West set towards the increase of the powers of the bishop of Rome until he reached a height at which subjection to the emperor at Constantinople became impossible. Residence in Rome, the old seat of empire, had in itself given him a great prestige; and to this prestige St Gregory (pope from 590 to 604) had added in a number of ways. He was one of the Fathers of the Church, and turned its theology into the channels in which it was to flow for centuries; he had acquired for his church the great spiritual colony of England by the mission of St Augustine; he had been the protector of Italy against the Lombards. As the popes thus became more and more spiritual emperors of the West, they found themselves less and less able to remain the subjects of the lay emperor of the East. Meanwhile the emperors of the East were led to interfere in ecclesiastical affairs in a manner which the popes and the Western Church refused to tolerate. Brought into contact with the pure monotheism of Mahommedanism, Leo the Isaurian (718-741) was stimulated into a crusade against image-worship, in order to remove from the Christian Church the charge of idolatry. The West clung to its images: the

Growing divergence between East and West. The popes.

popes revolted against his decrees; and the breach rapidly became irreparable. As the hold of the Eastern emperor on central Italy began to be shaken, the popes may have begun to cherish the hope of becoming their successors and of founding a temporal dominion; and that hope can only have contributed to the final dissolution of their connexion with the Eastern empire.

Thus, in the course of the 8th century, the Empire, *as represented by the emperors at Constantinople*, had begun to fade utterly out of the West. It had been forgotten by lay sovereigns; it was being abandoned by the pope, who had been its chosen apostle. But it did not follow that, because the Eastern emperor ceased to be the representative of the Empire for the West, the conception of Empire itself therefore perished. The popes only abandoned the representative; they did not abandon the conception. If they had abandoned the conception, they would have abandoned the idea that there was an order of the world; they would have committed themselves to a belief in the coming of Antichrist. The conception of the world as a single Empire-Church remained: what had to be discovered was a new representative of one of the two sides of that conception. For a brief time, it would seem, the pope himself cherished the idea of becoming, in his own person, the successor of the ancient Caesars in their own old capital. By the aid of the Frankish kings, he had been able to stop the Lombards from acquiring the succession to the derelict territories of the Eastern emperor in Italy (from which their last exarch had fled overseas in 752), and he had become the temporal sovereign of those territories. Successor to the Eastern emperor in central Italy, why should he not also become his successor as representative of the Empire—all the more, since he was the head of the Church, which was coextensive with the Empire? Some such hope seems to inspire the Donation of Constantine, a document forged between 754 and 774, in which Constantine is represented as having conferred on Silvester I. the imperial palace and insignia, and therewith *omnes Italiae seu occidentalium regionum provincias loca et civitates*. But the hope, if it ever was cherished, proved to be futile. The popes had 350
not the material force at their command which would have made them adequate to the position. The strong arm of the Frankish kings had alone delivered them from the Lombards: the same strong arm, they found, was needed to deliver them from the wild nobility of their own city. So they turned to the power which was strong enough to undertake the task which they could not themselves attempt, and they invited the Frankish king to become the representative of the imperial conception they cherished.[4] In the year 800 central Italy ceased to date its documents by the regnal years of the Eastern emperors; for Charlemagne was crowned emperor in their stead.

Coronation of Charlemagne as emperor of the West.

The king of the Franks was well fitted for the position which he was chosen to fill. He was king of a stock which had been from the first Athanasian, and had never been tainted, like most of the Germanic tribes, by the adoption of Arian tenets. His grandfather, Charles Martel, had saved Europe from the danger of a Mahommedan conquest by his victory at Poitiers (732); his father, Pippin the Short, had helped the English missionary Boniface to achieve the conversion of Germany. The popes themselves had turned to the Frankish kings for support again and again in the course of the 8th century. Gregory III., involved in bitter hostilities with the iconoclastic reformers of the East, appealed to Charles Martel for aid, and even offered the king, it is said, the titles of consul and patrician. Zacharias pronounced the deposition of the last of the Merovingians, and gave to Pippin the title of king (751); while his successor, Stephen II., hard pressed by the Lombards, who were eager to replace the Eastern emperors in the possession of central Italy, not only asked and received the aid of the new king, but also acquired, in virtue of Pippin's donation (754), the disputed exarchate itself. Thus was laid the foundation of the States of the Church; and the grateful pope rewarded the donation by the gift of the title of *patricius Romanorum*, which conferred on its recipient the duty and the privilege of protecting the Roman Church, along with some undefined measure of authority in Rome itself.[5] Finally, in 773, Pope Adrian I. had to appeal to Charles, the successor of Pippin, against the aggressions of the last of the Lombard kings; and in 774 Charles conquered the Lombard kingdom, and himself assumed its iron crown. Thus by the end of the 8th century the Frankish king stood on the very steps of the imperial throne. He ruled a realm which extended from the Pyrenees to the Harz, and from Hamburg to Rome—a realm which might be regarded as in itself a *de facto* empire. He bore the title of *patricius*, and he had shown that he did not bear it in vain by his vigorous defence of the papacy in 774. Here there stood, ready to hand, a natural representative of the conception of Empire; and Leo III., finding that he needed the aid of Charlemagne to maintain himself against his own Romans, finally took the decisive step of crowning him emperor, as he knelt in prayer at St Peter's, on Christmas Day, 800.

Theory of the Carolingian empire.

The coronation of Charlemagne in 800 marks the coalescence into a single unity of two facts, or rather, more strictly speaking, of a fact and a theory. The fact is German and secular: it is the wide *de facto* empire, which the Frankish sword had conquered, and Frankish policy had organized as a single whole. The theory is Latin and ecclesiastical: it is a theory of the necessary political unity of the world, and its necessary representation in the person of an emperor—a theory half springing from the unity of the old Roman empire, and half derived from the unity of the Christian Church as conceived in the New Testament. If we seek for the force which caused this fact and this theory to coalesce in the Carolingian empire, we can only answer—the papacy. The idea of Empire was in the Church; and the head of the Church translated this idea into fact. If, however, we seek to conceive the event of 800 from a political or legal point of view, and to determine the residence of the right of constituting an emperor, we at once drift into the fogs of centuries of controversy. Three answers are possible from three points of view; and all have their truth, according to the point of view. From the ecclesiastical point of view, the right resides with the pope. This theory was not promulgated (indeed no theory was promulgated) until the struggles of Papacy and Empire in the course of the middle ages; but by the time of Innocent III. it is becoming an established doctrine that a *translatio Imperii* took place in 800, whereby the pope transferred the Roman empire from the Greeks to the Germans in the person of the magnificent Charles.[6] One can only say that, as a matter of fact, the popes ceased to recognize the Eastern emperors, and recognized Charles instead, in the year 800; that, again, this recognition alone made Charles emperor, as nothing else could have done; but that no question arose, at the time, of any right of the pope to give the Empire to Charlemagne, for the simple reason that neither of the actors was acting or thinking in a legal spirit. If we now turn to study the point of view of the civil lawyer, animated by such a spirit, and basing himself on the code of Justinian, we shall find that an emperor must derive his institution and power from a *lex regia* passed by the *populus Romanus*; and such a view, strictly interpreted, will lead us to the conclusion that the citizens of Rome had given the crown to Charlemagne in 800, and continued to bestow it on successive emperors afterwards. There is indeed some speech, in the contemporary accounts of Charlemagne's coronation, of the presence of "ancients among the Romans" and of "the faithful people"; but they are merely present to witness or applaud, and the conception of the Roman people as the source of Empire is one that was only championed, at a far later date, by antiquarian idealists like Arnold of Brescia and Cola di Rienzi. The *faex Romuli*, a population of lodging-house keepers, living upon pilgrims to the papal court, could hardly be conceived, except by an ardent imagination, as heir to the *Quirites* of the past. Finally, from the point of view of the German tribesman, we must admit that the Empire was something which, once received by his king (no matter how), descended in the royal family as an heirloom; or to which (when the kingship became elective) a title was conferred, along with the kingship, by the vote of electors.[7]

But apart from these questions of origin, two difficulties have still to be faced with regard to the nature and position of the Carolingian empire. Did Charlemagne and his successors enter into a new relation with their subjects, in virtue of their coronation? And what was the nature of the relation between the new emperor now established in the West and the old emperor still reigning in the East? It is true that Charlemagne exacted a new oath of allegiance from his subjects after his coronation, and again that he had a revision of all the laws of his dominions made in 802. But the revision did not amount to much in bulk: what there was contained little that was Roman; and, on the whole, it hardly seems probable that Charlemagne entered into any new relation with his subjects. The relation of his empire to the empire in the East is a more difficult and important problem. In 797 the empress Irene had deposed and blinded her son, Constantine VI., and usurped his throne. Now it would seem that Charlemagne, whose thoughts were already set on Empire, hoped to depose and succeed Irene, and 351

Relations of the Carolingian to the Eastern empire.

thus to become sole representative of the conception of Empire, both for the East and for the West. Suddenly there came, in 800, his own coronation as emperor, an act apparently unpremeditated at the moment, taking him by surprise, as one gathers from Einhard's *Vita Karoli*, and interrupting his plans. It left him representative of the Empire for the West only, confronting another representative in the East. Such a position he did not desire: there had been a single Empire vested in a single person since 476, and he desired that there should still continue to be a single Empire, vested only in his own person. He now sought to achieve this unity by a proposal of marriage to Irene. The proposal failed, and he had to content himself with a recognition of his imperial title by the two successors of the empress. This did not, however, mean (at any rate in the issue) that henceforth there were to be two conjoint rulers, amicably ruling as colleagues a single Empire, in the manner of Arcadius and Honorius. The dual government of a single Empire established by Diocletian had finally vanished in 476; and the unity of the Empire was now conceived, as it had been conceived before the days of Diocletian, to demand a single representative. Henceforth there were two rulers, one at Aix-la-Chapelle and one at Constantinople, each claiming, whatever temporary concessions he might make, to be the sole ruler and representative of the Roman empire. On the one hand, the Western emperors held that, upon the deposition of Constantine VI., Charlemagne had succeeded him, after a slight interval, in the government of the whole Empire, both in the East and in the West; on the other hand, the Eastern emperors, in spite of their grudging recognition of Charlemagne at the moment, regarded themselves as the only lawful successors of Constantine VI., and viewed the Carolings and their later successors as upstarts and usurpers, with no right to their imperial pretensions. Henceforth two halves confronted one another, each claiming to be the whole; two finite bodies touched, and each yet claimed to be infinite.

If, as has been suggested, Charlemagne did not enter into any fundamentally new relations with his subjects after his coronation, it follows that the results of his coronation, in the sphere of policy and

Character of the Carolingian empire.

administration, cannot have been considerable. The Empire added a new sanction to a policy and administration already developed. Charlemagne had already showed himself *episcopus episcoporum*, anxious not only to suppress heresy and supervise the clergy within his borders, but also to extend true Christianity without them even before the year when his imperial coronation gave him a new title to supreme governorship in all cases ecclesiastical. He had already organized his empire on a new uniform system of counties, and the *missi dominici* were already at work to superintend the action of the counts, even before the *renovatio imperii Romani* came to suggest such uniformity and centralization. Charlemagne had a new title; but his subjects still obeyed the king of the Franks, and lived by Frankish law, in the old fashion. In their eyes, and in the eyes of Charlemagne's own descendants, the Empire was something appendant to the kingship of the Franks, which made that kingship unique among others, but did not radically alter its character. True, the kingship might be divided among brothers by the old Germanic custom of partition, while the Empire must inhere in one person; but that was the one difference, and the one difficulty, which might easily be solved by attaching the name of emperor to the eldest brother. Such was the conception of the Carolings: such was not, however, the conception of the Church. To the popes the Empire was a solemn office, to which the kings of the Franks might most naturally be called, in view of their power and the traditions of their house, but which by no means remained in their hands as a personal property. By thus seeking to dissociate the Empire from any indissoluble connexion with the Carolingian house, the popes were able to save it. Civil wars raged among the descendants of Charlemagne: partitions recurred: the Empire was finally dissolved, in the sense that the old realm of Charlemagne fell asunder, in 888. But the Empire, as an office, did not perish.

Break-up of the Carolingian empire.

Attitude of the papacy.

During the 9th century the popes had insisted, as each emperor died, that the new emperor needed coronation at their hands; and they had thus kept alive the conception of the Empire as an office to which they invited, if they did not appoint, each successive emperor. The quarrels of the Carolingian house helped them to make good their claim. John VIII. was able to select Charles the Bald in preference to other claimants in 875; and before the end of his pontificate he could write that “he who is to be ordained by us to the Empire must be by us first and foremost invited and elected.” Thus was the unity of the Empire preserved, and the conception of a united Empire continued, in spite of the eventual dissolution of the realm of Charlemagne. When the Carolingian emperors disappeared, Benedict IV. could crown Louis of Provence (901) and John X. could invite to the vacant throne an Italian potentate like Berengar of Friuli (915); and even when Berengar died in 924, and the Empire was vacant of an emperor, they could hold, and hold with truth, that the Empire was not dead, but only suspended, until such time as they should invite a new ruler to assume the office.

Various causes had contributed to the dissolution of the realm of Charlemagne. Partitions had split it; feudalism had begun to honeycomb it; incessant wars had destroyed its core, the fighting Franks of Austrasia. But, above all, the rise of divisions within the realm, which, whether animated by the spirit of nationality or no, were ultimately destined to develop into nations, had silently undermined the structure of Pippin and Charlemagne. Already in 842 the oath of Strassburg shows us one Caroling king swearing in French and another in German: already in 870 the partition of Mersen shows us the kings of France and Germany dividing the middle kingdom which lay between the two countries by the linguistic frontier of the Meuse and Moselle. The year 888 is the birth-year of modern Europe. France, Germany, Italy, stood distinct as three separate units, with Burgundy and Lorraine as debatable lands, as they were destined to remain for centuries to come.

The German kingdom and the empire.

If the conception of Empire was still to survive, the pope must ultimately invite the ruler of the strongest of these three units to assume the imperial crown; and this was what happened when in 962 Pope John XII. invited Otto I. of Germany to renew once more the Roman Empire. As the imperial strength of the whole Frankish tribe had given them the Empire in 800, so did the national strength of the East Frankish kingdom, now resting indeed on a Saxon rather than a Frankish basis, bring the Empire to its ruler in 962. The centre of political gravity had already been shifting to the east of the Rhine in the course of the 9th century. While the Northmen had carried their arms along the rivers and into the heart of France, Louis the German had consolidated his kingdom in a long reign of sixty years (817-876); and at the end of the 9th century two kings of Germany had already worn the imperial crown. Early in the 10th century the kingship of Germany had come to the vigorous Saxon dukes (919); and strong in their Saxon basis Henry I. and his son Otto had built a realm which, disunited as it was, was far more compact than that which the Carolings of the West ruled from Laon. Henry I. had thought in his later years of going to Rome for the imperial crown: under Otto I. the imperial idea becomes manifest. On the one hand, he established a semi-imperial position in the West: by 946 Louis IV. d’Outremer is his protégé, and it is his arms which maintain the young Conrad of Burgundy on his throne. On the other hand, he showed, by his policy towards the German Church, that he was the true heir of the Carolingian traditions. He made churchmen his ministers; he established missionary bishoprics on the Elbe which should spread Christianity among the Wends; and his dearest project was a new archbishopric of Magdeburg. The one thing needful was that he should, like Charlemagne, acquire the throne of Italy; and the dissolute condition of that country during the first half of the 10th century made its acquisition 352
not only possible, but almost imperative.

The Holy Roman Empire.

Begun in 952, the acquisition was completed ten years later; and all the conditions were now present for Otto’s assumption of the imperial throne. He was crowned by John XII. on Candlemas Day 962, and thus was begun the Holy Roman Empire, which lasted henceforth with a continuous life until 1806.[8]

The same ideas underlay the new empire which had underlain that of Charlemagne, strengthened and reinforced by the fact that they had already found a visible expression before in that earlier empire. Historically, there was the tradition of the old Roman empire, preserved by the Church as an idea, and preserved in the Church, and its imperial organization, as an actual fact. Ecclesiastically, there was the Pauline conception of a single Christian Church, one in subjection to Christ as its Head, and needing (so men still thought) a secular counterpart of its indivisible unity.[9] To these two sanctions philosophy later added a third; and the doctrine of Realism, that the one universal is the true abiding substance—the doctrine which pervades the *De monarchia* of Dante,—reinforced the feeling which demanded that Europe should be conceived as a single political unity. But if the Holy Roman empire of the German nation has the old foundations, it is none the less a thing *sui generis*.

Externally, it meant far less than the empire of Charlemagne; it meant simply a union of Germany and northern Italy (to which, after 1032, one must also add Burgundy, though the addition is in reality nominal) under a single rule. Historians of the 19th century, during the years in which the modern German empire was in travail, disputed sorely on the advantages of this union; but whatever its advantages or disadvantages, the fact remains that the union of Teutonic Germany and Latin Italy was, from an external point of view, the essential fact in the structure of the medieval Empire. Internally, again, the Empire of the Ottos and their successors was new and unprecedented. If Latin imperialism had been combined with Frankish tribalism in the Empire of Charlemagne, it now met and blended with feudalism. The Holy Roman emperor of the middle ages, as Frederick I. proudly told the Roman envoys, found his senate in the diet of the German baronage, his *equites* in the ranks of the German knights. Feudalism, indeed, came in time to invade the very conception of Empire itself. The emperors began to believe that their position of emperor made them feudal overlords of other kings and princes; and they came to be regarded as the topmost summit of the feudal pyramid, from whom kings held their kingdoms, while they themselves held directly of God. In this way the old conception of the world as a single political society entered upon a new phase: but the translation of that conception into feudal terms, which might have made Diocletian gasp, only gave it the greater hold on the feudal society of the middle ages. Yet in one way the feudal conception was a source of weakness to the Empire; for the popes, from the middle of the 12th century onwards, began to claim for themselves a feudal overlordship of the world, and to regard the emperor as the chief of their vassals. The theory of the *Translatio* buttressed their claim to be overlords of the Empire; and the emperors found that their very duty to defend the Papacy turned them into its vassals—for was not the *advocatus* who defended the lands of an abbey or church its tenant by feudal service, and might not analogy extend the feudal relation to the imperial advocate himself?

The Empire and feudalism.

The relation of the Empire to the Papacy is indeed the cardinal fact in its history for the three centuries which followed the coronation of Otto I. (962-1250). For a century (962-1076) the relation was one of amity. The pope and the emperor stood as co-ordinate sovereigns, ruling together the commonwealth of Europe.[10] If either stood before the other, the emperor stood before the pope. The Romans had sworn to Otto I. that they would never elect or ordain a pope without his consent; and the rights over papal elections conceived to belong to the office of *patricius*, which they generally held, enabled the emperors, upon occasion, to nominate the pope of their choice. The partnership of Otto III., son of a Byzantine princess, and his nominee Silvester II. (already distinguished as Gerbert, *scholasticus* of the chapter school of Reims) forms a remarkable page in the annals of Empire and Papacy. Otto, once the pupil of Silvester in classical studies, and taught by his mother the traditions of the Byzantine empire, dreamed of renewing the Empire of Constantine, with Rome itself for its centre; and this antiquarian idealism (which Arnold of Brescia and Cola di Rienzi were afterwards, though with some difference of aim, to share) was encouraged in his pupil by the pope. Tradition afterwards ascribed to the two the first project of a crusade, and the institution of the seven electors: in truth their faces were turned to the past rather than to the future, and they sought not to create, but to renovate. The dream of restoring the age of Constantine passed with the premature death of Otto; and after the death of Silvester II. the papacy was degraded into an appendage of the Tusculan family. From that degradation the Church was rescued by Henry III. (the second emperor of the new Salian house, which reigned from 1024 to 1125), when in 1046 he caused the deposition of three competing popes, and afterwards filled the papal chair with his own nominees; but it was rescued more effectually by itself, when in 1059 the celebrated bull *In nomine Domini* of Nicholas II. reserved the right of electing the popes to the college of cardinals (see Conclave). A new era of the Papacy begins with the decree, and that era found its exponent in Hildebrand. If under Henry III. the Empire stands in many respects at its zenith, and the emperor nominates to the Papacy, it sinks, under Henry IV., almost to the nadir of its fortunes, and a pope attempts, with no little success, to fight and defeat an emperor.

The Empire and the Papacy.

The rise of the Papacy, which the action of Henry III. in 1046 had helped to begin, and the bull of 1059 had greatly promoted, was ultimately due to an ecclesiastical revival, which goes by the name of the Cluniac movement. The aim of that movement was to separate the Church from the world, and thus to make it independent of the laity and the lay power; and it sought to realize its aim first by the prohibition of clerical marriage and simony, and ultimately by the prohibition of lay investiture. A decree of Gregory VII. in 1075 forbade emperor, king or prince to "presume to give investiture of bishoprics," under pain of excommunication; and Henry IV., contravening the decree, fell under the penalty, and the War of Investitures began (1076-1122). Whether or no Henry humiliated himself at Canossa (and the opinion of German historians now inclines to regard the traditional account as exaggerated) the Empire certainly suffered in his reign a great loss of prestige. The emperor lost his hold over Germany, where the aid of the pope strengthened the hands of the discontented nobility: he lost his hold over Italy, where the Lombard towns gradually acquired municipal independence, and the donation of the Countess Matilda gave the popes the germ of a new and stronger *dominium temporale*. The First Crusade came, and the emperor, its natural leader, could not lead it; while the centre of learning and civilization, in the course of the fifty years' War of Investitures, gradually shifted to France. The struggle was finally ended by a compromise—the Concordat of Worms—in 1122; but the Papacy, which had fought the long War of Investitures and inspired the First Crusade, was a far greater power than it had been at the beginning of the struggle, and the emperor, shaken in his hold on Germany and Italy, had lost both power and prestige (see Investiture). It is significant that 353

The Investiture contest.

a theory of the feudal subjection of the emperor to the pope, foreshadowed in the pontificate of Innocent II., and definitely enounced by the envoys of Adrian IV. at the diet of Besançon in 1157, now begins to arise. The popes, who had called the emperors to be heads of the European commonwealth in 800 and again in 962, begin to vindicate that headship for themselves. Gregory VII. had already claimed that the pope stood to the emperor, as the sun to the moon; and gradually the old co-ordination disappeared in a new subordination of the Empire to the papal *plenitudo potestatis*. The claim of ecclesiastical independence of the middle of the 11th century was rapidly becoming a claim of ecclesiastical supremacy in the middle of the 12th: the imperial claim to nominate popes, which had lasted till 1059, was turning into the papal claim to nominate emperors. Yet at this very time a new period of splendour dawned for the Empire; and the rule of the three Hohenstaufen emperors, Frederick I., Henry VI. and Frederick II. (1152-1250), marks the period of its history which attracts most sympathy and admiration.

The Hohenstaufen emperors.

Frederick I. regained a new strength in Germany, partly because he united in his veins the blood of the two great contending families, the Welfs and the Waiblingens; partly because he had acquired large patrimonial possessions in Swabia, which took the place of the last Saxon demesne; partly because he had a greater control over the German episcopate than his predecessors had enjoyed for many years past. At the same time the revival of interest in the study of Roman law gave the emperor, as source and centre of that law, a new dignity and prestige, particularly in Italy, the home and hearth of the revival. Confident in this new strength, he attempted to vindicate his claims on Italy, and sought, by uniting the two under his sway, to inspire with new life the old Ottonian Empire. He failed to crush Lombard municipal independence: defeated at Legnano in 1176, he had to recognize his defeat at the treaty of Constance in 1183. He failed to acquire control over the Papacy: a new struggle of Empire and Papacy, begun in the pontificate of Adrian IV. on the question of control over Rome, and continued in the pontificate of Alexander III., because Frederick recognized an anti-pope, ended in the emperor’s recognition of his defeat at Venice in 1177. The one success was the acquisition of the Norman kingdom for Henry VI., who was married to its heiress, Constance. But the one success of Frederick’s Italian policy proved the ruin of his house in the reign of his grandson Frederick II. On the one hand, the possession of Sicily induced Frederick II. to neglect Germany; and by two documents, one of 1220 and one of 1231, he practically abdicated his sovereign powers to the German princes in order to conciliate their support for his Italian policy. On the other hand, the possession of Sicily involved him in the third great struggle of Empire and Papacy. Strong in his Sicilian kingdom in the south, and seeking, like his grandfather, to establish his power in Lombardy, Frederick practically aimed at the unification of Italy, a policy which threatened to engulf the States of the Church and to reduce the Papacy to impotence. The popes excommunicated the emperor: they aided the Lombard towns to maintain their independence; finally, after Frederick’s death (1250), they summoned Charles of Anjou into Sicily to exterminate his house. By 1268 he had done his work, and the medieval Empire was practically at an end. When Rudolph of Habsburg succeeded in 1273, he was only the head of a federation of princes in Germany, while in Italy he abandoned all claims over the centre and south, and only retained titular rights in the Lombard plain.

Overthrow of the Empire in Italy.

Thus ended the first great chapter in the history of the Holy Roman Empire which Otto had founded in 962. In those three centuries the great fact had been its relation to the Papacy: in the last two of those three centuries the relation had been one of enmity. The basis of the enmity had been the papal claim to supreme headship of Latin Christianity, and to an independent temporal demesne in Italy as the condition of that headship. Because they desired supreme headship, the popes had sought to reduce the emperor’s headship to something lower than, and dependent upon, their own—to a mere fief held of St Peter: because they desired a temporal demesne, they had sought to expel him from Italy, since any imperial hold on Italy threatened their independence. They had succeeded in defeating the Empire, but they had also destroyed the Papacy; for the French aid which they had invoked against the Hohenstaufen developed, within fifty years of the fall of that house, into French control, and the captivity at Avignon (1308-1378) was the logical result of the final victory of Charles of Anjou at Tagliacozzo. The struggle seemed to have ended in nothing but the exhaustion of both combatants. Yet in many respects it had in reality made for progress. It had set men thinking of the respective limits of church and state, as the many *libelli de lite imperatorum et pontificum* show; and from that thought had issued a new conception of the state, as existing in its own right and supreme in its own sphere, a conception which is the necessary basis of the modern nation-state. If it had dislocated Germany into a number of territorial principalities, it had produced a college of electors to represent the cause of unity: if it had helped to prevent the unification of Italy, and had left to Italy the fatal legacy of Guelph and Ghibelline feuds, it had equally helped to produce Italian municipal independence.

The Empire from the election of Rudolph of Habsburg,

A new chapter of the history of the Empire fills the three centuries from 1273 to 1556—from the accession of Rudolph of Habsburg to the abdication of Charles V. Italy was now lost: the Empire had now no peculiar connexion with Rome, and far less touch with the Papacy. A new Germany had risen. The extinction of several royal stocks and the nomination of anti-kings in the course of civil wars had made the monarchy elective, and raised to the side of the emperor a college of electors (see Electors), which appears as definitely established soon after 1250. With Italy lost, and Germany thus transmuted, why should the Empire have still continued to exist? In the first place, it continued to exist

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because the Germans still found a king necessary and because, the German king having been called for three centuries emperor, it seemed necessary that he should still continue to bear the name. In this sense the Empire existed as the presidency of a Germanic confederation, and as something analogous to the modern German empire, with the one great difference that the Hohenzollerns now derive from Prussia a strength which enables them to make their imperial position a reality, while no Luxemburg or Habsburg was able to make his imperial position otherwise than honorary and nominal. In the second place, it continued to exist because the conception of the unity of western Europe still lingered, and was still conceived to need an exponent. In this sense the Empire existed as a presidency, still more honorary and still more nominal, of the nations of western Europe. In both capacities the emperor existed to a great extent because he was a legal necessity—because, in Germany, he was necessary for the investiture of princes with their principalities, and because, in Europe, he was necessary, as the source of all rights, to bestow crowns upon would-be kings, or to act as the head of the great orders of chivalry, or to give patents to notaries. With the history of the Empire regarded as a German confederation we are not here concerned. The reigns of the Habsburg, Luxemburg and Wittelsbach emperors belong to the history of 354
Germany. Yet two of these emperors, Henry VII. and Louis IV., should not pass without notice, the one for his own sake, the other for the sake of his adherents, and both because, by interfering in Italy, and coming into conflict with the Papacy, they brought once more into prominence the European aspect of the Empire.

Henry VII., the contemporary and the hero of Dante, descended into Italy in 1310, partly because he had no power and no occupation in Germany, partly because he was deeply imbued with the sense of his imperial dignity. Coming as a peacemaker and mediator, he was driven by Guelph opposition into a Ghibelline rôle; and he came into conflict with Clement V., the first of the Avignonese popes, who under the pressure of France attempted to enforce upon Henry a recognition of his feudal subjection. Henry asserted his independence: he claimed Rome for his capital, and the lordship of the world for his right; but, just as a struggle seemed impending, he died, in 1313. During the reign of his successor, Louis IV., the struggle came. Louis had been excommunicated by John XXII. in 1324 for acting as emperor before he had received papal recognition. None the less, in 1328, he came to Rome for his coronation. He had gathered round him strange allies; on the one hand, the more advanced Franciscans, apostles of the cause of clerical disendowment, and inimical to a wealthy papacy; on the other hand, jurists like Marsilius of Padua and John of Jandun, who brought to the cause of Louis the spirit and the doctrines which had already been used in the struggle between Boniface VIII. and Philip IV. of France. Marsilius in particular, in a treatise called the *Defensor Pacis*, insisted on the majesty of the lay state, and even on its superiority to the Church. Perhaps it was Marsilius, learned as he was in Roman law, and remembering the *lex regia* by which the Roman people had of old conferred its power on the emperor, who suggested to Louis the policy, which he followed, of receiving the imperial crown by the decree and at the hands of the Roman people. The policy was remarkable: Louis embraced an alliance which Frederick Barbarossa had spurned, and recognized the medieval Romans as the source of imperial power. Not less remarkable was the new attitude of the German electors, who for the first time supported an emperor against the pope, because they now felt menaced in their own electoral rights; and the one permanent result which finally flowed from the struggle was the enunciation and definition of the rights and privileges of the electors in the Golden Bull of 1356 (see Golden Bull).

In this struggle with the Papacy the Empire had shown something of its old universal aspect. It had come into connexion with Italy, and into close connexion with Rome: it had enlisted in defence of its rights at once an Italian like Marsilius and an Englishman like Ockham. The same universal aspect appeared once more in the age of the conciliar movement, at the beginning of the 15th century. One of the essential duties of the emperor, as defender of the Church, was to help the assembling and the deliberations of general councils of the Church. This was the duty discharged by Sigismund, when he forced John XXIII. to summon a council at Constance in 1414, and sought, though in vain, to guide its deliberations. The journey which Sigismund undertook in the interests of the council (1415-1417) is particularly noteworthy. He sought to make peace throughout western Europe, acting as international arbitrator—in virtue of his presidency of western Europe—between England and France, between Burgundians and Armagnacs; but he failed in his aim, and when he returned to the council, it was only to witness the defeat of the party of reform which he championed.

The Empire and the rise of the idea of national states.

National feeling and national antipathies proved too strong for Sigismund's attempt to revive the medieval empire for the purposes of international arbitration: the same feeling, the same antipathies, made inevitable the failure of the council itself, in which western Europe had sought to meet once more as a single religious commonwealth. Early in the 15th century, therefore, the conception of the unity of western Europe, as a single Empire-Church, was already waning in both its aspects. The unity of the Church Universal was dissolving, and the conception of the nation-church arising (as the separate concordats granted by Martin V. to the different nations prove); while the unity of the Empire was proved a dream, by the powerlessness of the emperor in the face of the struggle of England and France.

Renaissance and Reformation combined to complete the fall which the failure of Sigismund to guide the conciliar movement had already foreshadowed. The Renaissance, revolting against the medievalism of the *studium* and not sparing even the *sacerdotium* of the middle ages,

Influence of the

had little respect for the medieval *imperium*; and, going back to pure Latin and original Greek, it went back beyond even the classical empire to find its ideals and

Reformation. inspirations. But it is the coming of the Reformation, and with it of the nation-church, which finally marks the epoch at which the last vestige of the old conception of the political unity of the world disappears before the nation-state. Externally indeed it seemed, at the time of the Reformation, as if the old Empire had been revived in the person of Charles V., who owned territories as vast as those of Charlemagne. But Charles’s dominions were a dynastic agglomeration, knit together by no vivifying conception; and, though Charles was a champion of the one Catholic Church against the Reformation, he did not in any way seek to revive the power of the medieval empire. Meanwhile the reforming monarchs, while they cast off the Roman Church, cast off with it the Roman empire. Henry VIII. declared himself free, not only of the pope, but of all other foreign power; not only so, but as he sought to take the place of the pope with regard to his own church, so he sought to take the place of the emperor with regard to his kingdom, and spoke of his “imperial” crown, a style which recurs in later Tudor reigns.[11] The conception of one Empire passed out of Europe, or, if it remained, it remained only in an honorary precedence accorded by other sovereigns to the king of Germany, who still entitled himself emperor. In Germany itself the honorary presidency which the emperor enjoyed over the princes came to mean still less than before, when religious differences divided the country, and the principle of *cujus regio ejus religio* accentuated the local autonomy of the prince. When Charles abdicated in 1556, the change which the accession of Rudolph of Habsburg had already marked was complete: there was no empire except in Germany, and in Germany the Empire was nothing more than a convenient legal conception. The Reformation, by sweeping away the spiritual unity of western Christendom, had swept away any real conception of its political unity, and with that conception it had swept away the Empire; while it had also, by splitting Germany into two religious camps, and making the emperor at the most the head of a religious faction, dissipated the last vestiges of a real Empire in the country which had, since 962, been its peculiar home.

The Empire as a German confederation.

From 1556 to 1806 the Empire means a loose federation of the different princes of Germany, lay and ecclesiastical, under the presidency, elective in theory but hereditary in practice, of the house of Habsburg. It is an empire much in the same sense as the modern German empire, with a diet somewhat analogous to the modern Bundesrat, and a cumbrous imperial chamber for purposes of justice, hardly at all analogous to the highly organized system of federal justice which prevails in Germany to-day. The dissolution of the Holy Roman Empire into this loose federation had already been anticipated by the concessions made to the princes by Frederick II. in 1220 and 1231; but the final organization of Germany on federal lines was only attained in the treaty of Westphalia of 1648. The attempt of Ferdinand II., in the course of the Thirty Years’ War, to assert a practically monarchical authority over the princes of Germany, only led to the regular vindication by the princes of their own monarchical authority. The emperor, who had tried in the 15th century to be the international authority of all Europe, now sank to the position of less than inter-state arbitrator in Germany. That the Empire and the emperor were retained at all, when the princes became so many independent sovereigns, was due 355
partly to a lingering sense of quasi-national sentiment for a *magni nominis umbra*, partly to the need of some authority which should combine in one whole principalities of very different sizes and strengths, and should protect the weak from the strong, and all from France. But this authority only found its *symbol* in the emperor. Such real federal authority as there was remained with the diet, a congress of sovereign princes through their accredited representatives; and the emperor’s sole rights, as emperor, were those of granting titles and confirming tolls. The Habsburgs, emperors in each successive generation, never pursued an imperial, but always a dynastic policy; and they were perfectly ready to sacrifice to the aggrandizement of their house the honour of the Empire, as when they ceded Lorraine to France in return for Tuscany (1735).

End of the Holy Roman Empire.

It needed the cataclysm of the French Revolution finally to overthrow the Empire. Throughout the 18th century it lasted, a thing of long-winded protocols and never-ending lawsuits, “neither Holy, nor Roman, nor an Empire.” But with Napoleon came its destroyer. As far back as the end of the 13th century, French kings had been scheming to annex the title or at any rate absorb the territories of the Empire: at the beginning of the 19th century the annexation of the title by Napoleon seemed very imminent. Posing as the New Charlemagne (“because, like Charlemagne, I unite the crown of France to that of the Lombards, and my Empire marches with the East”), he resolved in 1806, during the dissolution and recomposition of Germany which followed the peace of Lunéville, to oust Francis II. from his title, and to make the Holy Roman Empire part and parcel of the “Napoleonic idea.” He was anticipated, however, by the prompt action of the proud Habsburg, who was equally resolved that no other should wear the crown which he himself was powerless to defend, and accordingly, on the 6th of August 1806, Francis resigned the imperial dignity. So perished the Empire. Out of its ashes sprang the Austrian Empire, for Francis, in 1804, partly to counter Napoleon’s assumption of the title of Emperor of the French, partly to prepare for the impending dissolution of the old Empire, had assumed the title of “Hereditary Emperor of Austria.” And in yet more recent times the German empire may be regarded, in a still more real sense than Austria, as the descendant and representative of the old Empire of the German nation.

General influence of

What had been the results of the Holy Roman Empire, in the course of its long history, upon Germany and upon Europe? It has been a *vexata quaestio* among German historians, whether or no the Empire ruined Germany. Some have argued that it diverted the attention of the German kings from their own country to Italy, and that, by bringing them into conflict with the popes, and by thus strengthening the hands of their rebellious baronage

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with a papal alliance, it prevented the development of a national German monarchy, such as other sovereigns of western Europe were able to found. Others again have emphasized the racial division of Saxon and Frank, of High German and Low German, as the great cause of the failure of Germany to grow into a united national whole, and have sought to ascribe to the influence of the Empire such unity as was achieved; while they have attributed the learning, the trade, the pre-eminence of medieval Germany to the Italian connexion and the prestige which the Empire brought. It is difficult to pronounce on either side; but one feels that the old localism and individualism which characterized the early German, and had never, on German soil, been combined with and counteracted by a large measure of Roman population and Roman civilization, as they were in Gaul and Spain, would in any case have continued to divide and disturb Germany till late in her history, even if the Empire had never come to reside within her borders. Of the larger question of the influence of the Empire on Europe we can here only say that it worked for good. An Empire which represented, as a Holy Empire, the unity of all the faithful as one body in their secular, no less than in their religious life—an Empire which, again, as a Roman Empire, represented with an unbroken continuity the order of Roman administration and law—such an empire could not but make for the betterment of the world. It was not an empire resting on force, a military empire; it was not, as in modern times empires have sometimes been, an autocracy warranted and stamped by the plébiscite of the mob. It was an empire resting neither on the sword nor on the ballot-box, but on two great ideas, taught by the clergy and received by the laity, that all believers in Christ form one body politic, and that the one model and type for the organization of that body is to be found in the past of Rome. It was indeed the weakness of the Empire that its roots were only the thoughts of men; for the lack of material force, from which it always suffered, hindered it from doing work it might well have done—the work, for instance, of international arbitration. Yet, on the other hand, it was the strength and glory of the Empire that it lived, all through the middle ages, an unconquerable idea of the mind of man. Because it was a being of their thought, it stirred men to reflection: the Empire, particularly in its clash with the Papacy, produced a political consciousness and a political speculation reflected for us in the many *libelli de lite imperatorum et pontificum*, and in the pages of Dante and Marsilius of Padua. Roman, it perpetuated the greatest monument of Roman thought—that ordered scheme of law, which either became, as in England, the model for the building of a native system, or, as in Germany from the end of the 15th century onwards, was received in its integrity and administered in the courts. Holy, it fortified and consolidated Christian thought, by giving a visible expression to the kingdom of God upon earth; and not only so, but it maintained, however imperfectly, some idea of international obligation, and some conception of a commonwealth of Europe.[12]

The Holy Roman Empire of western Europe had in its own day a contemporary and a rival—that east Roman empire of which we have already spoken. From Arcadius to John Palaeologus, from A.D. 395 to 1453, the Roman empire was continued at Constantinople—not as a theory and an idea, but as a simple and daily reality of politics and administration. In one sense the East Roman Empire was more lineally and really Roman than the West: it was absolutely continuous from ancient times. In another sense the Western Empire was the most Roman; for its capital—in theory at least—was Rome itself, and the Roman Church stood by its side, while Constantinople was Hellenic and even Oriental. Between the two Empires there was fixed an impassable gulf; and they were divided by deep differences of thought and temper, which appeared most particularly in the sphere of religion, and expressed themselves in the cleavage between the Catholic and the Orthodox Churches. Yet, as when Rome fell, the Catholic Church survived, and ultimately found for itself a new Empire of the West, so, when Constantinople fell, the Orthodox Church continued its life, and found for itself a new Empire of the East—the Empire of Russia. Under Ivan the Great (1462-1505) Moscow became the metropolis of Orthodoxy; Byzantine law influenced his code; and he took for his cognizance the double-headed eagle. Ivan the Terrible, his grandson, finally assumed in 1547 the title of Tsar; and henceforth the Russian emperor is, in theory and very largely in fact, the successor of the old East Roman emperor,[13] the head of the Orthodox Church, with the mission of vengeance on Islam for the fall of Constantinople.

Modern Empires.

In the 19th century the word “empire” has had a large and important bearing in politics. In France it has been the apanage of the Bonapartes, and has meant a centralized system of government by an efficient Caesar, resting immediately on the people, and annihilating the powers of the people’s representatives. Under Napoleon I. this conception had a Carolingian colour: under Napoleon III. there is less of Carolingianism, and more of Caesarism— 356 more of a popular dictatorship. While in modern France Empire has meant autocracy instead of representative government, in Germany it has meant a greater national unity and a federal government in the place of a confederation. The modern German empire is at once like and unlike the old Holy Roman Empire. It is unlike the old medieval Empire; for it has no connexion with the Catholic Church, and no relation to Rome. But it is like the Holy Roman Empire of the 17th and 18th centuries—for it represents a federation, but a more real and more unitary federation, of the several states of Germany. The likeness is perhaps more striking than the dissimilarity; and in virtue of this likeness, and because the memory of the old German *Kaiserzeit* was a driving force in 1870, we may speak of the modern German empire as the successor of the old Holy Roman Empire, if we remember that we are speaking of that Empire in its last two centuries of existence. The modern “Empire of Austria,” on the other hand, does not connote an empire in the sense of a federation, but is a convenient designation for the sum of the territories ruled by a single sovereign under various titles (king of Bohemia, archduke of Austria, &c.) and unified in a single political system.[14] The title of Emperor was assumed, as we have seen, through an historical accident; and, though the Habsburgs of to-day are personally the lineal descendants of the old Holy Roman emperors, they do not in any way possess an empire that represents the old Holy Empire. In England, of recent years, the term "Empire" and the conception of imperialism have become prominent and crucial. To Englishmen to-day, as to Germans before 1870, the term and the conception stand for the greater unity and definitely federal government of a number of separate states. For the German, indeed, Empire has meant, in great measure, the strengthening of a loose federal institution by the addition of a common personal superior: to us it means the turning of a loose union of separate states already under a common personal superior—the King—into a federal commonwealth living under some common federal institutions. But the aim is much the same; it is the integration of a people under a single scheme which shall be consistent with a large measure of political autonomy. We speak of imperial federation; and indeed our modern imperialism is closely allied to federalism. Yet we do well to cling to the term empire rather than federation; for the one term emphasizes the whole and its unity, the other the part and its independence. This imperialism, which is federalism viewed as making for a single whole, is very different from that Bonapartist imperialism, which means autocracy; for its essence is free co-ordination, and the self-government of each co-ordinated part. The British Empire (*q.v.*) is, in a sense, an aspiration rather than a reality, a thought rather than a fact; but, just for that reason, it is like the old Empire of which we have spoken; and though it be neither Roman nor Holy, yet it has, like its prototype, one law, if not the law of Rome—one faith, if not in matters of religion, at any rate in the field of political and social ideals.

Authorities.—See, in the first place, J. Bryce, *Holy Roman Empire* (1904 edition); J. von Döllinger, article on "The Empire of Charles the Great" (in *Essays on Historical and Literary Subjects*, translated by Margaret Warre, 1894); H. Fisher, *The Medieval Empire* (1898); E. Gibbon, *The Decline and Fall of the Roman Empire*, edited by J.B. Bury. It would be impossible to refer to all the books bearing on the article, but one may select (i.) for the period down to 476, Stuart Jones, *The Roman Empire* (1908), an excellent brief sketch; H. Schiller, *Geschichte der römischen Kaiserzeit* (1883-1888); O. Seeck, *Geschichte des Untergangs der antiken Welt* (Band I., Berlin, 1897-1898, Band II., 1901) (a remarkable and stimulating book); and the two excellent articles on "Imperium" and "Princeps" in Smith's *Dictionary of Greek and Roman Antiquities* (1890); (ii.) for the period from 476 down to 888, T. Hodgkin, *Italy and her Invaders* (1880-1900); F. Gregorovius, *Geschichte der Stadt Rom im Mittelalter* (1886-1894; Eng. trans., London, 1894-1900); E. Lavisse, *Histoire de France*, II. i. (1901); J.B. Bury, *History of the Later Roman Empire* (1889); (iii.) for the Holy Roman Empire of the German nation, W. von Giesebrecht, *Geschichte der deutschen Kaiserzeit* (1881-1890); J. Zeller, *Histoire d'Allemagne* (1872-1891); R.L. Poole, *Illustrations of Medieval Thought* (1884); S. Riezler, *Die literarischen Widersacher der Päpste zur Zeit Ludwigs des Baiers* (1874); J. Jannsen, *Geschichte des deutschen Volkes seit dem Ausgang des Mittelalters* (1885-1894); L. von Ranke, *Deutsche Geschichte im Zeitalter der Reformation* (1839-1847), and *Zur deutschen Geschichte. Vom Religionsfrieden bis zum dreissigjährigen Krieg* (1869); and T. Carlyle, *Frederick the Great* (1872-1873). On the fall of the Roman Empire and the transition to the modern German Empire see Sir J.R. Seeley, *Life and Times of Stein* (1878); H. von Treitschke, *Deutsche Geschichte* (1879-1894); and H. von Sybel, *Die Begründung des deutschen Reichs* (1890-1894, Eng. trans., *The Founding of the Germ. Emp.*, New York, 1890-1891). For institutional history, see R. Schröder, *Lehrbuch der deutschen Rechtsgeschichte* (1894). On the influence of the Holy Roman Empire upon the history of Germany, see J. Ficker, *Das deutsche Kaiserreich* (1861), and *Deutsches Königtum und Kaisertum* (1862); and H. von Sybel, *Die deutsche Nation und das Kaiserreich* (1861).

(E. Br.)

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1 Bryce points out, with much subtlety and truth, that the rise of a second Rome in the East not only helped to perpetuate the Empire by providing a new centre which would take the place of Rome when Rome fell, but also tended to make it more universal; "for, having lost its local centre, it subsisted no longer by historic right only, but, so to speak, naturally, as a part of an order of things which a change in external conditions seemed incapable of disturbing" (*Holy Roman Empire*, p. 8 of the edition of 1904).

2 The *de facto* importance of the event of 476 can only be seen in the light of later events, and it was not therefore noticed by contemporaries. Marcellinus is the only contemporary who remarks on its importance, cf. *Marcellini Chronicon* (*Mon. Germ. Hist., Chronica minora.* ii. 91), *Hesperium Romanae gentis imperium ... cum hoc Augustulo periit ... Gothorum dehinc regibus Romam tenentibus.*

3 A passage in Malchus, a Byzantine historian (quoted by Bryce, *Holy Roman Empire*, p. 25, note *u*, in the edition of 1904), expresses this truth exactly. The envoys sent to Zeno by Odoacer urge ὡς ἰδίας μὲν αὐτοῖς βασιλείας οὐ δέοι κοινὸς δὲ ἀποχρήσει μόνος ὤν αὐτοκράτωρ ἐπ᾽ ἀμφοτέροις τοῖς πέρασι. The envoys then suggest the name of Odoacer, as one able to manage their affairs, and ask Zeno to give him, *as an officer of the Empire*, the title of Patricius and the administration of Italy.

4 According to the view here followed, the Church was the ark in which the conception of Empire was saved during the dark ages between 600 and 800. Some influence should perhaps also be assigned to Roman law, which continued to be administered during these centuries, especially in the towns, and maintained the imperial tradition. But the influence of the Church is the essential fact.

5 In the 5th century the title *patricius* came to attach particularly to the head of the Roman army (*magister utriusque militiae*) to men like Aetius and Ricimer, who made and unmade emperors (cf. Mommsen, *Gesammelte Schriften*, iv. 537, 545 sqq.). Later it had been borne by the Greek exarchs of Ravenna. The concession to Pippin of this great title makes him military head of the Western empire, in the sense in which the title was used in the 5th century; it makes him representative of the Empire for Italy, in the sense in which it had been used of the exarchs.

6 See the famous bull *Venerabilem* (*Corp. Jur. Canon.* Decr. Greg. i. 6, c. 34).

7 Even on this view, an imperial coronation at the hands of the pope was necessary to complete the title; but this was regarded by the Germans (though not by the pope) as a form which necessarily followed.

8 It is a curious fact that imperial titles (*imperator* and *basileus*) are used in the Anglo-Saxon diplomata of the 10th century. Edred, for instance (946-955) is "imperator," "cyning and casere totius Britanniae," "basileus Anglorum hujusque insulae barbarorum": Edgar is "totius Albionis imperator Augustus" (cf. Stubbs, *Const. Hist.* i. c. vii. § 71). These titles partly show the turgidity of English Latinity in the 10th century, partly indicate the quasi-imperial position held by the Wessex kings after the reconquest of the Dane-law. But there seems to be no real ground for Freeman's view (*Norman Conquest*, i. 548 sqq.), that England was regarded as a third Empire, side by side with the other Empires of West and East Europe. That the titles were assumed in order to repudiate possible claims of the Western Empire to the overlordship of England is disproved by the fact that they are assumed at a time when there is no Western emperor. The assumption of an imperial style by Henry VIII., which is mentioned below, is explained by the Reformation, and does not mean any recurrence to a forgotten Anglo-Saxon style.

9 It is in virtue of this aspect that the Empire is holy. The term *sacrum imperium* seems to have been first used about the time of Frederick I., when the emperors were anxious to magnify the sanctity of their office in answer to papal opposition. The emperor himself (see under Emperor) was always regarded, and at his coronation treated, as a *persona ecclesiastica*.

10 The emperor claimed suzerainty over the greater part of Europe at various dates. Hungary and Poland, France and Spain, the Scandinavian peninsula, the British Isles, were all claimed for the Empire at different times (see Bryce, *Holy Roman Empire*, c. xii.). The "effective" empire, if indeed it may be called effective, embraced only Germany, Burgundy and the *regnum Italiae* (the old Lombard kingdom in the valley of the Po).

11 Cf. the Act 25 Henry VIII. c. 22, § 1: "the lawful kings and emperors of this realm."

12 The Papacy, consistent to the last, formally protested at the Congress of Vienna in 1815 against the failure of the Powers to restore the Holy Roman Empire, the "centre of political unity" (Ed.).

13 The Turks, occupying Constantinople, have also claimed to be the heirs of the old emperors of Constantinople; and their sultans have styled themselves *Keisar-i-Rûm*.

14 This does not, of course, apply to Hungary, which since 1867 has not formed part of the Austrian empire and is ruled by the head of the house of Habsburg not as emperor, but as king of Hungary.

EMPIRICISM (from Gr. ἔμπειρος, skilled in, from πεῖρα, experiment), in philosophy, the theory that all knowledge is derived from sense-given data. It is opposed to all forms of intuitionalism, and holds that the mind is originally an absolute blank (*tabula rasa*), on which, as it were, sense-given impressions are mechanically recorded, without any action on the part of the mind. The process by which the mind is thus stored consists of an infinity of individual impressions. The frequent or invariable recurrence of similar series of events gives birth in the mind to what are wrongly called "laws"; in fact, these "laws" are merely statements of experience gathered together by association, and have no other kind of validity. In other words from the empirical standpoint the statement of such a "law" does not contain the word "must"; it merely asserts that such and such series have been invariably observed. In this theory there can strictly be no "causation"; one thing is observed to succeed another, but observations cannot assert that it is "caused" by that thing; it is *post hoc*, but not *propter hoc*. The idea of *necessary* connexion is a purely mental idea, an a priori conception, in which observation of empirical data takes no part; empiricism in ethics likewise does away with the idea of the absolute authority of the moral law as conceived by the intuitionalists. The moral law is merely a collection of rules of conduct based on an infinite number of special cases in which the convenience of society or its rulers has subordinated the inclination of individuals. The fundamental objection to empiricism is that it fails to give an accurate explanation of experience; individual impressions as such are momentary, and their connexion into a body of coherent knowledge presupposes mental action distinct from mere receptivity. Empiricism was characteristic of all early speculation in Greece. During the middle ages the empiric spirit was in abeyance, but it revived from the time of Francis Bacon and was systematized especially in the English philosophers, Locke, Hume, the two Mills, Bentham and the associationist school generally.

See Association of Ideas; Metaphysics; Psychology; Logic; besides the biographies of the empirical philosophers.

In medicine, the term is applied to a school of physicians who, in the time of Celsus and Galen, advocated accurate observation of the phenomena of health and disease in the belief that only by the collection of a vast mass of instances would a true science of medicine be attained. This point of view was carried to extremes by those who discarded all real study, and based their treatment on rules of thumb. Hence the modern sense of empirical as applied to the guess work of an untrained quack or charlatan.

EMPLOYERS’ LIABILITY, and **WORKMEN’S COMPENSATION.**[1] The law of England as to the liability of employers in respect of personal injuries to their servants is regulated partly by the common law and partly by statute; but by the Employers’ Liability Act 1880, such exceptions have been grafted upon the common law, and by the Workmen’s Compensation Act 1906, principles so alien to the common law have been applied to most employments that it is impossible now to present any view of this branch of the law as a logical whole. All that can be done is to state the nature of the liability at common law. the extension of it effected by the Employers’ Liability Act 1880, and the new liabilities introduced by later acts. 357

Common law.

At common law the liability of a master is of a very limited character. There is, of course, nothing to prevent a master and servant from providing by special contract in any way they please for their mutual rights in cases of personal injury to the servant. In such cases the liability will depend upon the terms of the special contract. But apart from any special agreement, it may be broadly stated that a master is liable to his servants only for injuries caused by his own negligence. Injuries to a servant may arise from accident, from the nature of the service, or from negligence; and this negligence may be of the master, of another servant of the master, or of a stranger. If the injury is purely accidental the loss lies where it falls. If it arises from the nature of the service, the servant must bear it himself; he has undertaken a service to which certain risks are necessarily incident; if he is injured thereby, it is the fortune of war, and no one can be made responsible. If the injury is caused by the negligence of a stranger, the servant has his ordinary remedy against the wrong-doer or any one who is responsible as a principal for the conduct of the wrong-doer. If it is caused by the negligence of a fellow-servant, he likewise has his ordinary remedy against the actual wrong-doer; but, by virtue of what is known as the doctrine of common employment, he cannot at common law make the master liable as a principal. The only case (independently of modern legislation: *see below*) in which he can recover damages from the master is where the injury has been caused by negligence of the master himself. A master is negligent if he fails to exercise that skill and care which, in the circumstances of the particular employment, are used by employers of ordinary skill and carefulness. If he himself takes part in the work, he must act with such skill and care as may reasonably be demanded of one who takes upon himself to do work of that kind. If he entrusts the work to other servants, he must be careful in their selection, and must not negligently employ persons who are incompetent. He must take proper care so to arrange the system of work that his servants are not exposed to unnecessary danger. If tools or machinery are used, he must take proper care to provide such as are fit and proper for the work, and must either himself see that they are maintained in a fit condition or employ competent servants to do so for him. If he is bound by statute to take precautions for the safety of his servants, he must himself see that that obligation is discharged. For breach of any of these duties a master is liable to his servant who is injured thereby, but his liability extends no further.

Common employment.

That his obligations to a servant are so much less than to a stranger is chiefly due to the doctrine of common employment. As a rule a master is responsible for the negligence of his servant acting in the course of his employment; but, from about the middle of the 19th century, it became firmly rooted in the law that this principle did not apply where the person injured was himself a servant of the master and engaged in a common employment with the servant guilty of the negligence. In effect this rule protects a master as against his servant from the consequences of negligence on the part of any other of his servants; to this there is no qualification except that, for the rule to apply, both the injured and the negligent servant must be acting in pursuance of a common employment. They must both be working for a common object though not necessarily upon the same work.

It is not easy to define precisely what constitutes a common employment in this sense, and there is peculiarly little judicial authority as to the limit at which work for the same employer ceases to be work in a common employment. It does not depend on difference in grade; all engaged in one business, from the manager to the apprentice, are within the rule. It does not depend on difference in work, if the work each is doing is part of one larger operation; all the servants of a railway company, whether employed on the trains, or at the stations, or on the line, are in a common employment. It does not necessarily depend on difference of locality; a servant who packs goods at the factory and a servant who unpacks them in the shop may well be in a common employment. On the other hand, it is not enough that the two servants are working for the same employer, if there is nothing in common between them except that they are making money for the same man; apart from special circumstances, the crews of two ships owned by the same company are probably not in common employment while navigating their respective ships. The test in each case must be derived from the view, invented by the courts, upon which the doctrine was based, namely, that the servant by entering upon the service consented to run all the risks incidental to it, including the risk of negligence on the part of fellow-servants; if the relation between the two servants is such that the safety of the one may, in the ordinary course of things, be affected by the negligence of the other, that negligence must be taken to be one of the risks of the employment assented to by the servant, and both are engaged in a common employment. In ninety-nine cases out of a hundred it will be found that the doctrine is applicable, and the master protected from liability. It is thus seen that, in general, no action will lie against a master at the suit of his servant, unless the servant can prove personal negligence on the part of the master causing injury to the servant. And in such action the master may avail himself of those defences which he has against a stranger. He may rely upon contributory negligence, and show that the servant was himself negligent, and that, notwithstanding the negligence of the master, the injury was proximately caused by the negligence of the servant. Or (except in cases where the injury results from a breach of a statutory duty) he may prove such facts as establish the defence expressed in the maxim, *volenti non fit injuria*; that is, he may prove that the injured servant knew and appreciated the particular risk he was running, and incurred it voluntarily with full understanding of its nature. Mere knowledge on the part of the servant, or even his continuing to work with knowledge, does not necessarily establish this defence; it must be knowledge of such a kind and in such circumstances that it can be inferred that the servant contracted to take the risk upon himself. The action at common law is subject to the general rule that personal actions die with the person; except so far as the remedy for money loss caused by death by negligence has been preserved in favour of a husband or wife and certain near relatives, under Lord Campbell's Act (Fatal Accidents Act 1846).

The act of 1880.

Such was the law up to 1880. So long as industry was conducted on a small scale, and the master worked with his men, or was himself the manager, its hardship was perhaps little felt; his personal negligence could in many cases be established. But with the development of the factory system, and the ever-growing expansion of the scale on which all industries were conducted, it became increasingly difficult to bring home individual responsibility to the employer. As industry passed largely into the control of corporations, difficulty became almost impossibility. The employer was not liable to a servant for the negligence of a fellow-servant, and therefore, in most cases of injury, was not liable at all. It is not surprising that the condition of things thus brought about, partly by the growth of modern industry and partly by the decisions of the courts, caused grave dissatisfaction. The justice of the doctrine of common employment was vigorously called in question. In the result the Employers' Liability Act 1880 was passed. The effect of this act is to destroy the defence of common employment in certain specified cases. It does not abolish the doctrine altogether, nor, on the other hand, does it impose upon the master any new standard of duty which does not exist as regards strangers. All that it does is to place the servant, in certain cases, in the position of a stranger, making the master liable for the negligence of his servants notwithstanding the fact that they are in common employment with the servant injured. It is still necessary under the act, as at common law, to prove negligence, and the master may still rely upon the defences of contributory negligence and *volenti non fit injuria*. But under the act he cannot, as against the workmen who come within it and in the cases to which it applies, set up the defence that the negligence complained of was the negligence of a servant in a common employment. The act does not apply to all servants. It does not apply to domestic or menial servants, or to seamen, or to any except railway servants and "any person who, being a labourer, servant in husbandry, journeyman, artificer, handicraftsman, miner, or otherwise engaged in *manual* labour ... has entered into or works under a contract with an employer, whether the contract be oral or in writing, and be a contract of service or a contract personally to execute any work or labour." Whether a servant, not being one of those specially named, is within the act depends on whether manual labour is the real and substantial employment, or whether it is merely incidental thereto; thus a carman who handles 358
the goods he carries may be within the act, but a tramcar driver or an omnibus conductor is not. The act does not make the master liable for the negligence of all his servants, but, speaking generally, only for the negligent discharge of their duties by such as are entrusted with the supervision of machinery and plant, or with superintendence, or the power of giving orders, with the addition, in the case of a railway, of the negligence of those who are given the charge or control of signals, points, locomotive engines or trains. The cases dealt with by the act are five in number; in the first and fourth the words are wide enough to include negligence of the employer himself, for which, as has been seen, he is liable at common law. In such instances the workman has an alternative remedy either at common law or under the act, but in all other respects the rights given by the act are new, being limitations upon the defence of common employment, and can be enforced only under the act.

The first case is where the injury is caused by reason of any defect in the condition of the ways, works, machinery or plant connected with or used in the business of the employer, provided that such defect arises from, or has not been discovered or remedied owing to the negligence of the employer, or of some person in the service of the employer and entrusted by him with the duty of seeing that the ways, works, machinery or plant are in proper condition. The second case is where the injury is caused by reason of the negligence of any person in the service of the employer who has any superintendence entrusted to him (that is, a person whose sole or principal duty is that of superintendence, and who is not ordinarily engaged in manual labour) whilst in the exercise of such superintendence. The third case is where the injury is caused by reason of the negligence of any person in the service of the employer to whose orders or directions the workman at the time of the injury is bound to conform and does conform, where such injury results from his so conforming. The fourth case is where the injury is caused by reason of the act or omission of any person in the service of the employer done or made in obedience to the rules or by-laws of the employer, or in obedience to particular instructions given by any person delegated with the authority of the employer in that behalf, provided that the injury results from some impropriety or defect in such rules, by-laws or instructions. The fifth case is where the injury is caused by reason of the negligence of any person in the service of the employer who has the charge or control of any signal, points, locomotive engine or train upon a railway.

In all these cases it is provided that the employer shall not be liable if it can be shown that the workman knew of the defect or negligence which caused his injury, and failed within a reasonable time to give, or cause to be given, information thereof to the employer or some person superior to himself in the service of the employer, unless he was aware that the employer or such superior already knew of the said defect or negligence. It was inevitable that these provisions should call for judicial interpretation, and a considerable body of authority has grown up about the act. Where general words are used, it must always occur that, between the cases which are obviously within and those which are obviously without the words, there are many on the border line. Thus, under the act, the courts have been called upon to determine the precise meaning of "way," "works," "machinery," "plant," and to say what is precisely meant by a "defect" in the condition of each of them. They have had to say what is included in "railway" and in "train," what is meant by having "charge" or "control," and to what extent one whose principal duty is superintendence may participate in manual labour without losing his character of superintendent, and what is the precise meaning of negligence in superintendence. These are only illustrations of many points of detail which, having called for judicial interpretation, will be found fully dealt with in the text-books on the subject. A workman who, being within the act, is injured by such negligence of a fellow-servant as is included in one or other of the five cases mentioned above, has against his employer the remedies which the act gives him. These are not necessarily the same as those which a stranger would have in the like circumstances; the amount of compensation is not left at large for a jury to determine, but is limited to an amount not exceeding such sum as may be found to be equivalent to the estimated earnings, during the three years preceding the injury, of a person in the same grade employed during those years in the like employment and in the district in which the workman is employed at the time of the injury. Moreover, the right to recover is hedged about with technicalities which are unknown at the common law; proceedings must be taken in the county court, within a strictly limited time, and are maintainable only if certain elaborate provisions as to notice of injury have been complied with. Where the injury causes death the action is maintainable for the benefit of the like persons as are entitled under Lord Campbell's act in an action at common law.

Acts of 1897 to 1906.

The law continued in this condition up to 1897. In the majority of cases of injury to a servant, the doctrine of common employment still protected the master; and where, under the Employers' Liability Act, it failed to do so, the liability was of a limited character and often, owing to technicalities of procedure, difficult to enforce. Moreover, there is nothing in the act to prevent master and servant from entering into any special contract they please; and in many trades it became a common practice for contracts to be made wholly excluding the operation of the act. In 1893 an attempt was made to alter the law by a total abolition of the defence of common employment, so as to make a master as liable to a servant as to a stranger for the negligence of any of his servants acting in the course of their employment, and at the same time to prohibit any agreements to forego the rights so given to the servant. The bill did not become law, and no further change was made until, in 1897, parliament took the first step in what has been a complete revolution in the law of employers' liability. Up to that year, as has been seen, the foundation of a master's liability was negligence, either of the master himself, or, in certain cases, of his servants. But by the Workmen's Compensation Act 1897, a new principle was introduced, whereby certain servants in certain employments were given a right to compensation for injuries, wholly irrespective of any consideration of negligence or contributory negligence. As regards such servants in such employments the master was in effect made an insurer against accidental injuries. The act was confessedly tentative and partial; it dealt only with selected industries, and even within these industries was not of universal application. But where it did apply, it gave a right to a limited compensation in every case of injury by accident arising out of and in the course of the employment, whether that accident had been brought about by negligence or not, and whether the injured servant had or had not contributed to it by his own negligence.

The act applied only to employment on, or in, or about certain localities where, at the same time, the employer was what the act called an "undertaker," that is, the person whose business was there being carried on. If we wanted to know whether a workman was within the act, we had to ask, first, was he employed on, or in, or about a railway, or a factory, or a mine, or a quarry, or an engineering shop, or a building of the kind mentioned in the act; secondly, was he employed by one who was, in relation to that railway, &c., the undertaker as defined by the act; and thirdly, was he at the time of the accident at work on, or in, or about that railway, &c. Unless these three conditions were fulfilled the employment was not within the act.

The employments to which the act applied comprised railways, factories (which included docks, warehouses and steam laundries), mines, engineering works and most kinds of buildings. "Workman" included every person engaged in an employment to which the act applied, whether by manual labour or otherwise, and whether his agreement was one of service or apprenticeship or otherwise, expressed or implied, oral or in writing.

By the Workmen's Compensation Act 1900, the benefits of the act of 1897 were extended to agricultural labourers.

The Workmen's Compensation Act 1906 (which came into force on the 1st of July 1907) extended the right of compensation for injuries practically to all persons in service, and also introduced many provisions not contained in the acts of 1897 and 1900 (repealed). It does not apply to persons in the naval or military service of the crown (s. 9), or persons employed otherwise than by way of manual labour whose remuneration exceeds two hundred and fifty pounds a year, or persons whose 359
employment is of a casual nature, and who are employed otherwise than for the purposes of the employer's trade or business, or members of a police force, or out-workers, or members of the employer's family dwelling in his house. But it expressly applies to seamen.

Conditions of claim.

To entitle a workman engaged in an employment to which the act applies to compensation all the following conditions must be fulfilled: (1) There must be personal injury by accident. This will exclude injury wilfully inflicted, unless the injury results in death or serious and permanent disablement, but the act introduces a new provision by making the suspension or disablement from work or death caused by certain industrial diseases "accidents" within the meaning of the act. The industrial diseases specified in the 3rd schedule of the act were anthrax, ankylostomiasis, and lead, mercury, phosphorus and arsenic poisoning or their sequelae. But § 8 of the act authorized the secretary of state to make orders from time to time including other industrial diseases, and such orders have embraced glass workers' cataract, telegraphists' cramp, eczematous ulceration of the skin produced by dust or liquid, ulceration of the mucous membrane of the nose or mouth produced by dust, &c. To render the employer liable the workman must either obtain a certificate of disablement or be suspended or die by reason of the disease. If the disease has been contracted by a gradual process, all the employers who have employed the workman during the previous twelve months in the employment to which the disease was due are liable to contribute a share of the compensation to the employer primarily liable. (2) The accident must arise out of and in the course of the employment. In each case it will have to be determined whether the workman was at the time of the accident in the course of his employment, and whether the accident arose out of the employment. It will have to be considered when and where the particular employment began and ended. Other difficulties have arisen and will frequently arise when the workman at the time of the accident is doing something which is no part of the work he is employed to do. So far as the decisions have gone, they indicate that if what the workman is doing is no act of service, but merely for his own pleasure, or if he is improperly meddling with that which is no part of his work, the accident does not arise out of and in the course of his employment; but if, while on his master's work, he upon an emergency acts in his master's interest, though what he does is no part of the work he is employed to do, the accident does arise out of and in the course of his employment. (3) The injury must be such as disables the workman for a period of at least one week from earning full wages at the work at which he was employed. (4) Notice of the accident must be given as soon as practicable after the happening thereof, and before the workman has voluntarily left the employment in which he was injured; and the claim for compensation (by which is meant notice that he claims compensation under the act addressed by the workman to the employer) must be made within six months from the occurrence of the accident or, in case of death, from the time of death. Want of notice of the accident or defects in it are not to be a bar to proceedings, if occasioned by mistake or other reasonable cause, and the employer is not prejudiced thereby. But want of notice of a claim for compensation is a bar to proceedings, unless the employer by his conduct has estopped himself from relying upon it. (5) An injured workman must, if so required by the employer, submit himself to medical examination.

When these conditions are fulfilled, an employer who is within the act has no answer unless he can prove that the injury arose from the serious and wilful misconduct of the workman. The precise effect of these terms is not clear; but mere negligence is not within them.

Where the injury causes death, the right to compensation belongs to the workman's "dependents"; that is, such of the members of the workman's family as were at the time of the death wholly or in part dependent upon the earnings of the workman for their maintenance. "Members of a family" means wife or husband, father, mother, grandfather, grandmother, step-father, step-mother, son, daughter, grandson, granddaughter, step-son, step-daughter, brother, sister, half-brother, half-sister. The act of 1906 makes also a very remarkable departure in including illegitimate relations in the direct line among "dependents," for where a workman, being the parent or grandparent of an illegitimate child, leaves such a child dependent upon his earnings, or, being an illegitimate child, leaves a parent or grandparent so dependent upon his earnings, such child or parent is to be included in the "members of a family."

Amount.

Under the act compensation is for loss of wages only, and is, as has been said, based upon the actual previous earnings of the injured workman in the employment of the employers for whom he is working at the time of the injury. In case of death, if the workman leaves dependents who were wholly dependent on his earnings, the amount recovered is a sum equal to his earnings in the employment of the same employer during the three years next preceding the injury, or the sum of £150, whichever is the larger, but not exceeding £300; if the period of his employment by the same employer has been less than three years, then the amount of his earnings during the three years is to be deemed to be 156 times his average weekly earnings during the period of his actual employment under the said employer. If the workman leaves only dependents who were not wholly dependent, the amount recovered is such sum as may be reasonable and proportionate to the injury to them, but not exceeding the amount payable in the previous case. If the workman leaves no dependents, the amount recoverable is the reasonable expenses of his medical attendance and burial, not exceeding £10. In case of total or partial incapacity for work resulting from the injury, what is recovered is a weekly payment during the incapacity after the second week not exceeding 50% of the workman's average weekly earnings during the previous twelve months, if he has been so long employed, but if not, then for any less period during which he has been in the continuous employment of the same employer; such weekly payment is not to exceed £1—and in fixing it regard is to be had to the difference between the amount of his average weekly earnings before the accident and the average amount which he is able to earn after the accident. Any payments, not being wages, made by the employer in respect of the injury must also be taken into account. The weekly payment may from time to time be reviewed at the request of either party, upon evidence of a change in the circumstances since the award was made, and after six months may be redeemed by the employer by payment of a lump sum. A workman is within the act although at the time of the injury he has been in the employment for less than two weeks, and although there are no actual earnings from the same employer upon which a weekly average can be computed. But how are the average weekly earnings which he would have earned from the same employer to be estimated? The question must be determined as one of fact by reference to all the circumstances of the particular case. Suppose the workman to be engaged at six shillings a day and injured on the first day. If it can be inferred that he would have remained in such employment for a whole week, his average weekly earnings from the same employer may be taken at thirty shillings. If it can be inferred that he would have worked one day and no more, his average weekly earnings from the same employer may be taken at six shillings.

All questions as to liability or otherwise under the act, if not settled by agreement, are referred to arbitration in accordance with a scheme prescribed by the act. Contracting out is not permitted, save in one event: where a scheme of compensation, benefit or insurance for the workmen of an employer has been certified by the Registrar of Friendly Societies to be not less favourable to the workmen and their dependents than the provisions of the act, and that where the scheme provides for contributions by the workmen, it confers benefits at least equal to those contributions, in addition to the benefits to which the workmen would have been entitled under the act, and that a majority (to be ascertained by ballot) of the workmen to whom the scheme is applicable are in favour of it, the employer may contract with any of his workmen that the provisions of the scheme shall be substituted for the act; 360
such certificate may not be for more than five years, and may in certain circumstances be revoked. The act does not touch the workman's rights at common law or under the Employers' Liability Act, but the workman, if more than one remedy is open to him, can enforce only one. When the circumstances create a legal liability in some other person, *e.g.* where the injury is caused by the negligence of a sub-contractor or of a stranger, in such cases the employer, if required to pay compensation under the act, is entitled to be indemnified by such other person.

Under the Factory Acts, offences, when they result in death or bodily injury to health, may be punished by fine not exceeding £100, and the whole or any part of such fine may be applied for the benefit of the injured person or his family, or otherwise as the secretary of state determines. Similar provisions occur in the Mines Acts. Any sum so applied must be taken into account in estimating compensation under the Employers' Liability and Workmen's Compensation Acts.

Germany.

Law in Other Countries.—In *Germany* (*q.v.*) there is a system of compulsory state insurance against accidents to workmen. The law dates from 1884, being amended from time to time (1885, 1886, 1887, 1900, 1903) to embrace different classes of employment. Occupations are grouped into (1) industry; (2) agriculture; (3) building; (4) marine, to all of which one general law, with variations necessary to the particular occupation in question, is applicable. There are also special provisions for prisoners and government officials. Practically every kind of working-man is thus included, with the exception of domestic servants and artisans or labourers working on their own account. All workmen and officials whose salary does not exceed £150 a year come within the law. No compensation is payable where an accident is caused through a person's own gross carelessness, and where an accident has been contributed to by a criminal act or intentional wrongdoing the compensation may be refused or only partially allowed. With these exceptions, compensation for injury is payable in case of injury so long as the injured is unfit to work; in case of total incapacity an allowance is made equal to two-thirds of the injured person's annual earnings, in case of partial incapacity, in proportion to the degree that his wage-earning capacity has been affected. In case of death the compensation is either burial money or an allowance to the family varying in amount from 20 to 60% of the annual earnings according to circumstances. The provision of compensation for accidents falls entirely upon employers, and in order to lighten the burden thus falling upon them, and at the same time to guard against the possible insolvency of an individual employer, associations or self-administering bodies of employers have been formed—usually all the employers of each particular branch of industry in a district. These associations fix the amount of compensation after each accident, and at the end of the year assess the amount upon the individual employers. There is an appeal from the association to an arbitration court, and in particularly complicated cases there may be a further appeal to the imperial insurance department. No allowance is paid until after the lapse of thirteen weeks from the accident, and in the meantime the injured person is supported from a sick fund to which the employers contribute one-third, the employee contributing two-thirds. In Germany quite twelve millions of workpeople are insured; in 1905 a sum of nearly eight millions sterling was paid for accidents, and a million and a half to the families of those killed in accidents.

Austria.

In *Austria* the compulsory insurance of workmen was provided for by a law of 1887, with subsequent amendments. Briefly, nearly every class of industrial worker is included under the Austrian law, which is administered by special territorial insurance institutions, each of them embracing particular classes of industries or workers. The institutions are managed by committees, one-third of the members of each committee being chosen by the minister of the interior, one-third by the employers and one-third by the workers. Compensation is payable, in case of accidents, on a scale proportionate to the injured person's wages during the preceding year. In case of death, a certain sum is paid for funeral expenses, an annuity to the widow, if one is left, equal to 20% of the deceased's annual wages—if the widow remarries, she receives a lump sum equal to three annual payments in liquidation of the annuity—an annuity to each legitimate child equal to 15%, or, if the child has no mother, equal to 20% of the father's wages; an annuity to the father or mother, if dependent on the deceased for support, equal to 20% of the annual wages. As in the English act of 1906 illegitimate children are recognized by being granted an annuity in the case of the death of a father equal to 10% of his wages. In no case can the total amount of the annuities exceed 50% of the deceased's annual wages. Where the accident has resulted in total incapacity, the workman receives an annuity equal to 60% of his wages. No allowance is paid until after the fourth week, during which time the injured is supported by the sick-insurance institutions. The provision for the system is raised by contributions to the extent of nine-tenths by the employers and one-tenth by the workers, deducted from their wages. Instead of the German method by which an annual payment equal to the amount disbursed is required from each employer, he is required to provide the full amount necessary for the complete payment of the pension, this amount being placed to the credit of a special insurance fund.

France.

In *France* a system of compulsory state insurance against accidents was created by a law of 1898. The principal feature in the French law is the attempt to meet the possible insolvency of the employer by the establishment of a special guarantee fund, created by a small addition to the "business tax" (*contribution des patentes*), and, in the case of the mining industry, by a small tax on mines.

Norway.

Norway, by a law of 1894, amended in 1897 and 1899, adopted a system of compulsory insurance modelled to a great extent on the German system. Instead, however, of a trade association as in Germany, or a district insurance association as in Austria, there is a government insurance office, in which employers have to insure their workmen.

Denmark.

In *Denmark* a law was passed in 1897 rendering employers personally liable for the amount of compensation for accidents, but employers may relieve themselves of this liability by insuring workmen in an assurance association approved of by the minister of the interior. This course, however, is discretionary with employers.

Italy.

In *Italy*, although many attempts were made between 1889 and 1898 to introduce a system of compulsory insurance, it was not until the latter year that the principle was adopted. There is a National Bank for the Insurance of Working men against Accident (*Cassa Nazionale di Assicurazione per gli infortuni degli operaji sul lavoro*), created under a law of 1883. It has special privileges, such as exemption from taxation and the employment of the branch offices of the state post-office savings bank as local offices. Under the law of 1898 there is a primary obligation on the employer to insure his workmen with the National Bank, but he may, if he prefers, insure with other societies approved by government. Employers employing about five hundred workmen may, instead of insuring, establish a fund for the payment of not less than the statutory compensation, subject to giving adequate security for the sufficiency of the fund. Exemption from compulsory insurance is granted to employers who have established a mutual insurance association, which must comply with certain prescribed conditions. Railway companies, also, are exempt, if they have relief funds which conform with the provisions of the act.

Spain.

In *Spain* an act of the 30th of January 1900, adopted the principle of the personal responsibility of the employer for accidents to workmen other than those due to vis major. The act also lays down regulations for preventing accidents in dangerous trades, and releases the employer from personal liability on effecting adequate insurance of his workmen with an approved insurance company.

Holland.

Holland has adopted the principle of compulsory insurance by a law of the 2nd of January 1901. An employer has to pay the necessary premium to the State Insurance Office, or by depositing adequate security with the State Office he may undertake the payment of 361
the prescribed compensation himself. Or he may transfer his liability to an insurance company, provided the company deposit adequate security with the State Office. The State Insurance Office is under the management of directors appointed by the crown, and decides on all questions as to compensation; there is also a "Supervisory Board" of the State Office with joint representation of employers and workmen. There is an appeal from the State Office to Councils of Appeal, and from them to a National Board of Appeal.

Greece.

Greece has a law of the 21st of February 1901, providing for compensation for accidents causing incapacity of more than four days' duration to workmen in mines, quarries and smelting works. The employer is exclusively liable for such compensation and for medical expenses during the first three months; after that time he is liable for one-half, the other half being borne by a miners' provident fund, supported by certain taxes on the properties affected, fines, &c.

Sweden.

By a law of the 5th of July 1901, *Sweden* adopted the principle of the personal liability of the employer for industrial accidents. The employer can, however, insure himself against liability in the Royal Insurance Institute. Compensation becomes payable after the expiration of sixty days from the date of the accident.

Russia.

Russia has a law which came into force on the 1st of January 1904. Under this law employers in certain specified industries are bound to indemnify workers for incapacity of more than three days' duration due to injury arising out of their work. Employers are exempt from liability by insuring their workmen in insurance companies whose terms are not less favourable than those laid down by the law.

Belgium.

Belgium passed a law dealing with industrial accidents on the 24th of December 1903. It adopts the principle of the personal liability of the employer in certain specified trades or industries. There is a power of extension to such other undertakings as may be declared dangerous by the Commission on Labour Accidents. Employers may exempt themselves from their liability by contracting for the payment of compensation by an insurance company approved by the government or by the National Savings and Pension Fund. Where an employer does not so contract, he must (with certain exemptions) contribute to a special insurance fund. The law of 1903 also established a permanent Commission on Labour Accidents.

Switzerland.

Switzerland in 1899 adopted a law providing for accident insurance, but it was defeated on referendum in May 1900.

United States.

In the *United States* the law mainly depends on the doctrine of common employment, and the extent to which this doctrine is applied varies considerably in the different states, more particularly as to who are and who are not to be regarded as fellow-servants. The tendency, however, has been to increase the liability of the employer for the negligence of a fellow-servant, and in the case of employment on railways many states have passed laws either modifying or abrogating the doctrine. Colorado, by a law of 1901, has entirely abrogated it; and Alabama, Massachusetts and New York have laws generally similar to the English act of 1880. But the greatest departure, due to the initiative of President Roosevelt, has been the passing by the Federal Congress of the laws of April 22 and May 30, 1908, one giving damages to injured employees of interstate carriers by railroad, and common carriers by railroad in Territories, the District of Columbia, the Canal Zone and other territory governed by Congress, and the other giving regular wages for not more than one year to injured employees of the U.S. government in arsenals, navy yards, construction work on rivers, harbours and fortifications, hazardous work in connexion with the Panama Canal or Reclamation Service, and in government manufacturing establishments. These national laws, which were intended to serve as an example to the states, specifically provided for employers' liability and for the non-recognition of the doctrine of common employment.

British Colonies.

Most of the British colonial states have adopted the principle of the English Workmen's Compensation Act of 1897, and the various colonial acts are closely modelled on the English act, with more or less important variations in detail. The New Zealand Act was passed in 1900, and amended in 1901, 1902, 1903 and 1905. The act of 1905 (No. 50) fixes the minimum compensation for total or partial disablement at £1 a week when the worker's previous remuneration was not less than 30s. a week. South Australia passed a Workmen's Compensation Act in 1900 and Western Australia one in 1902. New South Wales passed one in 1905, and British Columbia in 1902.

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1 "Employ" comes through Fr. from Lat. *implicare*, to enfold, Late Lat. to direct upon something.

EMPOLI, a town of Tuscany, Italy, in the province of Florence, from which it is 20 m. W. by S. by rail. Pop. (1901) 7005 (town); 20,301 (commune). It is situated 89 ft. above sea-level, to the S. of the Arno. The principal church, the Collegiata, or Pieve di S. Andrea, founded in 1093, still preserves the lower part of the original arcaded façade in black, white and coloured marble. The works of art which it once contained are most of them preserved in a gallery close by. Some of the other churches contain interesting works of art. The principal square is surrounded by old houses with arcades. The painter Jacopo Chimenti (Jacopo da Empoli), 1554-1640, was born here. Empoli is on the main railway line from Florence to Pisa, and is the point of divergence of a line to Siena.

EMPORIA, a city and the county-seat of Lyon county, Kansas, U.S.A., on the Neosho river, about 60 m. S.W. of Topeka. Pop. (1890) 7551; (1900) 8223, of whom 686 were foreign-born and 663 were negroes; (1910 U.S. census) 9058. It is served by the Atchison, Topeka & Santa Fé, and the Missouri, Kansas & Texas railways. The city has a Carnegie library, and is the seat of the state normal school and of the College of Emporia (Presbyterian; 1883). Emporia's industrial interests are mainly centred in commerce with the surrounding farming region; but there are small flour mills, machine shops, foundries and other manufacturing establishments,—in 1905 the value of the factory product was $571,601. The municipality owns and operates the water-works and the electric-lighting plant. Emporia was settled in 1856 and was chartered as a city in 1870. The Emporia *Gazette*, established in 1890, was purchased in 1894 by William Allen White (b. 1868), a native of Emporia, who took over the editorship and made a great stir in 1896 by his editorial entitled "What's the matter with Kansas?"; he also wrote several volumes of excellent short stories, particularly *The Court of Boyville* (1889), *Stratagems and Spoils* (1901) and *In Our Town* (1906).

EMPORIUM (a Latin adaptation of the Gr. ἐμπόριον, from ἐν, in, and stem of πορεύεσθαι, to travel for purpose of trade) a trade-centre such as a commercial city, to which buyers and dealers resort for transaction of business from all parts of the world. The word is often applied to a large shop.

EMPSON, SIR RICHARD (d. 1510), minister of Henry VII., king of England, was a son of Peter Empson, an influential inhabitant of Towcester. Educated as a lawyer he soon attained considerable success in his profession, and in 1491 was one of the members of parliament for Northamptonshire and speaker of the House of Commons. Early in the reign of Henry VII. he became associated with Edmund Dudley (*q.v.*) in carrying out the king's rigorous and arbitrary system of taxation, and in consequence he became very unpopular. Retaining the royal favour, however, he was made a knight in 1504, and was soon high steward of the university of Cambridge, and chancellor of the duchy of Lancaster; but his official career ended with Henry's death in April 1509. Thrown into prison by order of the new king, Henry VIII., he was charged, like Dudley, with the crime of constructive treason, and was convicted at Northampton in October 1509. His attainder by the parliament followed, and he was beheaded on the 17th or 18th of August 1510. Empson left, so far as is known, a family of two sons and four daughters, and about 1513 his estates were restored to his elder son, Thomas.

See Francis Bacon, *History of Henry VII.*, edited by J.R. Lumby (Cambridge, 1881); and J.S. Brewer, *The Reign of Henry VIII.*, edited by J. Gairdner (London, 1884).

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EMPYEMA (from Gr. ἐν, within, and πῦον, pus), a term in medicine applied to an accumulation of purulent fluid within the cavity of the pleura (see Lung: *Surgery*).

EMPYREAN (from the Med. Lat. *empyreus*, an adaptation of the Gr. ἔρπνρος, in or on the fire, πῦρ), the place in the highest heaven, which in ancient cosmologies was supposed to be occupied by the element of fire. It was thus used as a name for the firmament, and in Christian literature for the dwelling-place of God and the blessed, and as the source of light. The word is used both as a substantive and as an adjective. Having the same Greek origin are the scientific words "empyreuma" and "empyreumatic," applied to the characteristic smell of burning or charring vegetable or animal matter.

EMS, a river of Germany, rising on the south slope of the Teutoburger Wald, at an altitude of 358 ft., and flowing generally north-west and north through Westphalia and Hanover to the east side of the Dollart, immediately south of Emden. After passing through the Dollart the navigable stream bifurcates, the eastern Ems going to the east, and the western Ems to the west, of the island of Borkum to the North Sea. Length, 200 m.

Between 1892 and 1899 the river was canalized along its right bank for a distance of 43 m. At the same time, and as part of the same general plan, a canal, the Dortmund-Ems Canal, was dug to connect the river (from Münster) with Herne in the Westphalian coal-field. At Henrichenburg a branch from Herne (5 m. long) connects with another branch from Dortmund (10½ m. long). Another branch, from Olfen (north of Dortmund), connects with Duisburg, and so with the Rhine. There is, however, a difference in elevation of 46 ft. between the two branches first named, and vessels are transferred from the one to the other by means of a huge lift. The canal, which was constructed to carry small steamers and boats up to 220 ft. in length and 750 tons burden, measures 169 m. in length, of which 108½ m. were actually dug, and cost altogether £3,728,750. The surface width throughout is 98½ ft., the bottom width 59 ft., and the depth 8⅙ ft.

See Victor Kurs, "Die künstlichen Wasserstrassen des deutschen Reichs," in *Geog. Zeitschrift* (1898), pp. 601-617 and 665-694; and *Deutsche Rundschau f. Geog. und Stat.* (1898), pp. 130-131.

EMS, a town and watering-place of Germany, in the Prussian province of Hesse-Nassau, romantically situated on both banks of the Lahn, in a valley surrounded by wooded mountains and vine-clad hills, 11 m. E. from Coblenz on the railway to Cassel and Berlin. Pop. 6500. It has two Evangelical, a Roman Catholic, an English and a Russian church. There is some mining industry (silver and lead). Ems is one of the most delightful and fashionable watering-places of Europe. Its waters—hot alkaline springs about twenty in number—are used both for drinking and bathing, and are efficacious in chronic nervous disorders, feminine complaints and affections of the liver and respiratory organs. On the right bank of the river lies the Kursaal with pretty gardens. A stone let into the promenade close by marks the spot where, on the 13th of July 1870, King William of Prussia had the famous interview with the French ambassador Count Benedetti (*q.v.*) which resulted in the war of 1870-1871. A funicular railway runs up to the Malberg (1000 ft.), where is a sanatorium and whence extensive views are obtained over the Rhine valley. Ems is largely frequented in the summer months by visitors from all parts of the world—the numbers amounting to about 11,000 annually—and many handsome villas have been erected for their accommodation. In August 1786 Ems was the scene of the conference of the delegates of the four German archbishops, known as the congress of Ems, which issued (August 25) in the famous joint pronouncement, known as the Punctation of Ems, against the interference of the papacy in the affairs of the Catholic Church in Germany (see Febronianism).

See Vogler, Ems, *seine Heilquellen, Kureinrichtungen*, &c. (Ems, 1888); and Hess, *Zur Geschichte der Stadt Ems* (Ems, 1895).

EMSER, JEROME, or Hieronymus (1477-1527), antagonist of Luther, was born of a good family at Ulm on the 20th of March 1477. He studied Greek at Tübingen and jurisprudence at Basel, and after acting for three years as chaplain and secretary to Raymond Peraudi, cardinal of Gurk, he began lecturing on classics in 1504 at Erfurt, where Luther may have been among his audience. In the same year he became secretary to Duke George of Albertine Saxony, who, unlike his cousin Frederick the Wise, the elector of Ernestine Saxony, remained the stanchest defender of Roman Catholicism among the princes of northern Germany. Duke George at this time was bent on securing the canonization of Bishop Benno of Meissen, and at his instance Emser travelled through Saxony and Bohemia in search of materials for a life of Benno, which he subsequently published in German and Latin. In pursuit of the same object he made an unsuccessful visit to Rome in 1510. Meanwhile he had also been lecturing on classics at Leipzig, but gradually turned his attention to theology and canon law. A prebend at Dresden (1509) and another at Meissen, which he obtained through Duke George’s influence, gave him means and leisure to pursue his studies.

At first Emser was on the side of the reformers, but like his patron he desired a practical reformation of the clergy without any doctrinal breach with the past or the church; and his liberal sympathies were mainly humanistic, like those of Erasmus and others who parted company with Luther after 1519. As late as that year Luther referred to him as “Emser noster,” but the disputation at Leipzig in that year completed the breach between them. Emser warned his Bohemian friends against Luther, and Luther retorted with an attack on Emser which outdid in scurrility all his polemical writings. Emser, who was further embittered by an attack of the Leipzig students, imitated Luther’s violence, and asserted that Luther’s whole crusade originated in nothing more than enmity to the Dominicans, Luther’s reply was to burn Emser’s books along with Leo X.’s bull of excommunication.

Emser next, in 1521, published an attack on Luther’s “Appeal to the German Nobility,” and eight works followed from his pen in the controversy, in which he defended the Roman doctrine of the Mass and the primacy of the pope. At Duke George’s instance he prepared, in 1523, a German translation of Henry VIII.’s “Assertio Septem Sacramentorum contra Lutherum,” and criticized Luther’s “New Testament.” He also entered into a controversy with Zwingli. He took an active part in organizing a reformed Roman Catholic Church in Germany, and in 1527 published a German version of the New Testament as a counterblast to Luther’s. He died on the 8th of November in that year and was buried at Dresden.

Emser was a vigorous controversialist, and next to Eck the most eminent of the German divines who stood by the old church. But he was hardly a great scholar; the errors he detected in Luther’s New Testament were for the most part legitimate variations from the Vulgate, and his own version is merely Luther’s adapted to Vulgate requirements.

Bibliography.—Waldau, *Nachricht von Hieronymus Emsers Leben und Schriften* (Anspach, 1783); Kawerau, *Hieronymus Emser* (Halle, 1898); *Akten und Briefe zur Kirchenpolitik Herzog Georgs von Sachsen* (Leipzig, 1905); *Allgemeine deutsche Biographie*, vi. 96-98 (1877). All histories of the Reformation in Germany contain notices of Emser; see especially Friedensburg, *Beiträge zum Briefwechsel der katholischen Gelehrten Deutschlands im Reformationszeitalter*.

(A. F. P.)

ENAMEL (formerly "amel," derived through the Fr. *amail, esmal, esmail*, from a Latin word *smaltum*, first found in a 9th-century life of Leo IV.), a term, strictly speaking, given to the hard vitreous compound, which is "fused" upon the surface of metallic objects either for the purpose of decoration or utility. This compound is a form of glass made of silica, minium and potash, which is stained by the chemical combination of various metallic oxides whilst in a melted condition in the crucible. This strict application of the term was widened to signify the metal object coated with enamel, so that to-day the term "an enamel" generally implies a work of art in enamel upon metal. The composition of the substance enamel which is used upon metal does not vary to any great extent from the enamels employed upon pottery and faience. But they differ in this respect, that the pottery enamel is usually applied to the "biscuit" surface of the ware in a raw state; that is, the compound has 363
not been previously "run down" or vitrified in the crucible by heat, as is the case with enamelling upon metal, although, in most of the enamelled iron advertisement tablets, the enamel is in the raw state and is treated in a similar manner to that employed upon pottery.

Examination of the enamels upon brick of the Assyrians shows that they were applied unvitrified. It was upon pottery and brick that the ancient Egyptians and Assyrians achieved their greatest work in enamelling. For as yet no work of such magnificence as the great enamelled walls of the palace of Rameses III. at Tell el-Yehudia in the Delta of the Nile, or the palace of Nimrod in Babylon, has been discovered upon metal of any kind. But there were gold ornaments and jewelry enamelled of noble design in opaque turquoise, cobalt, emerald green and purple, some of which can be seen at the British Museum and the Louvre. An example is shown in Plate I. fig. 3.

In the subsequent Greek and Roman civilizations enamel was also applied to articles of personal adornment. Many pieces of jewelry, exquisite in workmanship, have been found. But a greater application was made of it by the Greek sculptors in the 4th and 5th centuries B.C. For we find, in many instances, that not only were the eyes made of enamel—which (artistically speaking) is a somewhat doubtful manner of employing it,—as in the fine bronze head found at Anticythera (Cerigotto) in 1902, but in the colossal figure of Zeus for the temple at Olympia made by Pheidias the gold drapery was gorgeously enamelled with figures and flowers. This wonderful work by the greatest sculptor the world has ever seen was destroyed, as so many priceless works of art in enamel have been: doubtless on account of the precious metal upon which they were made. It was in all probability the crowning triumph of a long series of essays in this material. The art of ancient Rome lacked the inspiration of Greece, being mainly confined to copying Greek forms and style, and in the case of enamelling it did not depart from this attitude. But the Roman and Etruscan glass has many beautiful qualities of form and colour that do not seem entirely borrowed, and the enamel work upon them so far as we can discern is of graceful design and rich colour. No doubt, were it not, as has been remarked, for the fact that enamelling was generally done upon gold and silver, there would still be many works to testify to the art of that period. Such as there are, however, show a rare appreciation of enamel as a beautiful material. With the decline of this civilization the art of enamelling probably died out. For it has ever been one of those exquisite arts which exist only under the sunshine of an opulent luxurious time or sheltered from the rude winds of a poorer age by the affluence of patrons. The next time we hear of it is in an oft-quoted passage (*c.* A.D. 240) from the writings of the great sophist Philostratus, who says (*Icones*, i. 28):—"It is said that the barbarians in the ocean pour these colours into bronze moulds, that the colours become as hard as stone, preserving the designs,"—a more or less inaccurate description of the process of *champlevé*. This has been understood (from an interpretation given to a passage in the commentary on it by Olearius) to refer to the Celts of the British Islands. It also goes to prove that enamelling was not practised at this day in Greece. We have no British enamels to show so early as this, but belonging to a later period, from the 6th to the 9th century, a number of the finest gold and bronze ornaments, horse trappings, shields, fibulae and ciboria have been discovered of Celtic and Saxon make. The Saxon work has nothing to show so exquisitely wrought as that found in Ireland, where one or two pieces are to be seen now in the Dublin Museum, notably the Ardagh chalice and some gold brooches. In the chalice the enamel is of a minute inlaid character, and appears to have been made first in the form of a multi-colour bead, which was fused to the surface of its setting, and then polished down. Many of the pieces seem to have been made after this fashion, which does not speak very highly of the technical knowledge of enamelling, but it is none the less true enamelling of an elementary character. The shield at the British Museum has an inlay of red enamel which is remarkable in its quality. For centuries such a fine opaque red has not been discovered. An example of Irish work is shown in Plate II. fig. 10.

From Ireland the art was transferred to Byzantium, which is to be seen by the close resemblance of method, style, design and colour. The style and design changed in course of time, but the craft remained. It was at Byzantium that it flourished for several centuries.

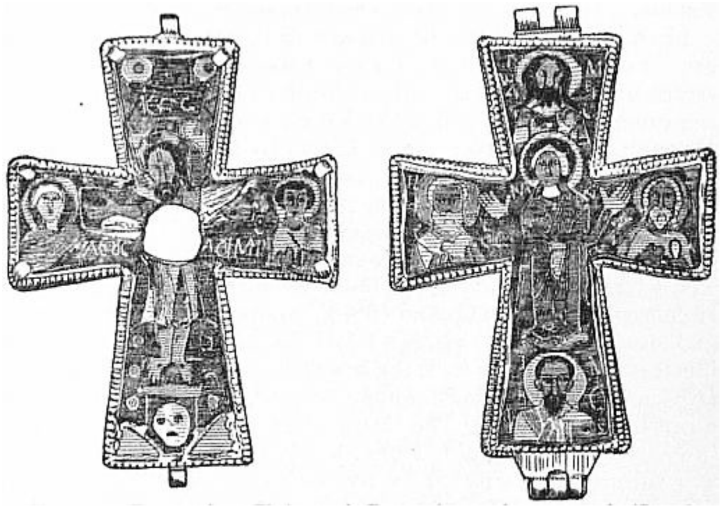


Fig. 1.—Byzantine Cloisonné Cross (*c.* 11th century) (South Kensington Museum).

The finest work we know of belonging to this period is the Pala d’Oro at St Mark’s, Venice, believed to have been brought from Constantinople to Venice about 1105. This magnificent altar-piece is in *cloisonné* enamel. A typical example is the ciborium and chalice belonging to the South Kensington loan collection. The design entirely covers the whole of the surface in one rich mass composed of circular or vesica-shaped medallions filled with sacred subjects and foliated scrolls. These are engraved and enamelled, and the metal bands of the scrolls and figures are engraved and gilt. The characteristic quality of the colour scheme is that it is composed almost wholly of primaries. Red, blue and yellow predominate, with a little white and black. Occasionally the secondaries, green and purple, are used, but through the whole period of Byzantine enamelling there is a total absence of what to-day is termed “subtle colouring.” The arrangement of the enamels is also distinct, in that the divisions of the colours are not always made by the cloison, but are frequently laid in side by side without the adjoining colours mingling or running together whilst being melted. For instance, in a leaf pattern or in the drapery, the dress may be cobalt, heightened with turquoise or green. Thus it is interesting to observe that the artist employed the metal dividing lines frequently for the sake of aesthetic result, and was not much hampered by technical difficulties. This was the rule when opaque enamels were used. It is also worthy of remark that these opaque enamels differ from those in common use to-day, in that they are not nearly so opaque. This quality, together with a dull, instead of a highly polished surface, gives a much softer appearance to the enamels. Again, the whole tone of the enamels is darker and richer. Many examples of Byzantine work (see fig. 1.) are to be seen in the public and private art collections throughout Europe. They are principally upon ecclesiastical objects, missal covers, croziers, chalices, ciboria, pyx, candlesticks, crosses and tabernacles. In most instances the enamels are made in separate little plates rudely fastened with nails, screws or rivets to a metal or wooden foundation. Theophilus, a monk of the 13th century, describes the process of enamelling as it was understood by the Byzantines of his time, which probably differed but little from earlier methods. The design and drawing of the figures in Byzantine enamels is similar to the mosaic and carving. The figures are treated entirely as decorations, with scarcely ever the least semblance of expression, although here and there an intention of piety or sorrow is to be descried through the awkward postures in which they are placed. In spite of this, the sense of decorative design, the simplicity of 364
conception, the strength of the general character, and the richness of the colour, places this period as one of the finest which the art of enamelling has seen, and it leads us to lay stress upon the principle that the simplest methods in design and manipulation attain a higher end than those which are elaborate and intricate. It might be asserted with truth that this style never arrived at the degree of delicacy and refinement of later styles. But the refinement was often at the expense of higher qualities.

The next great application of these kinds of enamelling was at Cologne, for there we find not only the renowned work of Nicolas of Verdun, the altar front at Klosterneuberg, which consists of fifty plates in *champlevé* enamel, but in that Rhenish province there are many shrines of magnificent conception. From here the secrets of the craft were taken to Limoges, where the greatest activity was displayed, as numerous examples are found throughout England, France and Spain, which no doubt were made there (see Plate I. fig. 6.) But no new method or distinct advance is to be noticed, during these successive revivals at Byzantium, Cologne or Limoges, and it is to early 14th-century Italy that we owe one of the most beautiful developments, that of the process subsequently called *basse-taille*, which signifies a low-cut relief upon which transparent enamel is fused.

In this process enamelling passed from a decorative to a fine art. For it demanded the highest knowledge of an artist with the consummate skill of both sculptor and enameller. Witness the superb gold cup, called the King’s Cup, now in the British Museum, and the silver cup at King’s Lynn. The first is in an excellent state of preservation, as it is upon gold, but the latter, like most of the ancient enamelling upon silver, has lost most of its enamel. This was due—as the present writer believes after much experiment—to the impurity of the silver employed. The King’s Cup is one of the finest works in enamelling extant. It consists of a gold cup and cover, hammered out of pure gold; and around the bowl, base and cover there are bands of figures, illustrating the scenes from the life of St Agnes. The hands and faces are of pale jasper, which over the carved gold gives a beautiful flesh tone. The draperies are in most resplendent ruby, sapphire, emerald, ivory, black and orange. The stem was subsequently altered by an additional piece inserted and enamelled with Tudor roses. It is a work of the 13th century, and belonged to Jean, duc de Berry, who gave it to his nephew, Charles VI. of France, in 1391. It afterwards came into the possession of the kings of England, from Henry VI. to James I., who gave it to Don Juan Velasco, constable of Castile. It was purchased by subscription with the aid of the treasury for the British Museum.

Other well-known pieces are the silver horn in the possession of the marquess of Aylesbury, and the crozier of William of Wykeham at New College, Oxford. The discovery about the same time of the process called *plique-à-jour* forms another most interesting and beautiful development. Owing to the difficulty of its manufacture and its extreme fragility there are very few examples left. One of the finest specimens is now at the Victoria and Albert Museum, South Kensington. It is in the form of two bands of emerald green enamel which decorate a silver beaker. They are in the form of little stained glass windows, the cloisons forming (as it were) the leads. These fine cloisons and shapes are most correct in form, and the whole piece shows a perfection of craftsmanship rarely equalled.

The end of the 15th century saw a development in enamelling which was not only remarkable, but revolutionary in its method. For until then the whole theory of enamelling had been that it relied upon the enclosing edges of the metal or the cloison to hold it to the metal ground and in part to preserve it in the shape of the pattern, much in the same way as a setting holds a stone or a jewel. All the enamel before this date had been sunk into cells or cloisons. Two discoveries were made; first, that enamels could be made which require no enclosing ribbon of metal, but that merely the enamel should be fused on both sides of the metal object; secondly, that after an enamel had been fused to a surface of metal, another could be superimposed and fused to the first layer without any danger of separation from each or from the metal ground. It is true that such processes had been employed upon glass on which enamel had been applied, as well as upon pottery; and it is probably due to the influence of a knowledge of both enamelling upon metal and upon glass or pottery that the discovery was made.

In most of these enamel paintings the subject was laid on with a white enamel upon a dark ground. The white was modulated; so that possessing a slight degree of translucency, it was grey in the thin parts and white in the thick. Thus was obtained a certain amount of light and shade. This gave the process called *grisaille*. But strange to say, it was not until a later period that this was practised alone, and then the modelling of the figures and draperies became very elaborate. At first it was only done in a slight degree, just sufficiently to give expression and to add to the richness of the form. For the enamellers were thinking of a plate upon which to put their wonderful colours, and not only of form. The painting in white was therefore invariably coloured with enamels. Probably the earliest painter in enamel was Nardon Pénicaud, many of whose works (one of them, dated 1503, is in the Cluny Museum) have been preserved with great care. He had many followers, the most distinguished of whom was Léonard Limosin (*i.e.* of Limoges). He excelled in portraiture. Examples of his work (between 1532 and 1574) are to be found in most of the larger public and private collections. Léonard Limosin and his Limoges contemporaries were very largely addicted to the employment of foil, which became too largely used, thus spoiling their otherwise fine serious work.

The family of Jean Pénicaud, Jean Court de Vigier, Pierre Raymond and Pierre Courteys were all great names of artists who excelled in the *grisaille* process. *Grisaille* is similar to *pâte-sur-pâte* in pottery, and depends for its attractive quality entirely upon form and composition. No comparison should be made with enamels in colour, for they occupy a different category—similar to cameo.

The casket shown in Plate II. fig. 9 is by Jean Pénicaud. It is a fine example of the enamelling in this style, very beautiful in colour. The hands and faces are in opaque white enamel; the draperies, garlands and flowers are in transparent green, turquoise blue, purple and cobalt over foil. The background is in transparent violet over white enamel ground, which is *semé* with gold stars. The draperies are also heightened with gold.

One of the most marvellous pieces of brilliant craft is the missal cover (Plate I. fig. 5) at the South Kensington Museum, said to have belonged to Henrietta Maria, queen of Charles I. The subjects are the "Creation of Adam and Eve" and the "Fountain of Youth." It is about 4 in. by 7 when opened out. The enamel is encrusted upon the figures, ornament and flowers which are beaten up in pure gold into high relief. The extraordinary minuteness and skill of handling, and the extreme brilliancy of the enamels, which are as brilliant to-day as on the day they were made, together form one of the unique specimens of art craftsmanship of the world. To the subdued taste of to-day, however, the effect is tawdry. The conception and design are also alike unworthy of the execution.

Since the Assyrian and Egyptian civilizations, there has been a succession of luxurious developments followed by lapses into the decline and death of the art of enamelling upon metals. In each revival there has been something added to that which was known and practised before. The last revival took place five hundred years ago, accompanying the rebirth of learning and the arts; but after flourishing for over a century, the art gradually fell into disuse, and remained so until the recent revival and further development. The development consists, first, in the more complete knowledge of the technical processes, following upon the great advances which science has made; and secondly, in a finer and more subtly artistic treatment of them. The advance in technical knowledge comprises greater facility and perfection in the production of the substance enamel, and its subsequent application to metal surfaces; more intimate knowledge of metals and their alloys to which it is applied, and greater ease in obtaining them from the metalliferous ores and reducing them to suitable dimensions and surfaces. For instance, it is now a simple matter to obtain perfectly pure copper by means of electricity. Again, formerly a flat sheet of metal was obtained by hammering, which involved an infinite amount of hard labour, whereas it is accomplished to-day with ease by means of flatting and rolling mills: *i.e.* after the metal has been obtained from the ore in the form of an ingot, it is stretched equally to any degree of thinness by steel rollers. Further, the furnaces have been greatly improved by the introduction of gas and electricity as the heating power, instead of the wood or charcoal employed.

PLATE I.

FIG. 3.—GRAECO-BACTRIAN GOLD AMULET, SHOWING THE GOLD STRIP FOR SETTING STONES, WHICH EXEMPLIFIES THE MANNER IN WHICH THE CLOISONS ARE SOLDERED FOR CLOISONNÉ.

FIG. 4.—CHINESE CLOISONNÉ BOWL.

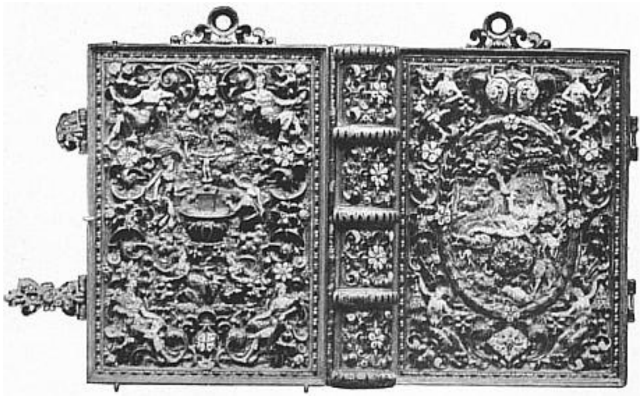


FIG. 5.—MISSAL COVER, ENCRUSTED ENAMEL.

(French, 17th century. Debased style.)

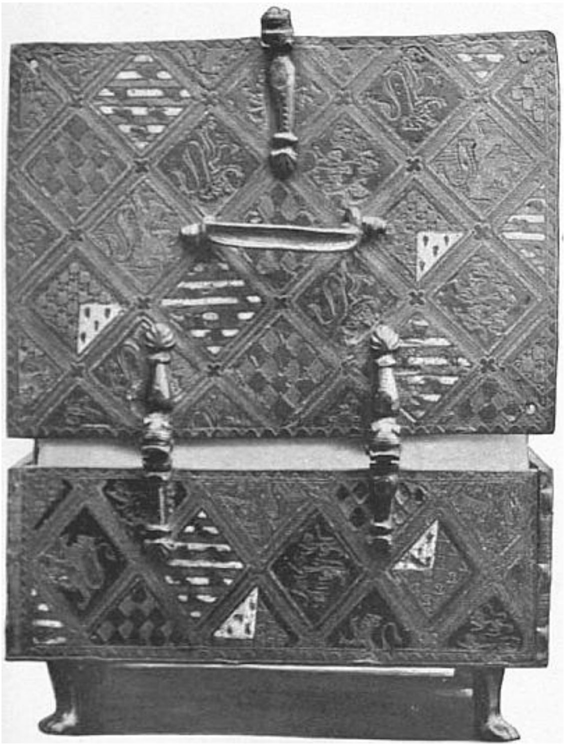


FIG. 6.—BOX IN COPPER PARTLY ENAMELLED IN OPAQUE ENAMELS CHAMPLEVÉ WITH COATS OF ARMS. (13th century, English or German. South Kensington Museum.)

FIG. 7.—PRAYER-BOOK COVER IN ENAMEL AND SILVER GILT, SET WITH RUBIES AND EMERALDS, BY ALEXANDER FISHER. (Size, closed, 4 × 3 in.)

PLATE II.

Fig. 8.—OVERMANTEL (24 × 18½ in.) IN CHAMPLEVÉ ENAMEL ON SILVER. SUBJECT: THE GARDEN OF THE SOUL. BY ALEXANDER FISHER.

Fig. 9.—PAINTED ENAMEL CASKET BY JEAN PÉNICAUD. (16th century.)

Fig. 10.—CELTIC CHAMPLEVÉ ENAMELLED CROZIER. (Irish, 9th century.)

In the manufacture of the substance enamel a much greater advance has been made, for whereas the colours, and consequently the schemes of colour, were extremely limited, we now possess an infinite gradation in the colours, as well as the transparency and opacity, the hardness and softness of enamels. There are only two colours which cannot yet be obtained; these are opaque vermilion and lemon yellow in a vitrified state. Many of the colours we now employ were not known by enamellers such as Léonard Limosin. Our enamels are also perfect in purity, brilliancy and durability, qualities which are largely due to the perfect knowledge of the proportion of parts composing an enamel and their complete combination. It is this complete combination, together with the absence of any destructible matter, which gives the enamel its lasting quality.

The base of enamel is a clear, colourless, transparent vitreous compound called flux, which is composed of silica, minium and potash. This flux or base—termed *fondant* in France—is coloured by the addition of oxides of metals while in a state of fusion, which stain the flux throughout its mass. Enamels are either hard or soft, according to the proportion of the silica to the other parts in its composition. They are termed hard when the temperature required to fuse them is very high. The harder the enamel the less liable is it to be affected by atmospheric agencies, which in soft enamels produce a decomposition of the surface first and ultimately of the whole enamel. It is therefore advisable to use hard enamels in all cases. This involves the employment of pure—or almost pure—metals for the plates, which are in most respects the best to receive and retain the enamel. For if there is an excess of alloy, either the metal will possibly melt before the enamel is fused or afterwards they will part company. To the inferior quality of old silver may be attributed the fact that in all cases the enamel has flown off it; if it has not yet wholly disappeared it will scale off in time. It is therefore essential that metals should be pure and the enamels hard. It is also noteworthy that enamels composed of a great amount of soda or potash, as compared with those wherein red lead is in greater proportion, are more liable to crack and have less cohesion to the metals. It is better not to use silver as a base, although it is capable of reflecting a higher and more brilliant white light than any other metal. Fine gold and pure copper as thin as possible are the best metals upon which to enamel. If silver is to be used, it should be fine silver, treated in the methods called *champlevé* and *cloisonné*.

The brilliancy of the substance enamel depends upon the perfect combination and proportion of its component parts. The intimacy of the combination depends upon an equal temperature being maintained throughout its fusion in the crucible. For this purpose it is better to obtain a flux which has been already fused and most carefully prepared, and afterwards to add the colouring oxides, which stain it dark or light according to the amount of oxide introduced. Many of the enamels are changed in colour by the difference of the proportion of the parts composing the flux, rather than by the change of the oxides. For instance, turquoise blue is obtained from the black oxide of copper by using a comparatively large proportion of carbonate of soda, and a yellow green from the same oxide by increasing the proportionate amount of the red lead. All transparent enamels are made opaque by the addition of calx, which is a mixture of tin and lead calcined. White enamel is made by the addition of stannic and arsenious acids to the flux. The amount of acid regulates the density or opacity of the enamel.

To elucidate the development which has occurred, it will be necessary to describe some of the processes. After the enamel has been procured in the lump, the next stage in the process, common to all methods of enamelling, is to pulverize it. To do this properly the enamel must first be placed in an agate mortar and covered with water; next, with a wooden mallet a number of sharp blows must be given to a pestle held vertically over the enamel, to break it; then holding the mortar firmly in the left hand, the pestle must be rotated with the right, with as much pressure as possible on the enamel, grinding it until the particles are reduced to a fine grain. The powder is then subjected to a series of washings in distilled water, until all the floury particles are removed. After this the metal is cleaned by immersion in acid and water. For copper, nitric acid is used; for silver, sulphuric, and for gold hydrochloric acid. All trace of acid is then removed, first by scratching with a brush and water, and finally by drying in warm oak sawdust. After this the pulverized enamel is carefully and evenly spread over those parts of the metal designed to receive it, in sufficient thickness just to cover them and no more. The piece is then dried in front of the furnace, and when dry is placed gently on a fire-clay or iron *planche*, and introduced carefully into the muffle of the furnace, which is heated to a bright pale red. It is now attentively watched until the enamel shines all over, when it is withdrawn from the furnace. The firing of enamel, unlike that of glass or pottery, takes only a few minutes, and in nearly all processes no annealing is required.

The following are the different modes of enamelling: *champlevé, cloisonné, basse-taille, plique-à-jour, painted enamel, encrusted,* and *miniature-painted*. These processes were known at successive periods of ancient art in the order in which they are named. To-day they are known in their entirety. Each has been largely developed and improved. No new method has been discovered, although variations have been introduced into all. The most important are those connected with painted enamels, encrusted enamels and *plique-à-jour*.

Champlevé enamelling is done by cutting away troughs or cells in the plate, leaving a metal line raised between them, which forms the outline of the design. In these cells the pulverized enamel is laid and then fused; afterwards it is filed with a corundum file, then smoothed with a pumice stone and polished by means of crocus powder and rouge. An example is shown in Plate II. fig. 8.

In *cloisonné enamel*, upon a metal plate or shape, thin metal strips are bent to the outline of the pattern, then fixed by silver solder or by the enamel itself. These strips form a raised outline, giving cells as in the case of *champlevé*. The rest of the process is identical with that of *champlevé* enamelling. An example is shown in Plate I. fig. 4.

The *basse-taille* process is also a combination of metal work in the form of engraving, carving and enamelling. The metal, either silver or gold, is engraved with a design, and then carved into a bas-relief (below the general surface of the metal like an Egyptian bas-relief) so that when the enamel is fused it is level with the uncarved parts of the design enamel, and the design shows through the transparent enamel.

Painted enamels are different from any of these processes both in method and in result. The metal in this case is either copper, silver or gold, but usually copper. It is cut with shears into a plate of the size required, and slightly domed with a burnisher or hammer, after which it is cleaned by acid and water. Then the enamel is laid equally over the whole surface both back and front, and afterwards “fired.” The first coat of enamel being fixed, the design is carried out, first by laying it in white enamel or any other which is opaque and most advantageous for subsequent coloration.

In the case of a *grisaille painted enamel* the white is mixed with water or turpentine, or spike oil of lavender, or essential oil of petroleum (according to the taste of the artist) and the white is painted thickly in the light parts and thinly in the grey ones, whereby a slight sense of relief is obtained and a 366
great degree of light and shade.

In *coloured painted enamels* the white is coloured by transparent enamels spread over the *grisaille* treatment, parts of which when fired are heightened by touches of gold, usually painted in lines. Other parts can be made more brilliant by the use of foil, over which the transparent enamels are placed and then fired. An example is shown in Plate I. fig. 7.

Enamels by the *plique-à-jour* method might be best described as *translucent cloisonné* enamels; for they are similar to *cloisonné*, except that the ground upon which they are fired is removed, thus making them transparent like stained glass.

Two new processes have been the subject of the present writer’s study and experiment for several years, which he has lately brought to fruition. The first is an inlay of transparent enamels similar to *plique-à-jour* without cloisons to divide the colours. For if enamels do not run together whilst in a melted state, as is seen in the case of painted and *basse-taille* enamels, there should be no necessity for it in this process. The result is a clear transparent subject in colour. The other process consists of a coloured enamel relief. It resembles the della Robbia relief, with this important difference, that the colour of the enamel by its nature permeates the whole depth of the relief, whereas in the della Robbia ware it is only on the surface. It also has a fresco surface, instead of one highly glazed. The quality of the enamel is as rare and unlike anything else as it is beautiful. It is in point of fact the only coloured sculpture in which the whole of its parts are one solid homogeneous mass, and through which the colour is one with the substance and is not applied. The process consists of the shapes of the various parts of the relief being selected for the different enamels, and these enamels melted together, in the mould of the relief, which is finished with lapidary’s tools.

Miniature enamel painting is not true enamelling, for after the white enamel is fired upon the gold plate, the colours used are not vitreous compounds—not enamels in fact—as is the case in any other form of metal enamelling; but they are either raw oxides or other forms of metal, with a little flux added, not combined. These colours are painted on the white enamel, and afterwards made to adhere to the surface by partially fusing the enamel, which when in a state of partial fusion becomes viscous.

There are many of these so-called enamels to-day, which are much easier of accomplishment than the true enamel, but they possess none of the beautiful quality of the latter. It is most apparent when parts of a work are true enamels and parts are done in the manner described above. These enamel paintings on enamel are afterwards coated over with a transparent flux, which gives them a surface of enamel. Many are done in this way for the market.

All these methods were used formerly, before the present revival; but they were not so completely understood or carried so far as they are to-day. Nor were the whole methods practised by any artist as they are now. The greatest advance has been in painted enamels. This process requires that both sides of the metal plate shall be covered with enamel; for this reason the plate is made convex on the top, so that the concave side does not touch the *planche* on which it is supported for firing, but rests on its edges throughout. There are several reasons why these plates are *bombé*, the principal one being that in the firing they resist the tendency to warp and curl up at the edges as a flat thin plate would do. Further, the enamel having been fused to both sides is not so liable to crack or to splint in subsequent firings. This is most important, for otherwise the white which is placed on afterwards would be a network of cracks. The manner of firing has also to do with this, but not nearly so much as the preliminary care and mechanical perfection with which a plate is prepared. Nearly all the old enamels are seen to be cracked in the white if minutely examined. To obviate this the following points must be observed: The plate must be of an excellent quality of metal, equal in thickness throughout, and perfectly regular in shape. It must be arched equally from end to end. The first coat of enamel must be of a perfectly regular equal thickness on both sides, entirely covering the plate. Whatever the medium employed in painting the white on to the enamel, it must be completely evaporated before the plate is placed in the furnace. The furnace must be heated to a bright red heat, and the *planche* must be red-hot before being taken out for the enamel to be placed upon it, and then quickly returned to the furnace and the muffle door shut tight so as to allow no draught of cool air to enter it. Then as soon as it has begun to fuse, which if a small piece, it would do in a minute or so, the muffle door is slightly opened to afford a view of it. As soon as it shines all over its surface, it is withdrawn from the muffle.

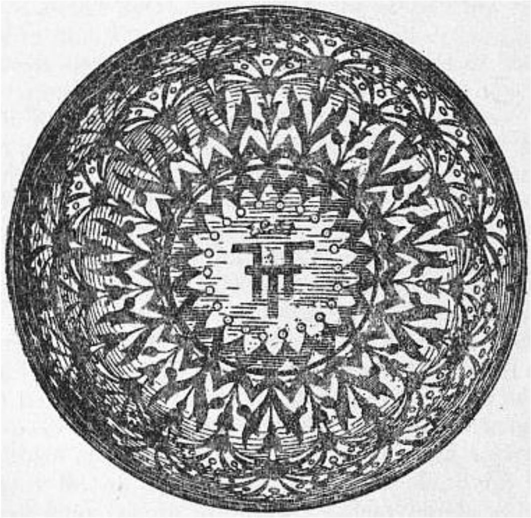


Fig. 2.—Modern French plique-à-jour bowl, by Fernand Thesmar.

The method of laying a white upon the enamel ground is a matter of individual taste, so far as the medium is concerned. By some, pure distilled water is preferred to any other liquid for mixing the enamel. Otherwise, turpentine and the fat oil of turpentine, as well as spike oil of lavender. The oil mixture takes longer to dry, and thus gives a greater chance for modelling into fine shades than the water. But it has several drawbacks. Firstly, there is the difficulty of drying the oil out—a process which takes some time and increases the risk of cracking in the drying process; and secondly, the enamel is not so fresh and clear after it is fired as when pure water has been employed. Besides there is a great difference in the result; the water involves a quick, decided, direct touch and method, which carries with it its own charm. The oil medium, besides giving an effect of laborious rounded stippled surfaces, is apt partly to reduce the enamel, thus giving it a dull surface. The coloration of the white is comparatively simple and is done by transparent enamels finely ground and evenly spread over the white after the latter has been fused. The only danger to be avoided is that of over-firing, which is produced by too great heat of a prolonged duration of firing, which causes the stannic and arsenious acids in the white to volatilize.

Plique-à-jour enamelling is done in the same way as *cloisonné* enamelling, except that the wires or strips of metal which enclose the enamel are not soldered to the metal base, but are soldered to each other only. Then these are simply placed upon a sheet of platinum, copper, silver, gold or hard brass, which, after the enamel is fused and sufficiently annealed and cooled, is easily removed. For small pieces of *plique-à-jour* there is no necessity to apply any metallic base, as the particles of enamel quickly fuse, become viscous, and when drawn out set quite hard. Neither is there any need for annealing, as would be the case in larger work. For an example, see fig. 2.

Commercially there has lately been an activity in enamels such as has never before occurred. This has been the case throughout Europe, Japan and the United States of America. In London there has been a demand for a cheap form of gaudy coloured enamel, fused into sunk spaces of metal obtained by stamping with a steel die; this has been applied to small objects of cheap jewelry, in the form of 367
brooches, bracelets and the like. There has also been a great demand for enamel watch-cases and small pendants, done mainly by hand, of a better class of work. Many of these have been produced in Birmingham, Berlin, Paris and London. In Paris copies of pictures in black and white enamel, with a little gold paint in the draperies and background, have been manufactured in very large quantities and sometimes of great dimensions. Another curious demand, followed by as astonishing a production, is that of the imitations (a harder name for which is "forgeries") of old enamels, made with much skill, giving all the technical excellence of the originals, even to the cracks and scratches incidental to age. These are duly signed, and will deceive the most expert. They are copies of enamels by Nardon and Jean Pénicaud, Léonard Limosin, Pierre Raymond, Courtois and others. The same artificers also produce copies of old Chinese *cloisonné* and *champlevé* enamels, as well as old Battersea enamel snuff-boxes, patch-boxes, and indeed every kind of enamelling formerly practised. It is advisable for the collector never to purchase any piece of enamelling as the work of an old master without having a pedigree extending at least over forty years. From Japan there has been a continuous flow of *cloisonné* enamelled vases, boxes and plates, either entirely covered with enamel or applied in parts. Compared with this enormous output, only a few small pieces of jewelry have come from Jaipur and other towns in India. There has also been a great quantity of *plique-à-jour* enamelling manufactured in Russia, Norway and Sweden. And finally, it has been used in an unprecedented manner in large pieces upon iron and copper for purposes of advertisement.

Amongst the chief workers in the modern revival of this art are Claudius Popelin, Alfred Meyer, Paul Grandhomme, Fernand Thesmar, Hubert von Herkomer and Alexander Fisher. The work of Claudius Popelin is characterized by good technical skill, correctness, and a careful copying of the work of the old masters. Consequently it suffers from a lack of invention and individuality. His work was devoted to the rendering of mythological subjects and fanciful portraits of historical people. Alfred Meyer and Grandhomme are both accomplished and careful enamellers; the former is a painter enameller and the author of a book dealing technically with enamelling. Grandhomme paints mythological subjects and portraits in a very tender manner, with considerably more artistic feeling than either Meyer or Popelin. There is a specimen of his work in the Luxemburg Museum. Fernand Thesmar is the great reviver of *plique-à-jour* enamelling in France. Specimens of his work are possessed by the art museums throughout Europe, and one is to be seen in the Victoria and Albert Museum, London. They are principally valued on account of their perfect technical achievement. Lucien Falize was an employer of artists and craftsmen, and to him we are indebted for the production of specimens of *basse-taille* enamel upon silver and gold, as well as for a book reviewing the revival of the art in France, bearing particularly on the work of Claudius Popelin. Until within recent years there was a clear division between the art and the crafts in the system of producing art objects. The artist was one person and the workman another. It is now acknowledged that the artist must also be the craftsman, especially in the higher branches of enamelling. M. Falize initiated the production of a gold cup which was enamelled in the *basse-taille* manner. The band of figures was designed by Olivier Merson, the painter, and carved by a metal carver and enamelled by an enameller, both able craftsmen employed by M. Falize. Other pieces of enamelling in *champlevé* and *cloisonné* were also produced under his supervision and on this system; therefore lacking the one quality which would make them complete as an expression of artistic emotion by the artist's own hands. M. René Lalique is among the jewellers who have applied enamelling to their work in a peculiarly technically perfect manner. In England, Professor Hubert von Herkomer has produced painted enamels of considerable dimensions, aiming at the execution of pictures in enamel, such as have been generally regarded as peculiar to the province of oil or water-colour painting. Among numerous works is a large shield, into which plaques of enamel are inserted, as well as several portraits, one of which, made in several pieces, is 6 ft. high—a portrait of the emperor William II. of Germany. The present writer rediscovered the making of many enamels, the secrets of which had been jealously guarded. He has worked in all these processes, developing them from the art side, and helping to make enamelling not only a decorative adjunct to metal-work, but raising it to a fine art. His work may be seen in the Victoria and Albert Museum, and Brussels Museum. Others who have been enamelling with success in various branches, and who have shown individuality in their work, are Mr John Eyre, Mrs Nelson Dawson, Miss Hart.

Literature.—Among older books on enamelling, apart from the works of Neri and Benvenuto Cellini, are J.-P. Ferrand, *L'Art du feu, ou de peindre en émail* (1721); Labarte, *Recherches sur la peinture en émail* (Paris, 1856); Marquis de Laborde, *Notice des émaux du Louvre* (Paris, 1852); Reboulleau, *Nouveau manuel complet de la peinture en verre, sur porcelaine et sur émail* (ed. by Magnier, Paris, 1866); Claudius Popelin, *L'Émail des peintres* (Paris, 1866); Emil Molinier, *Dictionnaire des émailleurs* (1885). Among useful recent books are H. Cunynghame's *Art of Enamelling on Metals* (1906); L. Falize, *Claudius Popelin et la renaissance des émaux peints*; L. Dalpayrat, *Limoges Enamels*; Alexander Fisher, *The Art of Enamelling upon Metal* (1906, "The Studio," London).

(A. Fi.*)

ENCAENIA, a festival commemorating a dedication, in Greek τὰ ἐγκαίνια (καινός, new), particularly used of the anniversary of the dedication of a church (see Dedication). The term is also used at the university of Oxford of the annual Commemoration, held in June, of founders and benefactors (see Oxford).

ENCAUSTIC PAINTING. The name *encaustic* (from the Greek for "burnt in") is applied to paintings executed with vehicles in which wax is the chief ingredient. The term was appropriately applied to the ancient methods of painting in wax, because these required heat to effect them. Wax may be used as a vehicle for painting without heat being requisite; nevertheless the ancient term *encaustic* has been retained, and is indiscriminately applied to all methods of painting in wax. The durability of wax, and its power of resisting the effects of the atmosphere, were well known to the Greeks, who used it for the protection of their sculptures. As a vehicle for painting it was commonly employed by them and by the Romans and Egyptians; but in recent times it has met with only a limited application. Of modern encaustic paintings those by Schnorr in the Residenz at Munich are the most important. Modern paintings in wax, in their chromatic range and in their general effect, occupy a middle place between those executed in oil and in fresco. Wax painting is not so easy as oil, but presents fewer technical difficulties than fresco.

Ancient authors often make mention of *encaustic*, which, if it had been described by the word *inurere*, to burn in, one might have supposed to have been a species of enamel painting. But the expressions "incausto pingere," "pictura encaustica," "ceris pingere," "pictura inurere," used by Pliny and other ancient writers, make it clear that some other species of painting is meant. Pliny distinguishes three species of encaustic painting. In the first they used a stylus, and painted either on ivory or on polished wood, previously saturated with some certain colour; the point of the stylus or stigma served for this operation, and its broad or blade end cleared off the small filaments which

arose from the outlines made by the stylus in the wax preparation. In the second method it appears that the wax colours, being prepared beforehand, and formed into small cylinders for use, were smoothly spread by the spatula after the outlines were determined, and thus the picture was proceeded with and finished. By the side of the painter stood a brazier which was used to heat the spatula and probably the prepared colours. This is the method which was probably used by the painters who decorated the houses of Herculaneum and of Pompeii, as artists practising this method of painting are depicted in the decorations. The third method was by painting by a brush dipped into wax liquefied by heat; the colours so applied attained considerable hardness, and could not be damaged either by the heat of the sun or by the effects of sea-water. It was thus that ships were 368
decorated; and this kind of encaustic was therefore styled "ship-painting."

About the year 1749 Count Caylus and J.J. Bachelier, a painter, made some experiments in encaustic painting, and the count undertook to explain an obscure passage in Pliny, supposed to be the following (xxxv. 39):—"Ceris pingere ac picturam inurere quis primus excogitaverit non constat. Quidam Aristidis inventum putant, postea consummatum a Praxitele; sed aliquanto vetustiores encausticae picturae exstitere, ut Polygnoti et Nicanoris et Arcesilai Pariorum. Lysippus quoque Aeginae picturae suae inscripsit ἐνέκαυσεν, quod profecto non fecisset nisi encaustica inventa." There are other passages in Pliny bearing upon this subject, in one of which (xxi. 49) he gives an account of the preparation of "Punica cera." The nature of this Punic wax, which was the essential ingredient of the ancient painting in encaustic, has not been definitely ascertained. The chevalier Lorgna, who investigated the subject in a small but valuable tract, asserts that the *nitron* which Pliny mentions is not the nitre of the moderns, but the *natron* of the ancients, viz. the native salt which is found crystallized in Egypt and other hot countries in sands surrounding lakes of salt water. This substance the Carthaginians, according to Pliny, used in preparing their wax, and hence the name Punic seems to be derived. Lorgna made a number of experiments with this salt, using from three to twenty parts of white melted wax with one of natron. He held the mixture in an iron vessel over a slow fire, stirring it gently with a wooden spatula, till the mass assumed the consistency of butter and the colour of milk. He then removed it from the fire, and put it in the shade in the open air to harden. The wax being cooled liquefied in water, and a milky emulsion resulted from it like that which could be made with the best Venetian soap.

Experiments, it is said, were made with this wax in painting in encaustic in the apartments of the Count Giovanni Battista Gasola by the Italian painter Antonio Paccheri, who dissolved the Punic wax when it was not so much hardened as to require to be "igni resoluta," as expressed by Pliny, with pure water slightly infused with gum-arabic, instead of sarcocolla, mentioned by Pliny. He afterwards mixed the colours with this wax so liquefied as he would have done with oil, and proceeded to paint in the same manner; nor were the colours seen to run or alter in the least; and the mixture was so flexible that the pencil ran smoother than it would have done with oil. The painting being dry, he treated it with caustic, and rubbed it with linen cloths, by which the colours acquired peculiar vivacity and brightness.

About the year 1755 further experiments were made by Count Caylus and several French artists. One method was to melt wax with oil of turpentine as a vehicle for the colours. It is well known that wax may be dissolved in spirit and used as a medium, but it dries too quickly to allow of perfect blending, and would by the evaporation of the spirit be prejudicial to the artist's health. Another method suggested about this time, and one which seems to tally very well with Pliny's description, is the following. Melt the wax with strong solution of salt of tartar, and let the colours be ground up in it. Place the picture when finished before the fire till by degrees the wax melts, swells, and is bloated up upon the picture; the picture is then gradually removed from the fire, and the colours, without being injuriously affected by the operation of the fire, become unalterable, spirits of wine having been burnt upon them without doing the least harm. Count Caylus's method was different, and much simpler: (1) the cloth or wood designed for the picture is waxed over, by rubbing it simply with a piece of beeswax; (2) the colours are mixed up with pure water; but as these colours will not adhere to the wax, the whole ground must be rubbed over with chalk or whiting before the colour is applied; and (3) when the picture is dry it is put near the fire, whereby the wax is melted and absorbs the colours. It must be allowed that nothing could well be simpler than this process, and it was thought that this kind of painting would be capable of withstanding the weather and of lasting longer than oil painting. This kind of painting has not the gloss of oil painting, so that the picture may be seen in any light, a quality of the very first importance in all methods of mural painting. The colours too, when so secured, are firm, and will bear washing, and have a property which is perhaps more important still, viz. that exposure to smoke and foul vapours merely leaves a deposit on the surface without injuring the work. The "encausto pingendi" of the ancients could not have been enamelling, as the word "inurere," taken in its rigorous sense, might at first lead one to suppose, nor could it have been painting produced in the same manner as encaustic tiles or encaustic tesserae; but that it must have been something akin to the count's process would appear from the words of Pliny already quoted, "Ceris pingere ac picturam inurere."

Werner of Neustadt found the following process very effectual in making wax soluble in water. For each pound of white wax he took twenty-four ounces of potash, which he dissolved in two pints of water, warming it gently. In this ley he boiled the wax, cut into little bits, for half an hour, after which he removed it from the fire and allowed it to cool. The wax floated on the surface of the liquor in the form of a white saponaceous matter; and this being triturated with water produced a sort of emulsion, which he called wax milk, or encaustic wax. This preparation may be mixed with all kinds of colours, and consequently can be applied in a single operation.

Mrs Hooker of Rottingdean, at the end of the 18th century, made many experiments to establish a method of painting in wax, and received a gold palette from the Society of Arts for her investigations in this branch of art. Her account is printed in the tenth volume of the Society’s Transactions (1792), under the name of Miss Emma Jane Greenland.

See also Lorgna, *Un Discorso sulla cera punica*; Pittore Vicenzo Requeno, *Saggi sul ristabilimento dell’ antica arte de’ Greci e Romani* (Parma, 1787); *Phil. Trans*. vol. xlix. part 2; Muntz on *Encaustic Painting*; W. Cave Thomas, *Methods of Mural Decoration* (London, 1869); Cros and Henry, *L’Encaustique*, &c. (1884); Donner von Richter, *Über Technisches in der Malerei der Alten* (1885).

(W. C. T.)

ENCEINTE (Lat. *in*, within, *cinctus*, girdled; to be distinguished from the word meaning “pregnant,” from *in*, not, and *cinctus*, *i.e.* with girdle loosened), a French term used technically in fortification for the inner ring of fortifications surrounding a town. Strictly the term was applied to the continuous line of bastions and curtains forming the “body of the place,” this last expression being often used as synonymous with *enceinte*. The outworks, however, close to the enceinte were not considered as forming part of it. In modern fortification the enceinte is usually simply the innermost continuous line of fortifications. In architecture generally an enceinte is the close or precinct of a cathedral, abbey, castle, &c.

ENCINA, JUAN DEL (1469-*c.* 1533), often called the founder of the Spanish drama, was born in 1469 near Salamanca probably at Encinas. On leaving the university of Salamanca he became a member of the household of the second duke of Alva. In 1492 the poet entertained his patron with a dramatic piece, the *Triunfo de la fama*, written to commemorate the fall of Granada. In 1496 he published his *Cancionero*, a collection of dramatic and lyrical poems. Some years afterwards he visited Rome, attracted the attention of Alexander VI. by his skill in music, and was appointed choirmaster. About 1518 Encina took orders, and made a pilgrimage to Jerusalem, where he said his first mass. Since 1509 he had held a lay canonry at Malaga; in 1519 he was appointed prior of Leon and is said to have died at Salamanca about 1533. His *Cancionero* is preceded by a prose treatise (*Arte de trobar*) on the condition of the poetic art in Spain. His fourteen dramatic pieces mark the transition from the purely ecclesiastical to the secular stage. The *Aucto del Repelón* and the *Égloga de Fileno* dramatize the adventures of shepherds; the latter, like *Plácida y Vitoriano*, is strongly influenced by the *Celestina*. The intrinsic interest of Encina’s plays is slight, but they are important from the historical point of view, for the lay pieces form a new departure, and the devout eclogues prepare the way for the *autos* of the 17th century. Moreover, Encina’s lyrical poems are remarkable for their intense sincerity and devout grace. 369

Bibliography.—*Teatro completo de Juan del Encina* (Madrid, 1893), edited by F. Asenjo Barbieri; *Cancionero musical de los siglos XV y XVI* (Madrid, 1894), edited by F. Asenjo Barbieri; R. Mitjana, *Sobre Juan del Encina, músico y poeta* (Málaga, 1895); M. Menendez y Pelayo, *Antologia depoetas liricos castellanos* (Madrid, 1890-1903), vol. vii.

ENCKE, JOHANN FRANZ (1791-1865), German astronomer, was born at Hamburg on the 23rd of September 1791. Matriculating at the university of Göttingen in 1811, he began by devoting himself to astronomy under Carl Friedrich Gauss; but he enlisted in the Hanseatic Legion for the campaign of 1813-14, and became lieutenant of artillery in the Prussian service in 1815. Having returned to Göttingen in 1816, he was at once appointed by Benhardt von Lindenau his assistant in the observatory of Seeberg near Gotha. There he completed his investigation of the comet of 1680, for which the Cotta prize was awarded to him in 1817; he correctly assigned a period of 71 years to the comet of 1812; and discovered the swift circulation of the remarkable comet which bears his name (see Comet). Eight masterly treatises on its movements were published by him in the Berlin *Abhandlungen* (1829-1859). From a fresh discussion of the transits of Venus in 1761 and 1769 he deduced (1822-1824) a solar parallax of 8″.57, long accepted as authoritative. In 1822 he became director of the Seeberg observatory, and in 1825 was promoted to a corresponding position at Berlin, where a new observatory, built under his superintendence, was inaugurated in 1835. He directed the preparation of the star-maps of the Berlin academy 1830-1859, edited from 1830 and greatly improved the *Astronomisches Jahrbuch*, and issued four volumes of the *Astronomische Beobachtungen* of the Berlin observatory (1840-1857). Much labour was bestowed by him upon facilitating the computation of the movements of the asteroids. With this end in view he expounded to the Berlin academy in 1849 a mode of determining an elliptic orbit from three observations, and communicated to that body in 1851 a new method of calculating planetary perturbations by means of rectangular co-ordinates (republished in W. Ostwald's *Klassiker der exacten Wissenschaften*, No. 141, 1903). Encke visited England in 1840. Incipient brain-disease compelled him to withdraw from official life in November 1863, and he died at Spandau on the 26th of August 1865. He contributed extensively to the periodical literature of astronomy, and was twice, in 1823 and 1830, the recipient of the Royal Astronomical Society's gold medal.

See *Johann Franz Encke, sein Leben und Wirken*, von Dr C. Bruhns (Leipzig, 1869), to which a list of his writings is appended. Also, *Month. Notices Roy. Astr. Society*, xxvi. 129; *V.J.S. Astr. Gesellschaft*, iv. 227; Berlin. *Abhandlungen* (1866), i., G. Hagen; *Sitzungsberichte*, Munich Acad. (1866), i. p. 395, &c.

(A. M. C.)

ENCLAVE (a French word from *enclaver*, to enclose), a term signifying a country or, more commonly, an outlying portion of a country, entirely surrounded by the territories of a foreign or other power, such as the detached portions of Prussia, Saxony, &c, enclosed in the Thuringian States. (From the point of view of the states possessing such detached portions of territory these become "exclaves.") "Enclave" is, however, generally used in a looser sense to describe a colony or other territory of a state, which, while possessing a seaboard, is entirely surrounded landward by the possession of some other power; or, if inland territory, nearly though not entirely so enclosed, *e.g.* the Lado Enclave in equatorial Africa.

ENCOIGNURE, in furniture, literally the angle, or return, formed by the junction of two walls. The word is now chiefly used to designate a small armoire, commode, cabinet or cupboard made to fit a corner; a *chaise encoignure* is called in English a three-cornered chair. In its origin the thing, like the word, is French, and the delightful Louis Quinze or Louis Seize *encoignure* in lacquer or in mahogany elaborately mounted in gilded bronze is not the least alluring piece of the great period of French furniture. It was made in a vast variety of forms so far as the front was concerned; in other respects it was strictly limited by its destination. As a rule these delicate and dainty receptacles were in pairs and placed in opposite angles; more often than not the top was formed of a slab of coloured marble.

ENCYCLICAL (from Late Lat. *encyclicus*, for *encyclius* = Gr. ἐγκύκλιος, from ἐν and κύκλος, "a circle"), an ecclesiastical epistle intended for general circulation, now almost exclusively used of such letters issued by the pope. The forms *encyclica* and *encyclic* are sometimes, but more rarely, used. The old adjectival use of the word in the sense of "general" (encircling) is now obsolete, though it survives in the term "encyclopaedia."

ENCYCLOPAEDIA. The Greeks seem to have understood by encyclopaedia (ἐγκυκλοπαιδεία, or ἐγκύκλιος παιδεία) instruction in the whole circle (ἐν κυκλῷ) or complete system of learning—education in arts and sciences. Thus Pliny, in the preface to his *Natural History*, says that his book treated of all the subjects of the encyclopaedia of the Greeks, "Jam omnia attingenda quae Graeci τῆς ἐγκυκλοπαιδείας vocant." Quintilian (*Inst. Orat.* i. 10) directs that before boys are placed under the rhetorician they should be instructed in the other arts, "ut efficiatur orbis ille doctrinae quam Graeci ἐγκυκλοπαιδείαν vocant." Galen (*De victus ratione in morbis acutis*, c. 11) speaks of those who are not educated ἐν τῇ ἐγκυκλοπαιδείᾳ. In these passages of Pliny and Quintilian, however, from one or both of which the modern use of the word seems to have been taken, ἐγκύκλιος παιδεία is now read, and this seems to have been the usual expression. Vitruvius (lib. vi. praef.) calls the encyclios or ἐγκύκλιος παιδεία of the Greeks "doctrinarum omnium disciplina," instruction in all branches of learning. Strabo (lib. iv. cap. 10) speaks of philosophy καὶ τὴν ἄλλην παιδείαν ἐγκύκλιον. Tzetzes (*Chiliades*, xi. 527), quoting from Porphyry’s *Lives of the Philosophers*, says that ἐγκύκλια μαθήματα was the circle of grammar, rhetoric, philosophy and the four arts under it, arithmetic, music, geometry and astronomy. Zonaras explains it as grammar, poetry, rhetoric, philosophy, mathematics and simply every art and science (ἁπλῶς πᾶσα τέχνη καὶ ἐπιστήμη), because sophists go through them as through a circle. The idea seems to be a complete course of instruction in all parts of knowledge. An epic poem was called cyclic when it contained the whole mythology; and among physicians κύκλῳ θεραπεύειν, *cyclo curare* (Vegetius, *De arte veterinaria*, ii. 5, 6), meant a cure effected by a regular and prescribed course of diet and medicine (see Wower, *De polymathia*, c. 24, § 14).

The word encyclopaedia was probably first used in English by Sir Thomas Elyot. “In an oratour is required to be a heape of all maner of lernyng: whiche of some is called the worlde of science, of other the circle of doctrine, whiche is in one worde of greke Encyclopedia” (*The Governour*, bk. i. chap. xiii.). In his Latin dictionary, 1538, he explains “Encyclios et Encyclia, the cykle or course of all doctrines,” and “Encyclopedia, that lernynge whiche comprehendeth all lyberall science and studies.” The term does not seem to have been used as the title of a book by the ancients or in the middle ages. The edition of the works of Joachimus Fortius Ringelbergius, printed at Basel in 1541, is called on the title-page *Lucubrationes vel potius absolutissima* κυκλοπαιδεια. Paulus Scalichius de Lika, an Hungarian count, wrote *Encyclopaediae seu orbis disciplinarum epistemon* (Basileae, 1599, 4to). Alsted published in 1608 *Encyclopaedia cursus philosophici*, and afterwards expanded this into his great work, noticed below, calling it without any limitation *Encyclopaedia*, because it treats of everything that can be learned by man in this life. This is now the most usual sense in which the word encyclopaedia is used—a book treating of all the various kinds of knowledge. The form “cyclopaedia” is not merely without any appearance of classical authority, but is etymologically less definite, complete and correct. For as Cyropaedia means “the instruction of Cyrus,” so cyclopaedia may mean “instruction of a circle.” Vossius says, “Cyclopaedia is sometimes found, but the best writers say encyclopaedia” (*De vitiis sermonis*, 1645, p. 402). Gesner says, “κύκλος est *circulus*, quae figura est simplicissima et perfectissima simul: nam incipi potest ubicunque in illa et ubicunque cohaeret. *Cyclopaedia* itaque significat omnem doctrinarum scientiam inter se cohaerere; *Encyclopaedia* est 370
institutio in illo circulo.” (*Isagoge*, 1774, i. 40).

In a more restricted sense, encyclopaedia means a system or classification of the various branches of knowledge, a subject on which many books have been published, especially in Germany, as Schmid’s *Allgemeine Encyklopädie und Methodologie der Wissenschaften* (Jena, 1810, 4to, 241 pages). In this sense the *Novum Organum* of Bacon has often been called an encyclopaedia. But it is “a grammar only of the sciences: a cyclopaedia is not a grammar, but a dictionary; and to confuse the meanings of grammar and dictionary is to lose the benefit of a distinction which it is fortunate that terms have been coined to convey” (*Quarterly Review*, cxiii. 354). Fortunius Licetus, an Italian physician, entitled several of his dissertations on Roman altars and other antiquities encyclopaedias (as, for instance, *Encyclopaedia ad. Aram mysticam Nonarii,* Pataviae, 1631, 4to), because in composing them he borrowed the aid of all the sciences. The *Encyclopaedia moralis* of Marcellinus de Pise (Paris, 1646, fol., 4 vols.) is a series of sermons. Encyclopaedia is often used to mean a book which is, or professes to be, a complete or very full collection or treatise relating to some particular subject, as Blaine’s work, *The Encyclopaedia of Rural Sports* (London, 1852); *The Encyclopaedia of Wit* (London, 1803); *The Vocal Encyclopaedia* (London, 1807, 16mo), a collection of songs, catches, &c. The word is frequently used for an alphabetical dictionary treating fully of some science or subject, as Murray, *Encyclopaedia of Geography* (London, 1834); Lefebvre Laboulaye, *Encyclopédie technologique: Dictionnaire des arts et manufactures* (Paris, 1845-1847). Whether under the name of “dictionary” or “encyclopaedia” large numbers of this class of reference-work have been published. These are essentially encyclopaedic, being *subject books* and not *word-books*. The important books of this character are referred to in the articles dealing with the respective subjects, but the following may be mentioned here: the *Jewish Encyclopedia*, in 12 vols. (1901), a descriptive record of the history, religion, literature and customs of the Jewish people from the earliest times; the *Encyclopaedia of Sport*, 2 vols. (1897-1898); Holtzendorff’s *Encyklopädie der Rechtswissenschaft* (1870; an edition in 2 vols., 1904); the *Dictionary of Political Economy*, edited by R.H. Inglis Palgrave, 3 vols. (1894; reprinted 1901); the Encyclopaedia Biblica, edited by T.K. Cheyne and J. Sutherland Black, 4 vols. (1899-1903); the *Dictionary of the Bible*, edited by James Hastings, 4 vols., with a supplementary volume (1904); an interesting series is the *Répertoire général du commerce*, dealing with the foreign trade of France, of which one part, the *Encyclopaedia of Trade between the United States of America and France*, with a preface by M. Gabriel Hanotaux, appeared, in French and English, in 1904.

The great Chinese encyclopaedias are referred to in the article on Chinese Literature. It will be sufficient to mention here the *Wên hien t‘ung k‘ao*, compiled by Ma Twa-lin in the 14th century, the encyclopaedia ordered to be compiled by the Emperor Yung-loh in the 15th century, and the *Ku Kin t‘u shu thi ch‘êng* prepared for the Emperor K‘ang-hi (d. 1721), in 5020 volumes. A copy of this enormous work, bound in some 700 volumes, is in the British Museum.

The most ancient encyclopaedia extant is Pliny’s *Natural History* in 37 books (including the preface) and 2493 chapters, which may be thus described generally:—book 1, preface; book 2, cosmography, astronomy and meteorology; books 3 to 6, geography; books 7 to 11, zoology, including man, and the invention of the arts; books 12 to 19, botany; books 20 to 32, medicines, vegetable and animal remedies, medical authors and magic; books 33 to 37, metals, fine arts, mineralogy and mineral remedies. Pliny, who died A.D. 79, was not a naturalist, a physician or an artist, and collected his work in his leisure intervals while engaged in public affairs. He says it contains 20,000 facts (too small a number by half, says Lemaire), collected from 2000 books by 100 authors. Hardouin has given a list of 464 authors quoted by him. His work was a very high authority in the middle ages, and 43 editions of it were printed before 1536.

Martianus Minneus Felix Capella, an African, wrote (early in the 5th cent.), in verse and prose, a sort of encyclopaedia, which is important from having been regarded in the middle ages as a model storehouse of learning, and used in the schools, where the scholars had to learn the verses by heart, as a text-book of high-class education in the arts. It is sometimes entitled *Satyra*, or *Satyricon*, but is usually known as *De nuptiis Philologiae et Mercurii*, though this title is sometimes confined to the first two books, a rather confused allegory ending with the apotheosis of Philologia and the celebration of her marriage in the milky way, where Apollo presents to her the seven liberal arts, who, in the succeeding seven books, describe their respective branches of knowledge, namely, grammar, dialectics (divided into metaphysics and logic), rhetoric, geometry (geography, with some single geometrical propositions), arithmetic (chiefly the properties of numbers), astronomy and music (including poetry). The style is that of an African of the 5th century, full of grandiloquence, metaphors and strange words. He seldom mentions his authorities, and sometimes quotes authors whom he does not even seem to have read. His work was frequently copied in the middle ages by ignorant transcribers, and was eight times printed from 1499 to 1599. The best annotated edition is by Kopp (Frankfort, 1836, 4to), and the most convenient and the best text is that of Eysserhardt (Lipsiae, 1866, 8vo).

Isidore, bishop of Seville from 600 to 630, wrote *Etymologiarum libri XX*. (often also entitled his *Origines*) at the request of his friend Braulio, bishop of Saragossa, who after Isidore's death divided the work into books, as it was left unfinished, and divided only into titles.

> The tenth book is an alphabet of 625 Latin words, not belonging to his other subjects, with their explanations as known to him, and often with their etymologies, frequently very absurd. The other books contain 448 chapters, and are:—1, grammar (Latin); 2, rhetoric and dialectics; 3, the four mathematical disciplines—arithmetic, geometry, music and astronomy; 4, medicine; 5, laws and times (chronology), with a short chronicle ending in 627; 6, ecclesiastical books and offices; 7, God, angels and the orders of the faithful; 8, the church and sects; 9, languages, society and relationships; 11, man and portents; 12, animals, in eight classes, namely, pecora et jumenta, beasts, small animals (including spiders, crickets and ants), serpents, worms, fishes, birds and small winged creatures, chiefly insects; 13, the world and its parts; 14, the earth and its parts, containing chapters on Asia, Europe and Libya, that is, Africa; 15, buildings, fields and their measures; 16, stones (of which one is echo) and metals; 17, de rebus rusticis; 18, war and games; 19, ships, buildings and garments; 20, provisions, domestic and rustic instruments.

Isidore appears to have known Hebrew and Greek, and to have been familiar with the Latin classical poets, but he is a mere collector, and his derivations given all through the work are not unfrequently absurd, and, unless when very obvious, will not bear criticism. He seldom mentions his authorities except when he quotes the poets or historians. Yet his work was a great one for the time, and for many centuries was a much valued authority and a rich source of material for other works, and he had a high reputation for learning both in his own time and in subsequent ages. His *Etymologies* were often imitated, quoted and copied. MSS. are very numerous: Antonio (whose editor, Bayer, saw nearly 40) says, "plures passimque reperiuntur in bibliothecarum angulis." This work was printed nine times before 1529.

Hrabanus Maurus, whose family name was Magnentius, was educated in the abbey of Fulda, ordained deacon in 802 ("Annales Francorum" in Bouquet, *Historiens de la France*, v. 66), sent to the school of St Martin of Tours, then directed by Alcuin, where he seems to have learned Greek, and is said by Trithemius to have been taught Hebrew, Syriac and Chaldee by Theophilus an Ephesian. In his *Commentaries on Joshua* (lib. ii. c. 5) he speaks of having resided at Sidon. He returned to Fulda and taught the school there. He became abbot of Fulda in 822, resigned in April 842, was ordained archbishop of Mainz on the 26th of July 847, and died on the 4th of February 856. He compiled an encyclopaedia *De universo* (also called in some MSS. *De universali natura, De natura rerum,* and *De origine rerum*) in 22 books and 325 chapters. It is chiefly a rearrangement of Isidore's *Etymologies*, 371
omitting the first four books, half of the fifth and the tenth (the seven liberal arts, law, medicine and the alphabet of words), and copying the rest, beginning with the seventh book, verbally, though with great omissions, and adding (according to Ritter, *Geschichte der Philosophie*, vii. 193, from Alcuin, Augustine or some other accessible source) the meanings given in the Bible to the subject matter of the chapter; while things not mentioned in Scripture, especially such as belong to classical antiquity, are omitted, so that his work seems to be formed of two alternating parts. His arrangement of beginning with God and the angels long prevailed in methodical encyclopaedias. His last six books follow very closely the order of the last five of Isidore, from which they are taken. His omissions are characteristic of the diminished literary activity and more contracted knowledge of his time. His work was presented to Louis the German, king of Bavaria, at Hersfeld in October 847, and was printed in 1473, fol., probably at Venice, and again at Strassburg by Mentelin about 1472-1475, fol., 334 pages.

Michael Constantine Psellus, the younger, wrote Διδασκαλία παντοδαπή, dedicated to the emperor Michael Ducas, who reigned 1071-1078. It was printed by Fabricius in his *Bibliotheca Graeca* (1712), vol. v., in 186 pages 4to and 193 chapters, each containing a question and answer. Beginning with divinity, it goes on through natural history and astronomy, and ends with chapters on excessive hunger, and why flesh hung from a fig-tree becomes tender. As collation with a Turin MS. showed that 35 chapters were wanting, Harles has omitted the text in his edition of Fabricius, and gives only the titles of the chapters (x. 84-88).

The author of the most famous encyclopaedia of the middle ages was Vincent (*q.v.*) of Beauvais (*c.* 1190-*c.* 1264), whose work *Bibliotheca mundi* or *Speculum majus*—divided, as we have it, into four parts, *Speculum naturale*, *Speculum doctrinale*, *Speculum morale* (this part should be ascribed to a later hand), and *Speculum historiale*—was the great compendium of mid-13th century knowledge. Vincent of Beauvais preserved several works of the middle ages and gives extracts from many lost classics and valuable readings of others, and did more than any other medieval writer to awaken a taste for classical literature. Fabricius (*Bibl. Graeca*, 1728, xiv. pp. 107-125) has given a list of 328 authors, Hebrew, Arabic, Greek and Latin, quoted in the *Speculum naturale*. To these should be added about 100 more for the *doctrinale* and *historiale*. As Vincent did not know Greek or Arabic, he used Latin translations. This work is dealt with separately in the article on Vincent of Beauvais.

Brunetto Latini of Florence (born 1230, died 1294), the master of Dante and Guido Cavalcanti, while an exile in France between 1260 and 1267, wrote in French *Li Livres dou Tresor*, in 3 books and 413 chapters. Book i. contains the origin of the world, the history of the Bible and of the foundation of governments, astronomy, geography, and lastly natural history, taken from Aristotle, Pliny, and the old French Bestiaries. The first part of Book ii., on morality, is from the *Ethics* of Aristotle, which Brunetto had translated into Italian. The second part is little more than a copy of the well-known collection of extracts from ancient and modern moralists, called the *Moralities of the Philosophers*, of which there are many MSS. in prose and verse. Book iii., on politics, begins with a treatise on rhetoric, chiefly from Cicero *De inventione*, with many extracts from other writers and Brunetto’s remarks. The last part, the most original and interesting of all, treats of the government of the Italian republics of the time. Like many of his contemporaries, Brunetto revised his work, so that there are two editions, the second made after his return from exile. MSS. are singularly numerous, and exist in all the dialects then used in France. Others were written in Italy. It was translated into Italian in the latter part of the 13th century by Bono Giamboni, and was printed at Trevigi, 1474, fol., Venice, 1528 and 1533. The *Tesoro* of Brunetto must not be confounded with his *Tesoretto*, an Italian poem of 2937 short lines. Napoleon I. had intended to have the French text of the *Tesoro* printed with commentaries, and appointed a commission for the purpose. It was at last published in the *Collection des documents inédits* (Paris, 1863, 4to, 772 pages), edited by Chabaille from 42 MSS.

Bartholomew de Glanville, an English Franciscan friar, wrote about 1360 a most popular work, *De proprietatibus rerum*, in 19 books and 1230 chapters.

> Book 1 relates to God; 2, angels; 3, the soul; 4, the substance of the body; 5, anatomy; 6, ages; 7, diseases; 8, the heavens (astronomy and astrology); 9, time; 10, matter and form; 11, air; 12, birds (including insects, 38 names, Aquila to Vespertilio); 13, water (with fishes); 14, the earth (42 mountains, Ararath to Ziph); 15, provinces (171 countries, Asia to Zeugia); 16, precious stones (including coral, pearl, salt, 104 names, Arena to Zinguttes); 17, trees and herbs (197, Arbor to Zucarum); 18, animals (114, Aries to Vipera); 19, colours, scents, flavours and liquors, with a list of 36 eggs (Aspis to Vultur). Some editions add book 20, accidents of things, that is, numbers, measures, weights and sounds. The Paris edition of 1574 has a book on bees.

There were 15 editions before 1500. An English translation was completed 11th February 1398 by John Trevisa, and printed by Wynkyn de Worde, Westminster, 1495? fol.; London, 1533, fol.; and with considerable additions by Stephen Batman, a physician, London, 1582, fol. It was translated into French by Jehan Corbichon at the command of Charles V. of France, and printed 14 times from 1482 to 1556. A Dutch translation was printed in 1479, and again at Haarlem, 1485, fol.; and a Spanish translation by Padre Vincente de Burgos, Tholosa, 1494, fol.

Pierre Bersuire (Berchorius), a Benedictine, prior of the abbey of St Eloi in Paris, where he died in 1362, wrote a kind of encyclopaedia, chiefly relating to divinity, in three parts:—*Reductorium morale super totam Bibliam*, 428 *moralitates* in 34 books on the Bible from Genesis to Apocalypse; *Reductorium morale de proprietatibus rerum*, in 14 books and 958 chapters, a methodical encyclopaedia or system of nature on the plan of Bartholomew de Glanville, and chiefly taken from him (Berchorius places animals next after fishes in books 9 and 10, and adopts as natural classes *volatilia*, *natatilia* and *gressibilia*); *Dictionarius*, an alphabetical dictionary of 3514 words used in the Bible with moral expositions, occupying in the last edition 1558 folio pages. The first part was printed 11 times from 1474 to 1515, and the third 4 times. The three parts were printed together as *Petri Berchorii opera omnia* (an incorrect title, for he wrote much besides), Moguntiae, 1609, fol., 3 vols., 2719 pages; Coloniae Agrippinae, 1631, fol., 3 vols.; *ib.* 1730-1731, fol., 6 vols., 2570 pages.

A very popular small encyclopaedia, *Margarita philosophica*, in 12 books, divided into 26 tractates and 573 chapters, was written by Georg Reisch, a German, prior of the Carthusians of Freiburg, and confessor of the emperor Maximilian I. Books 1-7 treat of the seven liberal arts; 8, 9, principles and origin of natural things; 10, 11, the soul, vegetative, sensitive and intellectual; 12, moral philosophy. The first edition, Heidelberg, 1496, 4to, was followed by 8 others to 1535. An Italian translation by the astronomer Giovanno Paolo Gallucci was published at Venice in 1594, 1138 small quarto pages, of which 343 consist of additional tracts appended by the translator.

Raphael Maffei, called Volaterranus, being a native of Volterra, where he was born in 1451 and died

5th January 1522, wrote *Commentarii Urbani* (Rome, 1506, fol., in 38 books), so called because written at Rome. This encyclopaedia, printed eight times up to 1603, is remarkable for the great importance given to geography, and also to biography, a subject not included in previous encyclopaedias. Indeed, the book is formed of three nearly equal parts,—geographia, 11 books; anthropologia (biography), 11 books; and philologia, 15 books. The books are not divided into short chapters in the ancient manner, like those of its predecessors. The edition of 1603 contains 814 folio pages. The first book consists of the table of contents and a classed index; books 2-12, geography; 13-23, lives of illustrious men, the popes occupying book 22, and the emperors book 23; 24-27, animals and plants; 28, metals, gems, stones, houses and other inanimate things; 34, de scientiis cyclicis (grammar and rhetoric); 35, de scientiis mathematicis, arithmetic, geometry, optica, catoptrica, 372
astronomy and astrology; 36-38, Aristotelica (on the works of Aristotle).

Giorgio Valla, born about 1430 at Placentia, and therefore called Placentinus, died at Venice in 1499 while lecturing on the immortality of the soul. Aldus published his work, edited by his son Giovanni Pietro Valla, *De expetendis et fugiendis rebus*, Venetiis, 1501, fol. 2 vols.

> It contains 49 books and 2119 chapters. Book 1 is introductory, on knowledge, philosophy and mathematics, considered generally (he divides everything to be sought or avoided into three kinds—those which are in the mind, in the body by nature or habit, and thirdly, external, coming from without); books 2-4, arithmetic; 5-9, music; 10-15, geometry, including Euclid and mechanics—book 15 being in three long chapters—de spiritualibus, that is, pneumatics and hydraulics, de catoptricis, and de optice; 16-19, astrology (with the structure and use of the astrolabe); 20-23, physics (including metaphysics); 24-30, medicine; 31-34, grammar; 35-37, dialectics; 38, poetry; 39, 40, rhetoric; 41, moral philosophy; 42-44, economics; 45, politics; 46-48, de corporis commodis et incommodis, on the good and evil of the body (and soul); 49, de rebus externis, as glory, grandeur, &c.

Antonio Zara, born 1574, made bishop of Petina in Istria 1600, finished on the 17th of January 1614 a work published as *Anatomia ingeniorum et scientiarum*, Venetiis, 1615, 4to, 664 pages, in four sections and 54 membra. The first section, on the dignity and excellence of man, in 16 membra, considers him in all his bodily and mental aspects. The first membrum describes his structure and his soul, and in the latter part contains the author’s preface, the deeds of his ancestors, an account of himself, and the dedication of his book to Ferdinand, archduke of Austria. Four membra treat of the discovery of character by chiromancy, physiognomy, dreams and astrology. The second section treats of 16 sciences of the imagination—writing, magic, poetry, oratory, courtiership (aulicitas), theoretical and mystic arithmetic, geometry, architecture, optics, cosmography, astrology, practical medicine, war, government. The third section treats of 8 sciences of intellect—logic, physics, metaphysics, theoretical medicine, ethics, practical jurisprudence, judicature, theoretical theology. The fourth section treats of 12 sciences of memory—grammar, practical arithmetic, human history, sacred canons, practical theology, sacred history, and lastly the creation and the final catastrophe. The book, now very rare, is well arranged, with a copious index, and is full of curious learning.

Johann Heinrich Alsted, born 1588, died 1638, published *Encyclopaedia septem tomis distincta*, Herbornae Nassoviorum, 1630, fol. 7 vols., 2543 pages of very small type. It is in 35 books, divided into 7 classes, preceded by 48 synoptical tables of the whole, and followed by an index of 119 pages.

> I. Praecognita disciplinarum, 4 books, hexilogia, technologia, archelogia, didactica, that is, on intellectual habits and on the classification, origin and study of the arts. II. Philology, 6 books, lexica, grammar, rhetoric, logic, oratory and poetry; book 5, lexica, contains dictionaries explained in Latin of 1076 Hebrew, 842 Syriac, 1934 Arabic, 1923 Greek and 2092 Latin words, and also nomenclator technologiae, &c., a classified vocabulary of terms used in the arts and sciences, in Latin, Greek and Hebrew, filling 34 pages; book 6 contains Hebrew, Aramaic, Greek, Latin and German grammars; book 10, poetica, contains a list of 61 Rotwelsch words. III. Theoretic philosophy, 10 books:—book 11, metaphysics; 12, pneumatics (on spirits); 13, physics; 14, arithmetic; 15, geometry; 16, cosmography; 17, uranometria (astronomy and astrology); 18, geography (with maps of the Old World, eastern Mediterranean, and Palestine under the Old and New Testaments, and a plate of Noah’s ark); 19, optics; 20, music. IV. Practical philosophy, 4 books:—21, ethics; 22, economics (on relationships); 23, politics, with florilegium politicum, 119 pages of extracts from historians, philosophers and orators; 24, scholastics (on education, with a florilegium of 25 pages). V. The three superior faculties:—25, theology; 26, jurisprudence; 27, medicine (ending with the rules of the Salernian school). VI. Mechanical arts in general:—book 28, mathematical mechanical arts; book 29, agriculture, gardening, care of animals, baking, brewing, preparing medicines, metallurgy (with mining); book 30, physical mechanical arts—printing, dialling, &c. Under paedutica (games) is Vida’s Latin poem on chess, and one by Leuschner on the ludus Lorzius. VII. Farragines disciplinarum, 5 books:—31, mnemonics; 32, history; 33, chronology; 34, architecture; 35, quodlibetica, miscellaneous arts, as magic, cabbala, alchemy, magnetism, &c., with others apparently distinguished and named by himself, as, paradoxologia, the art of explaining paradoxes; dipnosophistica, the art of philosophizing while feasting; cyclognomica, the art of conversing well de quovis scibili; tabacologia, the nature, use and abuse of tobacco, &c.—in all 35 articles in this book.

Alsted’s encyclopaedia was received with very great applause, and was highly valued. Lami (*Entretiens*, 1684, p. 188) thought it almost the only encyclopaedia which did not deserve to be despised. Alsted’s learning was very various, and his reading was very extensive and diversified. He gives few references, and Thomasius charges him with plagiarism, as he often copies literally without any acknowledgment. He wrote not long before the appearance of encyclopaedias in modern languages superseded his own and other Latin books, and but a short time before the alphabetical arrangement began to prevail over the methodical. His book was reprinted, Lugduni, 1649, fol. 4 vols., 2608 pages.

Jean de Magnon, historiographer to the king of France, undertook to write an encyclopaedia in French heroic verse, which was to fill ten volumes of 20,000 lines each, and to render libraries merely a useless ornament. But he did not live to finish it, as he was killed at night by robbers on the Pont Neuf in Paris, in April 1662. The part he left was printed as *La Science universelle*, Paris, 1663, fol., 348 pages,—10 books containing about 11,000 lines. They begin with the nature of God, and end with the history of the fall of man. His verses, say Chaudon and Delandine, are perhaps the most nerveless, incorrect, obscure and flat in French poetry; yet the author had been the friend of Molière, and had acted with him in comedy.

Louis Moréri (born on the 25th of March 1643 at Bargemont, in the diocese of Fréjus, died on the 10th of July 1680 at Paris) wrote a dictionary of history, genealogy and biography, *Le Grand Dictionnaire historique, ou le mélange curieux de l'histoire sacrée et profane*, Lyons, 1674, fol. He began a second edition on a larger scale, published at Lyons in 1681, in two volumes folio; the sixth edition was edited by Jean le Clerc, Amsterdam, 1691, fol. 4 vols.; the twentieth and last edition, Paris, 1759, fol. 10 vols. Moréri's dictionary, still very useful, was of great value and importance, although not the first of the kind. It superseded the very inferior compilation of Juigné-Broissinère, *Dictionnaire théologique*, *historique*, *poétique*, *cosmographique*, *et chronologique*, Paris, 1644, 4to; Rouen, 1668, &c.,—a translation, with additions, of the *Dictionarium historicum*, *geographicum*, *et poëticum* of Charles Estienne, published in 1553, 4to, and often afterwards. As such a work was much wanted, Juigné's book went through twelve editions in less than thirty years, notwithstanding its want of criticism, errors, anachronisms, defects and inferior style.

Johann Jacob Hofmann (born on the 11th of September 1635, died on the 10th of March 1706), son of a schoolmaster at Basel, which he is said never to have left, and where he was professor of Greek and History, wrote *Lexicon universale historico-geographico-chronologico-poëtico-philologicum*, Basileae, 1677, fol. 2 vols., 1823 pages, a dictionary of history, biography, geography, genealogies of princely families, chronology, mythology and philology. At the end is Nomenclator Μιξόγλωττος, an index of names of places, people, &c., in many languages, carefully collected, and explained in Latin, filling 110 pages; with an index of subjects not forming separate articles, occupying 34 pages. In 1683 he published a continuation in 2 vols. fol., 2293 pages, containing, besides additions to the subjects given in his lexicon, the history of animals, plants, stones, metals, elements, stars, and especially of man and his affairs, arts, honours, laws, magic, music, rites and a vast number of other subjects. In 1698 he published a second edition, Lugduni Batavorum, fol. 4 vols., 3742 pages, incorporating the continuation with additions. From the great extent of his plan, many articles, especially in history, are superficial and faulty.

Étienne Chauvin was born at Nismes on the 18th of April 1640. He fled to Rotterdam on the revocation of the edict of Nantes, and in 1688 supplied Bayle's place in his lectures on philosophy. In 1695 he was invited by the elector of Brandenburg to go as professor of philosophy to Berlin, where he became the representative of the Cartesian philosophy, and died on the 6th of April 1725. He wrote 373 *Lexicon rationale*, *sive thesaurus philosophicus ordine alphabetico digestus*, Rotterdami, 1692, fol., 746 pages and 30 plates. An improved and enlarged edition was printed as *Lexicon philosophicum secundis curis*, Leovardiae, 1713, large folio, 725 pages and 30 plates. This great work may be considered as a dictionary of the Cartesian philosophy, and was very much used by Brucker and other earlier historians of philosophy. It is written in a very dry and scholastic style, and seldom names authorities.

The great dictionary of French, begun by the French Academy on the 7th of February 1639, excluded all words especially belonging to science and the arts. But the success of the rival dictionary of Furetière, which, as its title-page, as well as that of the Essais published in 1684, conspicuously announced, professed to give "les termes de toutes les Sciences et des Arts," induced Thomas Corneille, a member of the Academy, to compile *Le Dictionnaire des arts et des sciences*, which the Academy published with the first edition of their dictionary, Paris, 1694, folio, as a supplement in two volumes containing 1236 pages. It was reprinted at Amsterdam, 1696, fol. 2 vols., and at Paris in 1720, and again in 1732, revised by Fontenelle. A long series of dictionaries of arts and sciences have followed Corneille in placing in their titles the arts before the sciences, which he probably did merely in order to differ from Furetière. Corneille professed to quote no author whom he had not consulted; to take plants from Dioscorides and Matthiolus, medicine from Ettmüller, chemistry from a MS. of Perrault, and architecture, painting and sculpture from Félibien; and to give an abridged history of animals, birds and fishes, and an account of all religious and military orders and their statutes, heresiarchs and heresies, and dignities and charges ancient and modern.

Pierre Bayle (born on the 18th of November 1647, died on the 28th of December 1706) wrote a very important and valuable work, *Dictionnaire historique et critique*, Rotterdam, 1697, fol. 2 vols. His design was to make a dictionary of the errors and omissions of Moréri and others, but he was much embarrassed by the numerous editions and supplements of Moréri. A second edition with an additional volume appeared at Amsterdam in 1702, fol. 3 vols. The fourth edition, Rotterdam, 1720, fol. 4 vols., was much enlarged from his manuscripts, and was edited by Prosper Marchand. It contains 3132 pages besides tables, &c. The ninth edition was published at Basel, 1741, fol. 10 vols. It was translated into English from the second edition, London, 1709, fol. 4 vols., with some slight additions and corrections by the author; and again from the fifth edition of 1730 by Birch and

Lockman, London, 1734-1740, fol. 5 vols. J.G. de Chaufepié published *Nouveau Dictionnaire historique*, Amsterdam, 1750-1756, fol. 4 vols., as a supplement to Bayle. It chiefly consists of the articles added by the English translators with many corrections and additions, and about 500 new articles added by himself, and contains in all about 1400 articles. Prosper Marchand, editor of the fourth edition, left at his death on the 14th of January 1756 materials for a supplementary *Dictionnaire historique*, La Haye, 1758, fol. 2 vols., 891 pages, 136 articles. It had occupied his leisure moments for forty years. Much of his work was written on small scraps of paper, sometimes 20 in half a page and no larger than a nail, in such small characters that not only the editor but the printer had to use powerful magnifiers. Bayle's dictionary was also translated into German, Leipzig, 1741-1744, fol. 4 vols., with a preface by J.C. Gottsched. It is still a work of great importance and value.

Vincenzo Maria Coronelli, a Franciscan friar, who was born in Venice about 1650, made cosmographer to the republic in 1685, became general of his order in 1702, and was found dead at his study table on the 9th of December 1718, began in 1701 to publish a general alphabetical encyclopaedia, written in Italian, at which he had been working for thirty years, *Biblioteca universale sacro-profana*. It was to explain more than 300,000 words, to include history and biography as well as all other subjects, and to extend to 45 volumes folio. Volumes 1-39 were to contain the dictionary A to Z; 40, 41, the supplement; 42, retractations and corrections; 43, universal index; 44, index divided into matters; 45, index in various languages. But seven volumes only were published, Venezia, 1701-1706, fol., 5609 pages, A to Caque. The first six volumes have each an index of from 28 to 48 pages (in all 224 pages) of subjects, whether forming articles or incidental. The articles in each are numbered, and amount to 30,269 in the six volumes, which complete the letter B. On an average 3 pages contain 22 articles. Each volume is dedicated to a different patron—the pope, the doge, the king of Spain, &c. This work is remarkable for the extent and completeness of its plan, and for being the first great alphabetical encyclopaedia, as well as for being written in a modern language, but it was hastily written and very incorrect. Never, perhaps, says Tiraboschi (*Storia della letteratura italiana*, viii. 546), was there so quick a writer; he composed a folio volume as easily as others would a page, but he never perfected his works, and what we have of this book will not induce us to regret the want of the remainder.

The first alphabetical encyclopaedia written in English was the work of a London clergyman, John Harris (born about 1667, elected first secretary of the Royal Society on the 30th of November 1709, died on the 7th of September 1719), *Lexicon technicum, or an universal English Dictionary of Arts and Sciences*, London, 1704, fol., 1220 pages, 4 plates, with many diagrams and figures printed in the text. Like many subsequent English encyclopaedias the pages are not numbered. It professes not merely to explain the terms used in the arts and sciences, but the arts and sciences themselves. The author complains that he found much less help from previous dictionaries than one would suppose, that Chauvin is full of obsolete school terms, and Corneille gives only bare explanations of terms, which often relate only to simple ideas and common things. He omits theology, antiquity, biography and poetry; gives only technical history, geography and chronology; and in logic, metaphysics, ethics, grammar and rhetoric, merely explains the terms used. In mathematics and anatomy he professes to be very full, but says that the catalogues and places of the stars are very imperfect, as Flamsteed refused to assist him. In botany he gave from Ray, Morrison and Tournefort "a pretty exact botanick lexicon, which was what we really wanted before," with an account of all the "kinds and subalternate species of plants, and their specific differences" on Ray's method. He gave a table of fossils from Dr Woodward, professor of medicine in Gresham College, and took great pains to describe the parts of a ship accurately and particularly, going often on board himself for the purpose. In law he abridged from the best writers what he thought necessary. He meant to have given at the end an alphabet for each art and science, and some more plates of anatomy and ships, "but the undertaker could not afford it at the price." A review of his work, extending to the unusual length of four pages, appeared in the *Philosophical Transactions*, 1704, p. 1699. This volume was reprinted in 1708. A second volume of 1419 pages and 4 plates appeared in 1710, with a list of about 1300 subscribers. Great part of it consisted of mathematical and astronomical tables, as he intended his work to serve as a small mathematical library. He was allowed by Sir Isaac Newton to print his treatise on acids. He gives a table of logarithms to seven figures of decimals (44 pages), and one of sines, tangents and secants (120 pages), a list of books filling two pages, and an index of the articles in both volumes under 26 heads, filling 50 pages. The longest lists are law (1700 articles), chyrurgery, anatomy, geometry, fortification, botany and music. The mathematical and physical part is considered very able. He often mentions his authorities, and gives lists of books on particular subjects, as botany and chronology. His dictionary was long very popular. The fifth edition was published in 1736, fol. 2 vols. A supplement, including no new subjects, appeared in 1744, London, fol., 996 pages, 6 plates. It was intended to rival Ephraim Chambers's work (see below), but, being considered a bookseller's speculation, was not well received.

Johann Hübner, rector of the Johanneum in Hamburg, born on the 17th of March 1668, wrote prefaces to two dictionaries written in German, which bore his name, and were long popular. The first 374 was *Reales Staats Zeitungs- und Conversations-Lexicon*, Leipzig, 1704, 8vo; second edition, 1706, 947 pages; at the end a register of arms, and indexes of Latin and French words; fifth edition, 1711; fifteenth edition 1735, 1119 pages. The thirty-first edition was edited and enlarged by F.A. Rüder, and published by Brockhaus, Leipzig, 1824-1828, 8vo, 4 vols., 3088 pages. It was translated into Hungarian by Fejer, Pesten, 1816, 8vo, 5 vols., 2958 pages. The second, published as a supplement, was *Curieuses und reales Natur- Kunst- Berg- Gewerb- und Handlungs-Lexicon*, Leipzig, 1712, 8vo, 788 pages, frequently reprinted to 1792. The first relates to the political state of the world, as religion, orders, states, rivers, towns, castles, mountains, genealogy, war, ships; the second to nature, science, art and commerce. They were the work of many authors, of whom Paul Jacob Marpurger, a celebrated and voluminous writer on trade and commerce, born at Nuremberg on the 27th of June 1656, was an extensive contributor, and is the only one named by Hübner.

Johann Theodor Jablonski, who was born at Danzig on the 15th of December 1654, appointed secretary to the newly founded Prussian Academy in 1700, when he went to Berlin, where he died on the 28th of April 1731, published *Allgemeines Lexicon der Künste und Wissenschaften*, Leipzig, 1721, 4to, a short but excellent encyclopaedia still valued in Germany. It does not include theology, history, geography, biography and genealogy. He not only names his authorities, but gives a list of their works. A new edition in 1748 was increased one-third to 1508 pages. An improved edition, Königsberg and Leipzig, 1767, 4to, 2 vols., 1852 pages, was edited by J.J. Schwabe, public teacher of philosophy at Leipzig.

Ephraim Chambers (*q.v.*) published his *Cyclopaedia; or an Universal Dictionary of Art and Sciences, containing an Explication of the Terms and an Account of the Things Signified thereby in the several Arts, Liberal and Mechanical, and the several Sciences, Human and Divine*, London, 1728, fol. 2 vols. The dedication to the king is dated October 15, 1727. Chambers endeavoured to connect the scattered articles relating to each subject by a system of references, and to consider “the several matters, not only in themselves, but relatively, or as they respect each other; both to treat them as so many wholes and as so many parts of some greater whole.” Under each article he refers to the subject to which it belongs, and also to its subordinate parts; thus Copyhold has a reference to Tenure, of which it is a particular kind, and other references to Rolls, Custom, Manor, Fine, Charter-land and Freehold. In his preface he gives an “analysis of the divisions of knowledge,” 47 in number, with classed lists of the articles belonging to each, intended to serve as table of contents and also as a rubric or directory indicating the order in which the articles should be read. But it does so very imperfectly, as the lists are curtailed by many *et caeteras*; thus 19 occur in a list of 119 articles under Anatomy, which has nearly 2200 articles in Rees’s index. He omits etymologies unless “they appeared of some significance”; he gives only one grammatical form of each word, unless peculiar ideas are arbitrarily attached to different forms, as *precipitate*, *precipitant*, *precipitation*, when each has an article; and he omits complex ideas generally known, and thus “gets free of a vast load of plebeian words.” His work, he says, is a collection, not the produce of one man’s wit, for that would go but a little way, but of the whole commonwealth of learning. “Nobody that fell in my way has been spared, antient or modern, foreign nor domestic, Christian or Jew nor heathen.” To the subjects given by Harris he adds theology, metaphysics, ethics, politics, logic, grammar, rhetoric and poetry, but excludes history, biography, genealogy, geography and chronology, except their technical parts. A second edition appeared in 1738, fol. 2 vols., 2466 pages, “retouched and amended in a thousand places.” A few articles are added and some others enlarged, but he was prevented from doing more because “the booksellers were alarmed with a bill in parliament containing a clause to oblige the publishers of all improved editions of books to print their improvements separately.” The bill after passing the Commons was unexpectedly thrown out by the Lords; but fearing that it might be revived, the booksellers thought it best to retreat though more than twenty sheets had been printed. Five other editions were published in London, 1739 to 1751-1752, besides one in Dublin, 1742, all in 2 vols. fol. An Italian translation, Venezia, 1748-1749, 4to, 9 vols., was the first complete Italian encyclopaedia. When Chambers was in France in 1739 he rejected very favourable proposals to publish an edition there dedicated to Louis XV. His work was judiciously, honestly and carefully done, and long maintained its popularity. But it had many defects and omissions, as he was well aware; and at his death, on the 15th of May 1740, he had collected and arranged materials for seven new volumes. John Lewis Scott was employed by the booksellers to select such articles as were fit for the press and to supply others. He is said to have done this very efficiently until appointed sub-preceptor to the prince of Wales and Prince Edward. His task was entrusted to Dr (afterwards called Sir John) Hill, who performed it very hastily, and with characteristic carelessness and self-sufficiency, copying freely from his own writings. The *Supplement* was published in London, 1753, fol. 2 vols., 3307 pages and 12 plates. As Hill was a botanist, the botanical part, which had been very defective in the *Cyclopaedia*, was the best.

Abraham Rees (1743-1825), a famous Nonconformist minister, published a revised and enlarged edition, “with the supplement and modern improvements incorporated in one alphabet,” London, 1778-1788, fol. 2 vols., 5010 pages (but not paginated), 159 plates. It was published in 418 numbers at 6d. each. Rees says that he has added more than 4400 new articles. At the end he gives an index of articles, classed under 100 heads, numbering about 57,000 and filling 80 pages. The heads, with 39 cross references, are arranged alphabetically. Subsequently there were reprints.

One of the largest and most comprehensive encyclopaedias was undertaken and in a great measure completed by Johann Heinrich Zedler, a bookseller of Leipzig, who was born at Breslau 7th January 1706, made a Prussian commerzienrath in 1731, and died at Leipzig in 1760,—*Grosses vollständiges Universal Lexicon Aller Wissenschaften und Künste welche bishero durch menschlichen Verstand und Witz erfunden und verbessert worden*, Halle and Leipzig, 1732-1750, fol. 64 vols., 64,309 pages; and *Nöthige Supplement*, *ib.* 1751-1754, vols. i. to iv., A to Caq, 3016 pages. The columns, two in a page, are numbered, varying from 1356 in vol. li. to 2588 in vol. xlix. Each volume has a dedication, with a portrait. The first nine are the emperor, the kings of Prussia and Poland, the empress of Russia, and the kings of England, France, Poland, Denmark and Sweden. The dedications, of which two are in verse, and all are signed by Zedler, amount to 459 pages. The supplement has no dedications or

portraits. The preface to the first volume of the work is by Johann Peter von Ludewig, chancellor of the university of Halle (born 15th August 1690, died 6th September 1743). Nine editors were employed, whom Ludewig compares to the nine muses; and the whole of each subject was entrusted to the same person, that all its parts might be uniformly treated. Carl Günther Ludovici (born at Leipzig 7th August 1707, public teacher of philosophy there from 1734, died 3rd July 1778) edited the work from vol. xix., beginning the letter M, and published in 1739, to the end, and also the supplement. The work was published by subscription. Johann Heinrich Wolff, an eminent merchant and shopkeeper in Leipzig, born there on the 29th of April 1690, came to Zedler's assistance by advancing the funds for expenses and becoming answerable for the subscriptions, and spared no cost that the work might be complete. Zedler very truly says, in his preface to vol. xviii., that his *Universal Lexicon* was a work such as no time and no nation could show, and both in its plan and execution it is much more comprehensive and complete than any previous encyclopaedia. Colleges, says Ludewig, where all sciences are taught and studied, are on that account called *universities*, and their teaching is called *studium universale*; but the *Universal Lexicon* contains not only what they teach in theology, jurisprudence, medicine, philosophy, history, mathematics, &c., but also many other things belonging 375
to courts, chanceries, hunting, forests, war and peace, and to artists, artizans, housekeepers and merchants not thought of in colleges. Its plan embraces not only history, geography and biography, but also genealogy, topography, and from vol. xviii., published in 1738, lives of illustrious living persons. Zedler inquires why death alone should make a deserving man capable of having his services and worthy deeds made known to the world in print. The lives of the dead, he says, are to be found in books, but those of the living are not to be met with anywhere, and would often be more useful if known. In consequence of this preface, many lives and genealogies were sent to him for publication. Cross references generally give not only the article referred to, but also the volume and column, and, when necessary, such brief information as may distinguish the word referred to from others similar but of different meaning. Lists of authorities, often long, exact and valuable are frequently appended to the articles. This work, which is well and carefully compiled, and very trustworthy, is still a most valuable book of reference on many subjects, especially topography, genealogy and biography. The genealogies and family histories are excellent, and many particulars are given of the lives and works of authors not easily found elsewhere.

A work on a new plan was published by Dennis de Coetlogon, a Frenchman naturalized in England, who styled himself "Knight of St Lazare, M.D., and member of the Royal Academy of Angers"—*An Universal History of Arts and Sciences*, London, 1745, fol. 2 vols., 2529 pages, 33 plates and 161 articles arranged alphabetically. He "endeavours to render each treatise as complete as possible, avoiding above all things needless repetitions, and never puzzling the reader with the least reference." Theology is divided into several treatises; Philosophy into Ethicks, Logick and Metaphysick, each under its letter; and Physick is subdivided into Anatomy, Botany, Geography, Geometry, &c. Military Art is divided into Army, Fortification, Gunnery. The royal licence is dated 13th March 1740-1741, the dedication is to the duke of Gisors, the pages are numbered, there is an appendix of 35 pages of astronomical tables, and the two indexes, one to each volume, fill 69 pages, and contain about 9000 subjects. The type is large and the style diffuse, but the subject matter is sometimes curious. The author says that his work is the only one of the kind, and that he wrote out with his own hand every line, even the index. But notwithstanding the novelty of his plan, his work does not seem ever to have been popular.

Gianfrancesco Pivati, born at Padua in 1689, died at Venice in 1764, secretary of the Academy of Sciences at Venice, who had published in 1744 a 4to volume containing a *Dizionario universale*, wrote *Nuovo dizionario scientifico e curioso sacro-profano*, Venezia, 1746-1751, fol. 10 vols., 7791 pages, 597 plates. It is a general encyclopaedia, including geography, but not history or biography. He gives frequent references to his authorities and much curious information. His preliminary discourse (80 pages) contains a history of the several sciences from mathematics to geography. The book was published by subscription, and at the end of the last volume is a *Catalogo dei Signori Associati*, 252 in number, who took 266 copies. It is also remarkable for the number of its plates, which are engraved on copper. In each volume they are placed together at the end, and are preceded by an explanatory index of subjects referring to the plates and to the articles they illustrate.

One of the greatest and most remarkable literary enterprises of the 18th century, the famous French *Encyclopédie*, originated in a French translation of Ephraim Chambers's *Cyclopaedia*, begun in 1743 and finished in 1745 by John Mills, an Englishman resident in France, assisted by Gottfried Sellius, a very learned native of Danzig, who, after being a professor at Halle and Göttingen, and residing in Holland, had settled in Paris. They applied to Lebreton, the king's printer, to publish the work, to fulfil the formalities required by French law, with which, as foreigners, they were not acquainted, and to solicit a royal privilege. This he obtained, but in his own name alone. Mills complained so loudly and bitterly of this deception that Lebreton had to acknowledge formally that the privilege belonged *en toute propriété* to John Mills. But, as he again took care not to acquaint Mills with the necessary legal formalities, this title soon became invalid. Mills then agreed to grant him part of his privilege, and in May 1745 the work was announced as *Encyclopédie ou dictionnaire universel des arts et des sciences*, folio, four volumes of 250 to 260 sheets each, with a fifth of at least 120 plates, and a vocabulary or list of articles in French, Latin, German, Italian and Spanish, with other lists for each language explained in French, so that foreigners might easily find any article wanted. It was to be published by subscription at 135 livres, but for large paper copies 200 livres, the first volume to be delivered in June 1746, and the two last at the end of 1748. The subscription list,

which was considerable, closed on the 31st of December 1745. Mills demanded an account, which Lebreton, who had again omitted certain formalities, insultingly refused. Mills brought an action against him, but before it was decided Lebreton procured the revocation of the privilege as informal, and obtained another for himself dated the 21st of January 1746. Thus, for unwittingly contravening regulations with which his unscrupulous publisher ought to have made him acquainted, Mills was despoiled of the work he had both planned and executed, and had to return to England. Jean Paul de Gua de Malves, professor of philosophy in the college of France (born at Carcassonne in 1713, died on the 15th of June 1785), was then engaged as editor merely to correct errors and add new discoveries. But he proposed a thorough revision, and obtained the assistance of many learned men and artists, among whom Desessarts names Louis, Condillac, d’Alembert and Diderot. But the publishers did not think his reputation high enough to ensure success, withheld their confidence, and often opposed his plans as too expensive. Tired at last of disputes, and too easily offended, de Gua resigned the editorship. The publishers, who had already made heavy advances, offered it to Diderot, who was probably recommended to them by his very well received *Dictionnaire universel de medicine*, Paris, 1746-1748, fol. 6 vols., published by Briasson, David and Durand, with notes and additions by Julien Busson, doctor regent of the faculty of medicine of Paris. It was a translation, made with the assistance of Eidous and Toussaint, of the celebrated work of Dr Robert James, inventor of the fever powders, *A Medicinal Dictionary*, London, 1743-1745, fol. 3 vols., 3275 pages and 98 plates, comprising a history of drugs, with chemistry, botany and natural history so far as they relate to medicine, and with an historical preface of 99 pages (in the translation 136). The proposed work was to have been similar in character. De Gua’s papers were handed over to Diderot in great confusion. He soon persuaded the publishers to undertake a far more original and comprehensive work. His friend d’Alembert undertook to edit the mathematics. Other subjects were allotted to 21 contributors, each of whom received the articles on this subject in Mills’ translation to serve as a basis for his work. But they were in most cases so badly composed and translated, so full of errors and omissions, that they were not used. The contributions were to be finished in three months, but none was ready in time, except Music by Rousseau, which he admits was hastily and badly done. Diderot was imprisoned at Vincennes, on the 29th of July 1749, for his *Lettre sur les aveugles*. He was closely confined for 28 days, and was then for three months and ten days a prisoner on parole in the castle. This did not stop the printing, though it caused delay. The prospectus by Diderot appeared in November 1750. The work was to form 8 vols. fol., with at least 600 plates. The first volume was published in July 1751, and delivered to the subscribers in August. The second appeared in January 1752. An *arrêt* of the council, 9th of February, suppressed both volumes as injurious to the king’s authority and to religion. Malesherbes, director-general of the Librairie, stopped the issue of volume ii., 9th of February, and on the 21st went with a *lettre de cachet* to Lebreton’s to seize the plates and the MSS., but did not find, says Barbier, even those of volume iii., as they had been taken to his own house by Diderot and one of 376
the publishers. The Jesuits tried to continue the work, but in vain. It was less easy, says Grimm, than to ruin philosophers. The *Dictionnaire de Trévoux* pronounced the completion of the *Encyclopédie* impossible, and the project ridiculous (5th edition, 1752, iii, 750). The government had to request the editors to resume the work as one honourable to the nation. The marquis d’Argenson writes, 7th of May 1752, that Mme de Pompadour had been urging them to proceed, and at the end of June he reports them as again at work. Volume iii., rather improved by the delay, appeared in October 1753; and volume vii., completing G, in November 1757. The clamours against the work soon recommenced. D’ Alembert retired in January 1758, weary of sermons, satires and intolerant and absurd censors. The parlement of Paris, by an *arrêt*, 23rd of January 1759, stopped the sale and distribution of the *Encyclopédie*, Helvetius’s *De l’Esprit*, and six other books; and by an *arrêt*, 6th February, ordered them all to be burnt, but referred the *Encyclopédie* for examination to a commission of nine. An *arrêt du conseil*, 7th of March, revoked the privilege of 1746, and stopped the printing. Volume viii. was then in the press. Malesherbes warned Diderot that he would have his papers seized next day; and when Diderot said he could not make a selection, or find a place of safety at such short notice, Malesherbes said, “Send them to me, they will not look for them there.” This, according to Mme de Vandeul, Diderot’s daughter, was done with perfect success. In the article Pardonner Diderot refers to these persecutions, and says, “In the space of some months we have seen our honour, fortune, liberty and life imperilled.” Malesherbes, Choiseul and Mme de Pompadour protected the work; Diderot obtained private permission to go on printing, but with a strict charge not to publish any part until the whole was finished. The Jesuits were condemned by the parlement of Paris in 1762, and by the king in November 1764. Volume i. of plates appeared in 1762, and volumes viii. to xvii., ten volumes of text, 9408 pages, completing the work, with the 4th volume of plates in 1765, when there were 4250 subscribers. The work circulated freely in the provinces and in foreign countries, and was secretly distributed in Paris and Versailles. The general assembly of the clergy, on the 20th of June 1765, approved articles in which it was condemned, and on the 27th of September adopted a *mémoire* to be presented to the king. They were forbidden to publish their acts which favoured the Jesuits, but Lebreton was required to give a list of his subscribers, and was put into the Bastille for eight days in 1766. A royal order was sent to the subscribers to deliver their copies to the lieutenant of police. Voltaire in 1774 relates that, at a *petit souper* of the king at Trianon, there was a debate on the composition of gunpowder. Mme de Pompadour said she did not know how her rouge or her silk stockings were made. The duc de la Vallière regretted that the king had confiscated their encyclopaedias, which could decide everything. The king said he had been told that the work was most dangerous, but as he wished to judge for himself, he sent for a copy. Three servants with difficulty brought in the 21 volumes. The company found everything they looked for, and the king allowed the confiscated copies to be returned. Mme de Pompadour died on the 15th of April 1764.

Lebreton had half of the property in the work, and Durand, David and Briasson had the rest. Lebreton, who had the largest printing office in Paris, employed 50 workmen in printing the last ten volumes. He had the articles set in type exactly as the authors sent them in, and when Diderot had corrected the last proof of each sheet, he and his foreman, hastily, secretly and by night, unknown to his partners in the work, cut out whatever seemed to them daring, or likely to give offence, mutilated most of the best articles without any regard to the consecutiveness of what was left, and burnt the manuscript as they proceeded. The printing of the work was nearly finished when Diderot, having to consult one of his great philosophical articles in the letter S, found it entirely mutilated. He was confounded, says Grimm, at discovering the atrocity of the printer; all the best articles were in the same confusion. This discovery put him into a state of frenzy and despair from rage and grief. His daughter never heard him speak coolly on the subject, and after twenty years it still made him angry. He believed that every one knew as well as he did what was wanting in each article, but in fact the mutilation was not perceived even by the authors, and for many years was known to few persons. Diderot at first refused to correct the remaining proofs, or to do more than write the explanations of the plates. He required, according to Mme de Vandeul, that a copy, now at St Petersburg with his library, should be printed with columns in which all was restored. The mutilations began as far back as the article Intendant. But how far, says Rosenkranz, this murderous, incredible and infamous operation was carried cannot now be exactly ascertained. Diderot’s articles, not including those on arts and trades, were reprinted in Naigeon’s edition (Paris, 1821, 8vo, 22 vols.). They fill 4132 pages, and number 1139, of which 601 were written for the last ten volumes. They are on very many subjects, but principally on grammar, history, morality, philosophy, literature and metaphysics. As a contributor, his special department of the work was philosophy, and arts and trades. He passed whole days in workshops, and began by examining a machine carefully, then he had it taken to pieces and put together again, then he watched it at work, and lastly worked it himself. He thus learned to use such complicated machines as the stocking and cut velvet looms. He at first received 1200 livres a year as editor, but afterwards 2500 livres a volume, besides a final sum of 20,000 livres. Although after his engagement he did not suffer from poverty as he had done before, he was obliged to sell his library in order to provide for his daughter. De Jaucourt spared neither time, trouble nor expense in perfecting the work, for which he received nothing, and he employed several secretaries at it for ten years. To pay them he had to sell his house in Paris, which Lebreton bought with the profits derived from De Jaucourt’s work. All the publishers made large fortunes; their expenses amounted to 1,158,000 livres and their profits to 2,162,000. D’Alembert’s “Discours Preliminaire,” 45 pages, written in 1750, prefixed to the first volume, and delivered before the French Academy on his reception on the 19th of December 1754, consists of a systematic arrangement of the various branches of knowledge, and an account of their progress since their revival. His system, chiefly taken from Bacon, divides them into three classes, under memory, reason and imagination. Arts and trades are placed under natural history, superstition and magic under science de Dieu, and orthography and heraldry under logic. The literary world is divided into three corresponding classes—*érudits*, *philosophes* and *beaux esprits*. As in Ephraim Chambers’s *Cyclopaedia*, history and biography were excluded, except incidentally; thus Aristotle’s life is given in the article Aristotelisme. The science to which an article belongs is generally named at the beginning of it, references are given to other articles, and the authors’ names are marked by initials, of which lists are given in the earlier volumes, but sometimes their names are subscribed in full. Articles by Diderot have no mark, and those inserted by him as editor have an asterisk prefixed. Among the contributors were Voltaire, Euler, Marmontel, Montesquieu, D’Anville, D’Holbach and Turgot, the leader of the new school of economists which made its first appearance in the pages of the *Encyclopédie*. Louis wrote the surgery, Daubenton natural history, Eidous heraldry and art, Toussaint jurisprudence, and Condamine articles on South America.

No encyclopaedia perhaps has been of such political importance, or has occupied so conspicuous a place in the civil and literary history of its century. It sought not only to give information, but to guide opinion. It was, as Rosenkranz says (*Diderot*, i. 157), theistic and heretical. It was opposed to the church, then all-powerful in France, and it treated dogma historically. It was, as Desnoiresterres says (*Voltaire*, v. 164), a war machine; as it progressed, its attacks both on the church and the still more despotic government, as well as on Christianity itself, became bolder and more undisguised, and it was met by opposition and persecution unparalleled in the history of encyclopaedias. Its execution is very unequal, and its articles of very different value. It was not constructed on a regular plan, or subjected to sufficient supervision; articles were sent in by the contributors, and not seen by the editors until they were in type. In each subject there are some excellent articles, but others are very inferior or altogether omitted, and references are often given to articles which do not exist. Thus marine is said to be more than three-fourths deficient; and in geography errors and omissions abound —even capitals and sovereign states are overlooked, while villages are given as towns, and towns are described which never existed. The style is too generally loose, digressive and inexact; dates are seldom given; and discursiveness, verbosity and dogmatism are frequent faults. Voltaire was constantly demanding truth, brevity and method, and said it was built half of marble and half of wood. D’Alembert compared it to a harlequin’s coat, in which there is some good stuff but too many rags. Diderot was dissatisfied with it as a whole; much of it was compiled in haste; and carelessly written articles and incompetent contributors were admitted for want of money to pay good writers. Zedler’s *Universal Lexicon* is on the whole much more useful for reference than its far more brilliant successor. The permanent value of encyclopaedias depends on the proportion of exact and precise facts they contain and on their systematic regularity. 377

The first edition of the *Encyclopédie*, in 17 vols. folio, 16,288 pages, was imitated by a counterfeit edition printed at Geneva as the volumes appeared in Paris. Eleven folio volumes of plates were published at Paris (1762 to 1772), containing 2888 plates and 923 pages of explanation, &c. A supplement was printed at Amsterdam and Paris (1776-1777), fol. 5 vols., 3874 pages, with 224 plates. History was introduced at the wish of the public, but only "the general features which mark epochs in the annals of the world." The astronomy was by Delalande, mathematics by Condorcet, tables by Bernouilli, natural history by Adanson, anatomy and physiology by Haller. Daubenton, Condamine, Marmontel and other old contributors wrote many articles, and several were taken from foreign editions. A very full and elaborate index of the articles and subjects of the 33 volumes was printed at Amsterdam in 1780, fol. 2 vols. 1852 pages. It was made by Pierre Mouchon, who was born at Geneva on the 30th of July 1735, consecrated minister on the 18th of August 1758, pastor of the French church at Basel 1766, elected a pastor in Geneva on the 6th of March 1788, principal of the college there 22nd of April 1791, died on the 20th of August 1797. This *Table analytique*, which took him five years to make, was undertaken for the publishers Cramer and De Tournes, who gave him 800 louis for it. Though very exact and full, he designedly omits the attacks on Christianity. This index was rendered more useful and indispensable by the very diffuse and digressive style of the work, and by the vast number of its articles. A complete copy of the first edition of the *Encyclopédie* consists of 35 vols. fol., printed 1751-1780, containing 23,135 pages and 3132 plates. It was written by about 160 contributors. About 1761 Panckoucke and other publishers in Paris proposed a new and revised edition, and bought the plates for 250,000 livres. But, as Diderot indignantly refused to edit what he considered a fraud on the subscribers to the as yet unfinished work, they began simply to reprint the work, promising supplementary volumes. When three volumes were printed the whole was seized in 1770 by the government at the complaint of the clergy, and was lodged in the Bastille. The plan of a second French edition was laid aside then, to be revived twenty years later in a very different form. Foreign editions of the *Encyclopédie* are numerous, and it is difficult to enumerate them correctly. One, with notes by Ottavio Diodati, Dr Sebastiano Paoli and Carlo Giuliani, appeared at Lucca (1758-1771), fol. 17 vols. of text and 10 of plates. Though it was very much expurgated, all engaged in it were excommunicated by the pope in 1759. An attempt made at Siena to publish an Italian translation failed. An addition by the abbé Serafini and Dr Gonnella (Livourne, 1770), &c., fol. 33 vols., returned a profit of 60,000 piastres, and was protected by Leopold II., who secured the pope's silence. Other editions are Genève, Cramer (1772-1776), a facsimile reprint. Genève, Pellet (1777-1779), 4to, 36 vols. of text and 3 of plates, with 6 vols. of Mouchon's index (Lyon, 1780), 4to; Genève et Neufchâtel, Pellet (1778-1779), 4to, 36 vols. of text and 3 of plates; Lausanne (1778-1781), 36 vols. 4to, or 72 octavo, of text and 3 of plates (1779-1780); Lausanne et Bern, chez les Sociétés Typographiques (1780-1782), 36 vols. 8vo of text and 3 vols. 4to of plates (1782). These four editions have the supplement incorporated. Fortuné Barthelemy de Felice, an Italian monk, born at Rome on the 24th of August 1723, who had been professor at Rome and Naples, and had become a Protestant, printed a very incorrect though successful edition (Yverdun, 1770-1780) 4to, 42 vols. of text, 5 of supplement and 10 of plates. It professed to be a new work, standing in the same relationship to the *Encyclopédie* as that did to Chambers's, which is far from being the case. Sir Joseph Ayloffe issued proposals, 14th December 1751, for an English translation of the *Encyclopédie*, to be finished by Christmas 1756, in 10 vols. 4to, with at least 600 plates. No. 1 appeared in January 1752, but met with little success. Several selections of articles and extracts have been published under the title of *L'Esprit de l'Encyclopédie*. The last was by Hennequin (Paris, 1822-1823), 8vo, 15 vols. An English selection is *Select Essays from the Encyclopedy* (London, 1773), 8vo. The articles of most of the principal contributors have been reprinted in the editions of their respective works. Voltaire wrote 8 vols. 8vo of a kind of fragmentary supplement, *Questions sur l'Encyclopédie*, frequently printed, and usually included in editions of his works, together with his contributions to the *Encyclopédie* and his *Dictionnaire philosophique*. Several special dictionaries have been formed from the *Encyclopédie*, as the *Dictionnaire portatif des arts et métiers* (Paris, 1766), 8vo, 2 vols. about 1300 pages, by Philippe Macquer, brother of the author of the *Dict. de chimie*. An enlarged edition by the abbé Jaubert (Paris, 1773), 5 vols. 8vo, 3017 pages, was much valued and often reprinted. The books attacking and defending the *Encyclopédie* are very many. No original work of the 18th century, says Lanfrey, has been more depreciated, ridiculed and calumniated. It has been called chaos, nothingness, the Tower of Babel, a work of disorder and destruction, the gospel of Satan and even the ruins of Palmyra.

The *Encyclopaedia Britannica*, "by a society of gentlemen in Scotland, printed in Edinburgh for A. Bell and C. Macfarquhar, and sold by Colin Macfarquhar at his printing office in Nicolson Street," was completed in 1771 in 3 volumes 4to, containing 2670 pages, and 160 copperplates engraved by Andrew Bell. It was published in numbers, of which the two first were issued in December 1768, "price 6d. each, or 8d on a finer paper," and was to be completed in 100 weekly numbers. It was compiled, as the title-page says, on a new plan. The different sciences and arts were "digested into distinct treatises or systems," of which there are 45 with cross headings, that is, titles printed across the page, and about 30 other articles more than three pages long. The longest are "Anatomy," 166 pages, and "Surgery," 238 pages. "The various technical terms, &c., are explained as they occur in the order of the alphabet." "Instead of dismembering the sciences, by attempting to treat them intelligibly under a multitude of technical terms, they have digested the principles of every science in the form of systems or distinct treatises, and explained the terms as they occur in the order of the alphabet, with references to the sciences to which they belong." This plan, as the compilers say, differs from that of all the previous dictionaries of arts and sciences. Its merit and novelty consist in the combination of De Coetlogon's plan with that in common use,—on the one hand keeping important subjects together, and on the other facilitating reference by numerous separate articles. It is doubtful to whom the credit of this plan is due. The editor, William Smellie, a printer (born in 1740, died on the 24th of June 1795), afterwards secretary and superintendent of natural history to the Society of Scottish Antiquaries, is said by his biographer to have devised the plan and written or compiled all the chief articles; and he prints, but without date, part of a letter written and signed by Andrew Bell by which he was engaged in the work:—“Sir, As we are engaged in publishing a dictionary of the arts and sciences, and as you have informed us that there are fifteen capital sciences which you will undertake for and write up the subdivisions and detached parts of these conform to your plan, and likewise to prepare the whole work for the press, &c., &c., we hereby agree to allow you £200 for your trouble, &c.” Prof. Macvey Napier says that Smellie “was more likely to have suggested that great improvement than any of his known coadjutors.” Archibald Constable, who was interested in the work from 1788, and was afterwards intimately acquainted with Bell, says Colin Macfarquhar was the actual projector of the *Encyclopaedia*, and the editor of the two first editions, while Smellie was merely “a contributor for hire” (*Memoirs*, ii. 311). Dr Gleig, in his preface to the third edition, says: “The idea had been conceived by him (Colin Macfarquhar) and his friend Mr Andrew Bell, engraver. By whom these gentlemen were assisted in digesting the plan which attracted to that work so much public attention, or whether they had any assistance, are questions in which our readers cannot be interested.” Macfarquhar, according to Constable, was a person of excellent taste and very general knowledge, though at starting he had little or no capital, and was obliged to associate Bell, then the principal engraver in Edinburgh, as a partner in his undertaking.

The second edition was begun in 1776, and was published in numbers, of which the first was issued on the 21st of June 1777, and the last, No. 181, on the 18th of September 1784, forming 10 vols. 4to, dated 1778 to 1783, and containing 8595 pages and 340 plates. The pagination is continuous, ending 378
with page 9200, but 295 pages are inserted in various places, and page 7099 is followed by 8000. The number and length of the articles were much increased, 72 have cross headings, and more than 150 others may be classed as long articles. At the end is an appendix (“Abatement” to “Wood”) of 200 pages, containing, under the heading Botanical Table, a list of the 931 genera included in the 58 natural orders of Linnaeus, and followed by a list of 526 books, said to have been the principal authorities used. All the maps are placed together under the article “Geography” (195 pages). Most of the long articles have numbered marginal titles; “Scotland,” 84 pages, has 837. “Medicine,” 309 pages, and “Pharmacy” have each an index. The plan of the work was enlarged by the addition of history and biography, which encyclopaedias in general had long omitted. “From the time of the second edition of this work, every cyclopaedia of note, in England and elsewhere, has been a cyclopaedia, not solely of arts and sciences, but of the whole wide circle of general learning and miscellaneous information” (*Quarterly Review*, cxiii. 362). Smellie was applied to by Bell to edit the second edition, and to take a share of one-third in the work; but he refused, because the other persons concerned in it, at the suggestion of “a very distinguished nobleman of very high rank” (said by Professor Napier to have been the duke of Buccleuch), insisted upon the introduction of a system of general biography which he considered inconsistent with the character of a dictionary of arts and sciences. James Tytler, M.A., seems to have been selected as the next most eligible compiler. His father, a man of extensive knowledge, was 53 years minister of Fearn in Forfarshire, and died in 1785. Tytler (outlawed by the High Court of Justiciary, 7th of January 1793, buried at Salem in Massachusetts on the 11th of January 1804, aged fifty-eight) “wrote,” says Watt, “many of the scientific treatises and histories, and almost all the minor articles” (*Bibliotheca Brit.*).

After about a year’s preparation, the third edition was announced in 1787; the first number was published early in 1788, and the first volume in October 1788. There were to be 300 weekly numbers, price 1s. each, forming 30 parts at 10s. 6d. each, and 15 volumes, with 360 plates. It was completed in 1797 in 18 vols. 4to, containing 14,579 pages and 542 plates. Among the multifarious articles represented in the frontispiece, which was required by the traditional fashion of the period, is a balloon. The maps are, as in subsequent editions, distributed among the articles relating to the respective countries. It was edited by Colin Macfarquhar as far as the article “Mysteries” (by Dr Doig, vol. xii.), when he died, on the 2nd of April 1793, in his forty-eighth year, “worn out,” says Constable, “by fatigue and anxiety of mind.” His children’s trustees and Andrew Bell requested George Gleig of Stirling (consecrated on the 30th of October 1808 assistant and successor to the bishop of Brechin), who had written about twelve articles, to edit the rest of the work; “and for the time, and the limited sum allowed him for the reward of contributors, his part in the work was considered very well done” (Constable, ii. 312). Professor Robison was induced by Gleig to become a contributor. He first revised the article “Optics,” and then wrote a series of articles on natural philosophy, which attracted great attention and were long highly esteemed by scientific men. The sub-editors were James Walker (Primus Scotiae Episcopus 27th of May 1837, died on the 5th of March 1841, aged seventy) until 1795, then James Thomson, succeeded in November 1796 by his brother Thomas, afterwards professor of chemistry at Glasgow, who remained connected with the *Encyclopaedia* until 1800. According to Kerr (*Smellie’s Life*, i. 364-365), 10,000 copies were printed, and the profit to the proprietors was £42,000, besides the payments for their respective work in the conduct of the publication as tradesmen,—Bell as engraver of all the plates, and Macfarquhar as sole printer. According to Constable (*Memoirs*, ii. 312), the impression was begun at 5000 copies, and concluded with a sale of 13,000. James Hunter, “an active bookseller of no character,” who had a shop in Middle Row, Holborn, sold the book to the trade, and on his failure Thomson Bonar, a wine merchant, who had married Bell’s daughter, became the seller of the book. He quarrelled with his father-in-law, who would not see him for ten years before his death in 1809. When the edition was completed, the copyright and remaining books were sold in order to wind up the concern, and “the whole was purchased by Bell, who gave £13 a copy, sold all the complete copies to the trade, printed up the odd volumes, and thus kept the work in the market for several years” (Constable, ii. 312)

The supplement of the third edition, printed for Thomson Bonar, and edited by Gleig, was published in 1801 in 2 vols. 4to, containing 1624 pages and 50 copperplates engraved by D. Lizars. In the dedication to the king, dated Stirling, 10th December 1800, Dr Gleig says: "The French *Encyclopédie* had been accused, and justly accused, of having disseminated far and wide the seeds of anarchy and atheism. If the *Encyclopaedia Britannica* shall in any degree counteract the tendency of that pestiferous work, even these two volumes will not be wholly unworthy of your Majesty's attention." Professor Robison added 19 articles to the series he had begun when the third edition was so far advanced. Professor Playfair assisted in "Mathematics." Dr Thomas Thomson wrote "Chemistry," "Mineralogy" and other articles, in which the use of symbols was for the first time introduced into chemistry; and these articles formed the first outline of his *System of Chemistry*, published at Edinburgh in 1802, 8vo, 4 vols.; the sixth edition, 1821.

The fourth edition, printed for Andrew Bell, was begun in 1800 or 1801, and finished in 1810 in 20 vols. 4to, containing 16,033 pages, with 581 plates engraved by Bell. The dedication to the king, signed Andrew Bell, is dated Lauristoun, Edinburgh, 1809. The preface is that of the third edition with the necessary alterations and additions in the latter part. No articles were reprinted from the supplement, as Bell had not the copyright. Professor Wallace's articles on mathematics were much valued, and raised the scientific character of the work. Dr Thomas Thomson declined the editorship, and recommended Dr James Millar, afterwards editor of the *Encyclopaedia Edinensis* (died on the 13th of July 1827). He was fond of natural history and a good chemist, but, according to Constable, slow and dilatory and not well qualified. Andrew Bell died on the 10th of June 1809, aged eighty-three, "leaving," says Constable, "two sets of trustees, one literary to make the money, the other legal to lay it out after it was made." The edition began with 1250 copies and concluded at 4000, of which two-thirds passed through the hands of Constable's firm. Early in 1804 Andrew Bell had offered Constable and his partner Hunter the copyright of the work, printing materials, &c., and all that was then printed of the fourth edition, for £20,000. This offer was in agitation in March 1804, when the two partners were in London. On the 5th of May 1804, after Lord Jeffrey's arrival in Edinburgh, as he relates to Francis Horner, they entrusted him with a design, on which he found that most of his friends had embarked with great eagerness, "for publishing an entire new encyclopaedia upon an improved plan. Stewart, I understand, is to lend his name, and to write the preliminary discourse, besides other articles. Playfair is to superintend the mathematical department, and Robison the natural philosophy. Thomas Thomson is extremely zealous in the cause. W. Scott has embraced it with great affection.... The authors are to be paid at least as well as reviewers, and are to retain the copyright of their articles for separate publication if they think proper" (Cockburn, *Life of Lord Jeffrey*, 1852, ii. 90). It was then, perhaps, that Constable gave £100 to Bonar for the copyright of the supplement.

The fifth edition was begun immediately after the fourth as a mere reprint. "The management of the edition, or rather mismanagement, went on under the *lawyer trustees* for several years, and at last the whole property was again brought to the market by public sale. There were about 1800 copies printed of the five first volumes, which formed one lot, the copyright formed another lot, and so on. The whole was purchased by myself and in my name for between £13,000 and £14,000, and it was said by the wise booksellers of Edinburgh and others that I had completely ruined myself and all connected with me by a purchase to such an enormous amount; this was early in 1812" (Constable, ii. 314). Bonar, who lived next door to the printing office, thought he could conduct the book, and had resolved on the purchase. Having a good deal of money, he seemed to Constable a formidable rival, whose alliance was to be secured. After "sundry interviews" it was agreed that Constable should buy the copyright in his own name, and that Bonar should have one-third, and also one-third of the copyright of the supplement, for which he gave £200. Dr James Millar corrected and revised the last 15 volumes. The preface is dated the 1st of December 1814. The printing was superintended by Bonar, who died on the 26th of July 1814. His trustees were repaid his advances on the work, about £6000, and the copyright was valued at £11,000, of which they received one-third, Constable adding £500, as the book had been so extremely successful. It was published in 20 vols., 16,017 pages, 582 plates, price £36, and dated 1817. 379

Soon after the purchase of the copyright, Constable began to prepare for the publication of a supplement, to be of four or, at the very utmost, five volumes. "The first article arranged for was one on 'Chemistry' by Sir Humphry Davy, but he went abroad [in October 1813] and I released him from his engagement, and employed Mr Brande; the second article was Mr Stewart's Dissertation, for which I agreed to pay him £1000, leaving the extent of it to himself, but with this understanding, that it was not to be under ten sheets, and might extend to twenty" (Constable, ii. 318). Dugald Stewart, in a letter to Constable, the 15th of November 1812, though he declines to engage to execute any of his own suggestions, recommends that four discourses should "stand in front," forming "a general map of the various departments of human knowledge," similar to "the excellent discourse prefixed by D'Alembert to the French *Encyclopédie*," together with historical sketches of the progress since Bacon's time of modern discoveries in metaphysical, moral and political philosophy, in mathematics and physics, in chemistry, and in zoology, botany and mineralogy. He would only promise to undertake the general map and the first historical sketch, if his health and other engagements permitted, after the second volume of his *Philosophy of the Human Mind* (published in 1813) had gone to press. For the second he recommended Playfair, for chemistry Sir Humphry Davy. He received £1000 for the first part of his dissertation (166 pages), and £700 for the second (257 pages), the right of publication being limited to the Supplement and *Encyclopaedia*. Constable next contracted with Professor Playfair for a dissertation "to be equal in length or not to Mr Stewart's, for £250; but a short time afterwards I felt that to pay one eminent individual £1000 because he would not take less would be quite unfair, and I wrote to the worthy Professor that I had fixed his payment at £500.” Constable gave him £500 for the first part (127 pages), and would have given as much for the second (90 pages) if it had been as long. His next object was to find out the greatest defects in the book, and he gave Professor Leslie £200 and Graham Dalyell £100 for looking over it. He then wrote out a prospectus and submitted it in print to Stewart, “but the cautious philosopher referred” him to Playfair, who “returned it next day very greatly improved.” For this Constable sent him six dozen of very fine old sherry, only feeling regret that he had nothing better to offer. He at first intended to have two editors, “one for the strictly literary and the other for the scientific department.” He applied to Dr Thomas Brown, who “preferred writing trash of poetry to useful and lucrative employment.” At last he fixed on Mr Macvey Napier (born 1777), whom he had known from 1798, and who “had been a hard student, and at college laid a good foundation for his future career, though more perhaps in general information than in what would be, strictly speaking, called scholarship; this, however, does not fit him the less for his present task.” Constable, in a letter dated the 11th of June 1813, offered him £300 before the first part went to press, £150 on the completion at press of each of the eight half volumes, £500 if the work was reprinted or extended beyond 7000 copies and £200 for incidental expenses. “In this way the composition of the four volumes, including the introductory dissertations, will amount to considerably more than £9000.” In a postscript the certain payment is characteristically increased to £1575, the contingent to £735, and the allowance for incidental expenses to £300 (Constable, ii. 326). Napier went to London, and obtained the co-operation of many literary men. The supplement was published in half-volume parts from December 1816 to April 1824. It formed six volumes 4to, containing 4933 pages, 125 plates, 9 maps, three dissertations and 669 articles, of which a list is given at the end. The first dissertation, on the “progress of metaphysical, ethical and political philosophy,” was by Stewart, who completed his plan only in respect to metaphysics. He had thought it would be easy to adapt the intellectual map or general survey of human knowledge, sketched by Bacon and improved by D’Alembert, to the advanced state of the sciences, while its unrivalled authority would have softened criticism. But on closer examination he found the logical views on which this systematic arrangement was based essentially erroneous; and, doubting whether the time had come for a successful repetition of this bold experiment, he forebore to substitute a new scheme of his own. Sir James Mackintosh characterized this discourse as “the most splendid of Mr. Stewart’s works, a composition which no other living writer of English prose has equalled” (*Edinburgh Review*, xxvii. 191, September 1816). The second dissertation, “On the progress of mathematics and physics,” was by Playfair, who died 19th July 1819, when he had only finished the period of Newton and Leibnitz. The third, by Professor Brande, “On the progress of chemistry from the early middle ages to 1800,” was the only one completed. These historical dissertations were admirable and delightful compositions, and important and interesting additions to the *Encyclopaedia*; but it is difficult to see why they should form a separate department distinct from the general alphabet. The preface, dated March 1824, begins with an account of the more important previous encyclopaedias, relates the history of this to the sixth edition, describes the preparation for the supplement and gives an “outline of the contents,” and mentions under each great division of knowledge the principal articles and their authors’ names, often with remarks on the characters of both. Among the distinguished contributors were Leslie, Playfair, Ivory, Sir John Barrow, Tredgold, Jeffrey, John Bird Sumner, Blanco White, Hamilton Smith and Hazlitt. Sir Walter Scott, to gratify his generous friend Constable, laid aside *Waverley*, which he was completing for publication, and in April and May 1814 wrote “Chivalry.” He also wrote “Drama” in November 1818, and “Romance” in the summer of 1823. As it seemed to the editor that encyclopaedias had previously attended little to political philosophy, he wrote “Balance of Power,” and procured from James Mill “Banks for Savings,” “Education,” “Law of Nations,” “Liberty of the Press,” and other articles, which, reprinted cheaply, had a wide circulation. M’Culloch wrote “Corn Laws,” “Interest,” “Money,” “Political Economy,” &c. Mr Ricardo wrote “Commerce” and “Funding System,” and Professor Malthus, in his article “Population,” gave a comprehensive summary of the facts and reasonings on which his theory rested. In the article “Egypt” Dr Thomas Young “first gave to the public an extended view of the results of his successful interpretation of the hieroglyphic characters on the stone of Rosetta,” with a vocabulary of 221 words in English, Coptic, Hieroglyphic and Enchorial, engraved on four plates. There were about 160 biographies, chiefly of persons who had died within the preceding 30 years. Constable “wished short biographical notices of the first founders of this great work, but they were, in the opinion of my editor, too insignificant to entitle them to the rank which such separate notice, it was supposed, would have given them as literary men, although his own consequence in the world had its origin in their exertions” (*Memoirs*, ii. 326). It is to be regretted that this wish was not carried out, as was done in the latter volumes of Zedler. Arago wrote “Double Refraction” and “Polarization of Light,” a note to which mentions his name as author. Playfair wrote “Aepinus,” and “Physical Astronomy.” Biot wrote “Electricity” and “Pendulum.” He “gave his assistance with alacrity,” though his articles had to be translated. Signatures, on the plan of the *Encyclopédie*, were annexed to each article, the list forming a triple alphabet, A to XXX, with the full names of the 72 contributors arranged apparently in the order of their first occurrence. At the end of vol. vi. are Addenda and Corrigenda, including “Interpolation,” by Leslie, and “Polarization of Light,” by Arago.

The sixth edition, “revised, corrected and improved,” appeared in half-volume parts, price 16s. in boards, vol. xx. part ii. completing the work in May 1823. Constable, thinking it not wise to reprint so large a book year after year without correction, in 1820 selected Mr Charles Maclaren (1782-1866), as editor. “His attention was chiefly directed to the historical and geographical articles. He was to keep the press going, and have the whole completed in three years.” He wrote “America,” “Greece,” “Troy,” &c. Many of the large articles as “Agriculture,” “Chemistry,” “Conchology,” were new or nearly so; and references were given to the supplement. A new edition in 25 vols. was contemplated, not to be announced till a certain time after the supplement was finished; but Constable’s house stopped payment on the 19th of January 1826, and his copyrights were sold by auction. Those of the

Encyclopaedia were bought by contract, on the 16th of July 1828, for £6150, by Thomas Allan, proprietor of the *Caledonian Mercury*, Adam Black, Abram Thomson, bookbinder, and Alexander Wight, banker, who, with the trustee of Constable's estate, had previously begun the seventh edition. Not many years later Mr Black purchased all the shares and became sole proprietor.

The seventh edition, 21 vols. 4to (with an index of 187 pages, compiled by Robert Cox), containing 17,101 pages and 506 plates, edited by Macvey Napier, assisted by James Browne, LL.D., was begun in 1827, and published from March 1830 to January 1842. It was reset throughout and stereotyped. Mathematical diagrams were printed in the text from woodcuts. The first half of the preface was nearly that of the supplement. The list of signatures, containing 167 names, consists of four alphabets with additions, and differs altogether from that in the supplement: many names are omitted, the order is changed and 103 are added. A list follows of over 300 articles, without signatures, by 87 writers. The dissertations—1st, Stewart's, 289 pages; 2nd, "Ethics" (136 pages), by Sir James Mackintosh, whose death prevented the addition of "Political Philosophy"; 3rd, Playfair's, 139 pages; 4th, its continuation by Sir John Leslie, 100 pages—and their index of 30 pages, fill vol. i. As they did not include Greek philosophy, "Aristotle," "Plato" and "Socrates" were supplied by Dr Hampden, 380
afterwards bishop of Hereford. Among the numerous contributors of eminence, mention may be made of Sir David Brewster, Prof. Phillips, Prof. Spalding, John Hill Burton, Thomas De Quincey, Patrick Fraser Tytler, Capt. Basil Hall, Sir Thomas Dick Lauder, Antonio Panizzi, John Scott Russell and Robert Stephenson. Zoology was divided into 11 chief articles, "Mammalia," "Ornithology," "Reptilia," "Ichthyology," "Mollusca," "Crustacea," "Arachnides," "Entomology," "Helminthology," "Zoophytes," and "Animalcule"—all by James Wilson.

The eighth edition, 1853-1860, 4to, 21 vols. (and index of 239 pages, 1861), containing 17,957 pages and 402 plates, with many woodcuts, was edited by Dr Thomas Stewart Traill, professor of medical jurisprudence in Edinburgh University. The dissertations were reprinted, with one on the "Rise, Progress and Corruptions of Christianity" (97 pages), by Archbishop Whately, and a continuation of Leslie's to 1850, by Professor James David Forbes, 198 pages, the work of nearly three years, called by himself his "magnum opus" (Life, pp. 361, 366). Lord Macaulay, Charles Kingsley, Isaac Taylor, Hepworth Dixon, Robert Chambers, Rev. Charles Merivale, Rev. F.W. Farrar, Sir John Richardson, Dr Scoresby, Dr Hooker, Henry Austin Layard, Edw. B. Eastwick, John Crawfurd, Augustus Petermann, Baron Bunsen, Sir John Herschel, Dr Lankester, Professors Owen, Rankine, William Thomson, Aytoun, Blackie, Daniel Wilson and Jukes, were some of the many eminent new contributors found among the 344 authors, of whom an alphabetical list is given, with a key to the signatures. In the preface a list of 279 articles by 189 writers, classed under 15 heads, is given. This edition was not wholly reset like the seventh, but many long articles were retained almost or entirely intact.

The publication of the ninth edition (A. & C. Black) was commenced in January 1875, under the editorship of Thomas Spencer Baynes until 1880, and subsequently of W. Robertson Smith, and completed in 1889, 24 vols., with index. This great edition retained a certain amount of the valuable material in the eighth, but was substantially a new work; and it was universally acknowledged to stand in the forefront of the scholarship of its time. Its contributors included the most distinguished men of letters and of science. In 1898 a reprint, sold at about half the original price, and on the plan of payment by instalments, was issued by *The Times* of London; and in 1902, under the joint editorship of Sir Donald Mackenzie Wallace, President Arthur T. Hadley of Yale University, and Hugh Chisholm, eleven supplementary volumes were published, forming, with the 24 vols. of the ninth edition, a tenth edition of 35 volumes. These included a volume of maps, and an elaborate index (vol. 35) to the whole edition, comprising some 600,000 entries. In May 1903 a start was made with the preparation of the 11th edition, under the general editorship of Hugh Chisholm, with W. Alison Phillips as chief assistant-editor, and a staff of editorial assistants, the whole work of organization being conducted up to December 1909 from *The Times* office. Arrangements were then made by which the copyright and control of the *Encyclopaedia Britannica* passed to Cambridge University, for the publication at the University Press in 1910-1911 of the 29 volumes (one being Index) of the 11th edition, a distinctive feature of this issue being the appearance of the whole series of volumes practically at the same time.

A new and enlarged edition of the *Encyclopédie* arranged as a system of separate dictionaries, and entitled *Encyclopédie méthodique ou par ordre de matières*, was undertaken by Charles Joseph Panckoucke, a publisher of Paris (born at Lille on the 26th of November 1736, died on the 19th of December 1798). His privilege was dated the 20th of June 1780. The articles belonging to different subjects would readily form distinct dictionaries, although, having been constructed for an alphabetical plan, they seemed unsuited for any system wholly methodical. Two copies of the book and its supplement were cut up into articles, which were sorted into subjects. The division adopted was: 1, mathematics; 2 physics; 3, medicine; 4, anatomy and physiology; 5, surgery; 6, chemistry, metallurgy and pharmacy; 7, agriculture; 8, natural history of animals, in six parts; 9, botany; 10, minerals; 11, physical geography; 12, ancient and modern geography; 13, antiquities; 14, history; 15, theology; 16, philosophy; 17, metaphysics, logic and morality; 18, grammar and literature; 19, law; 20, finance; 21, political economy; 22, commerce; 23, marine; 24, art militaire; 25, beaux arts; 26, arts et métiers—all forming distinct dictionaries entrusted to different editors. The first object of each editor was to exclude all articles belonging to other subjects, and to take care that those of a doubtful nature should not be omitted by all. In some words (such as air, which belonged equally to chemistry, physics and medicine) the methodical arrangement has the unexpected effect of breaking up the single article into several widely separated. Each dictionary was to have an introduction and a classified table of the principal articles. History and its minor parts, as inscriptions, fables, medals, were to be included. Theology, which was neither complete, exact nor orthodox, was to be by the abbé Bergier, confessor to Monsieur. The whole work was to be completed and connected together by a Vocabulaire

Universel, 1 vol. 4to, with references to all the places where each word occurred, and a very exact history of the *Encyclopédie* and its editions by Panckoucke. The prospectus, issued early in 1782, proposed three editions—84 vols. 8vo, 43 vols. 4to with 3 columns to a page, and 53 vols. 4to of about 100 sheets with 2 columns to a page, each edition having 7 vols. 4to of 250 to 300 plates each. The subscription was to be 672 livres from the 15th of March to July 1782, then 751, and 888 after April 1783. It was to be issued in livraisons of 2 vols. each, the first (jurisprudence, vol. i., literature, vol. i.) to appear in July 1782, and the whole to be finished in 1787. The number of subscribers, 4072, was so great that the subscription list of 672 livres was closed on the 30th of April. Twenty-five printing offices were employed, and in November 1782 the 1st livraison (jurisprudence, vol. i., and half vol. each of arts et métiers and histoire naturelle) was issued. A Spanish prospectus was sent out, and obtained 330 Spanish subscribers, with the inquisitor-general at their head. The complaints of the subscribers and his own heavy advances, over 150,000 livres, induced Panckoucke, in November 1788, to appeal to the authors to finish the work. Those *en retard* made new contracts, giving their word of honour to put their parts to press in 1788, and to continue them without interruption, so that Panckoucke hoped to finish the whole, including the vocabulary (4 or 5 vols.), in 1792. Whole sciences, as architecture, engineering, hunting, police, games, &c., had been overlooked in the prospectus; a new division was made in 44 parts, to contain 51 dictionaries and about 124 vols. Permission was obtained on the 27th of February 1789, to receive subscriptions for the separate dictionaries. Two thousand subscribers were lost by the Revolution. The 50th livraison appeared on the 23rd of July 1792, when all the dictionaries eventually published had been begun except seven—jeux familiers and mathématiques, physics, art oratoire, physical geography, chasses and pêches; and 18 were finished,—mathematics, games, surgery, ancient and modern geography, history, theology, logic, grammar, jurisprudence, finance, political economy, commerce, marine, arts militaires, arts académiques, arts et métiers, encyclopediana. Supplements were added to military art in 1797, and to history in 1807, but not to any of the other 16, though required for most long before 1832. The publication was continued by Henri Agasse, Panckoucke’s son-in-law, from 1794 to 1813, and then by Mme Agasse, his widow, to 1832, when it was completed in 102 livraisons or 337 parts, forming 166½ vols. of text, and 51 parts containing 6439 plates. The letterpress issued with the plates amounts to 5458 pages, making with the text 124,210 pages. To save expense the plates belonging to architecture were not published. Pharmacy (separated from chemistry), minerals, education, ponts et chaussées had been announced but were not published, neither was the Vocabulaire Universel, the key and index to the whole work, so that it is difficult to carry out any research or to find all the articles on any subject. The original parts have been so often subdivided, and have been so added to by other dictionaries, supplements and appendices, that, without going into great detail, an exact account cannot be given of the work, which contains 88 alphabets, with 83 indexes, and 166 introductions, discourses, prefaces, &c. Many dictionaries have a classed index of articles; that of économie politique is very excellent, giving the contents of each article, so that any passage can be found easily. The largest dictionaries are medicine, 13 vols., 10,330 pages; zoology, 7 dictionaries, 13,645 pages, 1206 plates; botany, 12,002 pages, 1000 plates (34 only of cryptogamic plants); geography, 3 dictionaries and 2 atlases, 9090 pages, 193 maps and plates; jurisprudence (with police and municipalities), 10 vols., 7607 pages. Anatomy, 4 vols., 2866 pages, is not a dictionary but a series of systematic 381
treatises. Assemblée Nationale was to be in three parts,—(1) the history of the Revolution, (2) debates, and (3) laws and decrees. Only vol. ii., debates, appeared, 1792, 804 pages, Absens to Aurillac. Ten volumes of a Spanish translation with a vol. of plates were published at Madrid to 1806—viz. historia natural, i. ii.; grammatica, i.; arte militar, i., ii.; geografia, i.-iii.; fabricas, i., ii., plates, vol. i. A French edition was printed at Padua, with the plates, says Peignot, very carefully engraved. Probably no more unmanageable body of dictionaries has ever been published except Migne’s *Encyclopédie théologique*, Paris, 1844-1875, 4to, 168 vols., 101 dictionaries, 119,059 pages.

No work of reference has been more useful and successful, or more frequently copied, imitated and translated, than that known as the *Conversations Lexikon* of Brockhaus. It was begun as *Conversations Lexikon mit vorzüglicher Rücksicht auf die gegenwärtigen Zeiten*, Leipzig, 1796 to 1808, 8vo, 6 vols., 2762 pages, by Dr Gotthelf Renatus Löbel (born on the 1st of April 1767 at Thalwitz near Wurzen in Saxony, died on the 14th of February 1799), who intended to supersede Hübner, and included geography, history, and in part biography, besides mythology, philosophy, natural history, &c. Vols. i.-iv. (A to R) appeared 1796 to 1800, vol. v. in 1806. Friedrich Arnold Brockhaus (*q.v.*) bought the work with its copyright on the 25th of October 1808, for 1800 thalers from the printer, who seems to have got it in payment of his bill. The editor, Christian Wilhelm Franke, by contract dated the 16th of November, was to finish vol. vi. by the 5th of December, and the already projected supplement, 2 vols., by Michaelmas 1809, for 8 thalers a printed sheet. No penalty was specified, but, says his grandson, Brockhaus was to learn that such contracts, whether under penalty or not, are not kept, for the supplement was finished only in 1811. Brockhaus issued a new impression as *Conversations Lexikon oder kurzgefasstes Handwörterbuch*, &c, 1809-1811, and on removing to Altenburg in 1811 began himself to edit the 2nd edition (1812-1819, 10 vols.), and, when vol. iv. was published, the 3rd (1814-1819). He carried on both editions together until 1817, when he removed to Leipzig, and began the 4th edition as *Allgemeine deutsche Realencyclopädie für die gebildeten Stände. Conversations Lexikon*. This title was, in the 14th edition, changed to that of *Brockhaus’ Konversations Lexicon*. The 5th edition was at once begun, and was finished in eighteen months. Dr Ludwig Hain assisted in editing the 4th and 5th editions until he left Leipzig in April 1820, when Professor F.C. Hasse took his place. The 12,000 copies of the 5th edition being exhausted while vol. x. was at press, a 2nd unaltered impression of 10,000 was required in 1820 and a 3rd of 10,000 in 1822. The 6th edition, 10 vols., was begun in September 1822. Brockhaus died in 1823, and his two eldest sons, Friedrich and Heinrich, who carried on the business for the heirs and became sole possessors in 1829, finished the edition with Hasse's assistance in September 1823. The 7th edition (1827-1829, 12 vols., 10,489 pages, 13,000 copies, 2nd impression 14,000) was edited by Hasse. The 8th edition (1833-1836, 12 vols., 10,689 pages, 31,000 copies to 1842), begun in the autumn of 1832, ended May 1837, was edited by Dr Karl August Espe (born February 1804, died in the Irrenanstalt at Stötteritz near Leipzig on the 24th of November 1850) with the aid of many learned and distinguished writers. A general index, Universal Register, 242 pages, was added in 1839. The 9th edition (1843-1847, 15 vols., 11,470 pages, over 30,000 copies) was edited by Dr Espe. The 10th edition (1851-1855, 12,564 pages) was also in 15 vols., for convenience in reference, and was edited by Dr August Kurtzel aided by Oskar Pilz. Friedrich Brockhaus had retired in 1849; Dr Heinrich Edward, the elder son of Heinrich, made partner in 1854, assisted in this edition, and Heinrich Rudolf, the younger son, partner since 1863, in the 11th (1864-1868, 15 vols. of 60 sheets, 13,366 pages).

Kurtzel died on the 24th of April 1871, and Pilz was sole editor until March 1872, when Dr Gustav Stockmann joined, who was alone from April until joined by Dr Karl Wippermann in October. Besides the Universal Register of 136 pages and about 50,000 articles, each volume has an index. The supplement, 2 vols, 1764 pages, was begun in February 1871, and finished in April 1873. The 12th edition, begun in 1875, was completed in 1879 in 15 vols., the 13th edition (1882-1887), in 16 vols., and the 14th (1901-1903) in 16 vols. with a supplementary volume in 1904. The *Conversations Lexicon* is intended, not for scientific use, but to promote general mental improvement by giving the results of research and discovery in a simple and popular form without extended details. The articles, often too brief, are very excellent and trustworthy, especially on German subjects, give references to the best books, and include biographies of living men.

One of the best German encyclopaedias is that of Meyer, *Neues Konversations-Lexicon*. The first edition, in 37 vols., was published in 1839-1852. The later editions, following closely the arrangement of Brockhaus, are the 4th (1885-1890, 17 vols.), the 5th (1894-1898, 18 vols.), and the 6th (begun in 1902).

The most copious German encyclopaedia is Ersch and Gruber's *Allgemeine Encyklopädie der Wissenschaften und Künste*, Leipzig. It was designed and begun in 1813 by Professor Johann Samuel Ersch (born at Gross Glogau on the 23rd of June 1766, chief librarian at Halle, died on the 16th of January 1828) to satisfy the wants of Germans, only in part supplied by foreign works. It was stopped by the war until 1816, when Professor Hufeland (born at Danzig on the 19th of October 1760) joined, but he died on the 25th of November 1817 while the specimen part was at press. The editors of the different sections at various times have been some of the best-known men of learning in Germany, including J.G. Gruber, M.H.E. Meier, Hermann Brockhaus, W. Müller and A.G. Hoffmann of Jena.

The work is divided into three sections (1) A-G, of which 99 vols. had appeared by 1905, (2) H-N, 43 vols., (3) O-Z, 25 vols. All articles bear the authors' names, and those not ready in time were placed at the end of their letter. The longest in the work is Griechenland, vols. 80-87, 3668 pages, with a table of contents. It began to appear after vol. 73 (Götze to Gondouin), and hence does not come in its proper place, which is in vol. 91. Gross Britannien contains 700 pages, and Indien by Benfey 356.

The *Encyclopaedia Metropolitana* (London, 1845, 4to, 28 vols., issued in 59 parts in 1817-1845, 22,426 pages, 565 plates) professed to give sciences and systematic arts entire and in their natural sequence, as shown in the introductory treatise on method by S.T. Coleridge. "The plan was the proposal of the poet Coleridge, and it had at least enough of a poetical character to be eminently unpractical" (*Quarterly Review*, cxiii., 379). However defective the plan, the excellence of many of the treatises by Archbishop Whately, Sir John Herschel, Professors Barlow, Peacock, de Morgan, &c., is undoubted. It is in four divisions, the last only being alphabetical:—I. *Pure Sciences*, 2 vols., 1813 pages, 16 plates, 28 treatises, includes grammar, law and theology; II. *Mixed and Applied Sciences*, 8 vols., 5391 pages, 437 plates, 42 treatises, including fine arts, useful arts, natural history and its "application," the medical sciences; III. *History and Biography*, 5 vols., 4458 pages, 7 maps, containing biography (135 essays) chronologically arranged (to Thomas Aquinas in vol. 3), and interspersed with (210) chapters on history (to 1815), as the most philosophical, interesting and natural form (but modern lives were so many that the plan broke down, and a division of biography, to be in 2 vols., was announced but not published); IV. *Miscellaneous*, 12 vols., 10,338 pages, 105 plates, including geography, a dictionary of English (the first form of Richardson's) and descriptive natural history. The index, 364 pages, contains about 9000 articles. A re-issue in 38 vols. 4to, was announced in 1849. Of a second edition 42 vols. 8vo, 14,744 pages, belonging to divisions i. to iii., were published in 1849-1858.

The very excellent and useful *English Cyclopaedia* (London, 1854-1862, 4to, 23 vols., 12,117 pages; supplements, 1869-1873, 4 vols., 2858 pages), conducted by Charles Knight, based on the *Penny Cyclopaedia* (London, 1833-1846, 4to, 29 vols., 15,625 pages), of which he had the copyright, is in four divisions all alphabetical, and evidently very unequal as classes:—1, geography; 2, natural history; 3, biography (with 703 lives of living persons); 4, arts and sciences. The synoptical index, 168 pages, has four columns on a page, one for each division, so that the order is alphabetical and yet the words are classed.

Chambers's Encyclopaedia (Edinburgh, W. & R. Chambers), 1860-1868, 8vo, 10 vols., 8283 pages, edited in part by the publishers, but under the charge of Dr Andrew Findlater as "acting editor" throughout, was founded on the 10th edition of *Brockhaus*. A revised edition appeared in 1874, 8320 pages. In the list of 126 contributors were J.H. Burton, Emmanuel Deutsch, Professor Goldstücker, 382

&c. The index of matters not having special articles contained about 1500 headings. The articles were generally excellent, more especially on Jewish literature, folk-lore and practical science; but, as in *Brockhaus*, the scope of the work did not allow extended treatment. A further revision took place, and in 1888-1892 an entirely new edition was published, in 10 vols., still further new editions being issued in 1895 and in 1901.

An excellent brief compilation, the *Harmsworth Encyclopaedia* (1905), was published in 40 fortnightly parts (sevenpence each) in England, and as *Nelson's Encyclopaedia* (revised) in 12 vols. (1906) in America. It was originally prepared for Messrs Nelson of Edinburgh and for the Carmelite Press, London.

In the United States various encyclopaedias have been published, but without rivalling there the *Encyclopædia Britannica*, the 9th edition of which was extensively pirated. Several American Supplements were also issued.

The *New American Cyclopaedia*, New York (Appleton & Co.), 1858-1863, 16 vols., 12,752 pages, was the work of the editors, George Ripley and Charles Anderson Dana, and 364 contributors, chiefly American. A supplementary work, the *American Annual Cyclopaedia*, a yearly 8vo vol. of about 800 pages and 250 articles, was started in 1861, but ceased in 1902. In a new edition, the *American Cyclopaedia*, 1873-1876, 8vo, 16 vols., 13,484 pages, by the same editors, 4 associate editors, 31 revisers and a librarian, each article passed through the hands of 6 or 8 revisers.

Other American encyclopaedias are Alvin J. Johnson's *New Universal Cyclopaedia*, 1875-1877, in 4 vols., a new edition of which (excellently planned) was published in 8 vols., 1893-1895, under the name of *Johnson's Universal Cyclopaedia*; the *Encyclopaedia Americana*, edited by Francis Lieber, which appeared in 1839-1847 in 14 vols.; a new work under the same title, published in 1903-1904 in 16 vols.; the *International Cyclopaedia*, first published in 1884 (revised in 1891, 1894 and 1898), and superseded in 1902 (revised, 1906) by the *New International Encyclopaedia* in 17 vols.

In Europe a great impetus was given to the compilation of encyclopaedias by the appearance of Brockhaus' *Conversations-Lexicon* (see above), which, as a begetter of these works, must rank, in the 19th century, with the *Cyclopaedia* of Ephraim Chambers in the 18th. The following, although in no sense an exhaustive list, may be here mentioned. In France, *Le Grand Dictionnaire universel du XIX^e^ siècle*, of Pierre Larousse (15 vols., 1866-1876), with supplementary volumes in 1877, 1887 and 1890; the *Nouveau Larousse illustré, dictionnaire universel encyclopédique* (7 vols., 1901-1904), (this is in no way a re-issue or an abridgment of *Le Grand Dictionnaire* of Pierre Larousse); *La Grande Encyclopédie, inventaire raisonné des sciences, des lettres, et des arts*, in 31 vols. (1886-1903). In Italy, the *Nuova Enciclopedia Italiana* (14 vols., 1841-1851, and in 25 vols., 1875-1888). In Spain, the *Diccionario enciclopedico Hispano-Americano de litteratura, ciencias y artes*, published at Barcelona (25 vols., 1877-1899). The Russian encyclopaedia, *Russkiy Entsiklopedicheskiy Slovar* (41 vols., 1905, 2 supplementary vols., 1908) was begun in 1890 as a Russian version of Brockhaus' *Conversations-Lexicon*, but has become a monumental encyclopaedia, to which all the best Russian men of science and letters have contributed. Elaborate encyclopaedias have also appeared in the Polish, Hungarian, Bohemian and Rumanian languages. Of Scandinavian encyclopaedias there have been re-issues of the *Nordësk Conversations-Lexicon*, first published in 1858-1863, and of the *Svenskt Conversations-Lexicon*, first published in 1845-1851.

ENDECOTT, JOHN (*c.* 1588-1665), English colonial governor in America, was born probably at Dorchester, Dorsetshire, England, about 1588. Little is known of him before 1628, when he was one of the six "joint adventurers" who purchased from the Plymouth Company a strip of land about 60 m. wide along the Massachusetts coast and extending westward to the Pacific Ocean. By his associates Endecott was entrusted with the responsibility of leading the first colonists to the region, and with some sixty persons proceeded to Naumkeag (later Salem) where Roger Conant, a seceder from the colony at Plymouth, had begun a settlement two years earlier. Endecott experienced some trouble with the previous settlers and with Thomas Morton's settlement at "Merry Mount" (Mount Wollaston, now Quincy), where, in accordance with his strict Puritanical tenets, he cut down the maypole and dispersed the merrymakers. He was the local governor of the Massachusetts Bay Colony from the 30th of April 1629 to the 12th of June 1630, when John Winthrop, who had succeeded Matthew Cradock as governor of the company on the 20th of October 1629, brought the charter to Salem and became governor of the colony as well as of the company. In the years immediately following he continued to take a prominent part in the affairs of the colony, serving as an assistant and as a military commissioner, and commanding, although with little success, an expedition against the Pequots in 1636. At Salem he was a member of the congregation of Roger Williams, whom he resolutely defended in his trouble with the New England clerical hierarchy, and excited by Williams's teachings, cut the cross of St George from the English flag in token of his hatred of all symbols of Romanism. He was deputy-governor in 1641-1644, and governor in 1644-1645, and served also as sergeant-major-general (commander-in-chief) of the militia and as one of the commissioners of the United Colonies of New England, of which in 1658 he was president. On the death of John Winthrop in 1649 he became governor, and by annual re-elections served continuously until his death, with the exception of two years (1650-1651 and 1654-1655), when he was deputy-governor. Under his authority the colony of Massachusetts Bay made rapid progress, and except in the matter of religious intolerance—he showed great bigotry and harshness, particularly towards the Quakers—his rule was just and praiseworthy. Of him Edward Eggleston says: “A strange mixture of rashness, pious zeal, genial manners, hot temper, and harsh bigotry, his extravagances supply the condiment of humour to a very serious history—it is perhaps the principal debt posterity owes him.” He died on the 15th of March 1665.

See C.M. Endicott, *Memoirs of John Endecott* (Salem, 1847), and a “Memoir of John Endecott” in *Antiquarian Papers* of the American Antiquarian Society (Worcester, Mass., 1879).

A lineal descendant, William Crowninshield Endicott (1826-1900), graduated at Harvard in 1847, was a justice of the Massachusetts supreme court in 1873-1882, and was secretary of war in President Cleveland’s cabinet from 1885 to 1889. His daughter, Mary Crowninshield Endicott, was married to the English statesman Mr Joseph Chamberlain in 1888.

ENDIVE, *Cichorium Endivia*, an annual esculent plant of the natural order Compositae, commonly reputed to have been introduced into Europe from the East Indies, but, according to some authorities, more probably indigenous to Egypt. It has been cultivated in England for more than three hundred years, and is mentioned by John Gerarde in his *Herbal* (1597). There are numerous varieties of the endive, forming two groups, namely, the curled or narrow-leaved (var. *crispa*), and the Batavian or broad-leaved (var. *latifolia*), the leaves of which are not curled. The former varieties are those most used for salads, the latter being grown chiefly for culinary purposes. The plant requires a light, rich and dry soil, in an unshaded situation. In the climate of England sowing for the main crop should begin about the second or third week in June; but for plants required to be used young it may be as early as the latter half of April, and for winter crops up to the middle of August. The seed should be finely spread in drills 4 in. asunder, and then lightly covered. After reaching an inch in height the young plants are thinned; and when about a month old they may be placed out at distances of 12 or 15 in., in drills 3 in. in depth, care being taken in removing them from the seed-bed to disturb their roots as little as possible. The Batavian require more room than the curled-leaved varieties. Transplantation, where early crops are required, has been found inadvisable. Rapidity of growth is promoted by the application of liquid manures. The bleaching of endive, in order to prevent the development of the natural bitter taste of the leaves, and to improve their appearance, is begun about three months after the sowing, and is best effected either by tying the outer leaves around the inner, or, as in damp seasons, by the use of the bleaching-pot. The bleaching may be completed in ten days 383
or so in summer, but in winter it takes three or four weeks. For late crops, protection from frost is requisite; and to secure fine winter endive, it has been recommended to take up the full-grown plants in November, and to place them under shelter, in a soil of moderately dry sand or of half-decayed peat earth. Where forcing-houses are employed, endive may be sown in January, so as to procure by the end of the following month plants ready for use.

ENDOEUS, an early sculptor, who worked at Athens in the middle of the 6th century B.C. We are told that he made an image of Athena dedicated by Callias the contemporary of Pisistratus at Athens about 564 B.C. An inscription bearing his name has been found at Athens, written in Ionian dialect. The tradition which made him a pupil of Daedalus is apparently misleading, since Daedalus had no connexion with Ionic art.

ENDOGAMY (Gr. ἔνδον, within, and γάμος, marriage), marriage within the tribe or community, the term adopted to express the custom compelling those of a tribe to marry among themselves. Endogamy was probably characteristic of the very early stages of social organization (see Family), and is to-day found only among races low in the scale of civilization. As a custom it is believed to have been preceded in most lands by the far more general rule of Exogamy (*q.v.*). Lord Avebury (*Origin of Civilisation*, p. 154) points out that “there is not the opposition between exogamy and endogamy which Mr McLennan supposed.” Some races which are endogamous as regards the tribe are exogamous as regards the gens. Thus the Abors, Kochs, Hos and other peoples of India, are forbidden to marry out of the tribe; but the tribe itself is divided into “keelis” or clans, and no man is allowed to take as wife a girl of his own “keeli”. Endogamy must have in most cases arisen from racial pride, and a contempt, either well or ill founded, for the surrounding peoples.

Among the Ahtena of Alaska, though the tribes are extremely militant and constantly at war, the captured women are never made wives, but are used as slaves. Endogamy also prevails among tribes of Central America. With the Yerkalas of southern India a custom prevails by which the first two daughters of a family may be claimed by the maternal uncle as wives for his sons. The value of a wife is fixed at twenty pagodas (a 16th-century Indian coin equivalent to about five shillings), and should the uncle forgo his claim he is entitled to share in the price paid for his nieces. Among some of the Karen tribes marriages between near relatives are usual. The Douignaks, a branch of the Chukmas, seem to have practised endogamy; and they “abandoned the parent stem during the chiefship of Janubrix Khan about 1782. The reason of this split was a disagreement on the subject of marriages. The chief passed an order that the Douignaks should intermarry with the tribe in general. This was contrary to an ancient custom and caused discontent and eventually a break in the tribe” (Lewin’s *Hill Tracts of Chittagong*, p. 65). This is interesting as being one of the few cases in which evidence of a change in this respect is available. The Kalangs of Java are endogamous, and every man must first prove his common descent before he can enter a family. The Manchu Tatars prohibit those who have the same family names from marrying. Among the Bedouins “a man has an exclusive right to the hand of his cousin.” Hottentots seldom marry out of their own kraal, and David Livingstone quotes other examples. Endogamy seems to have existed in the Sandwich Islands and in New Zealand. A community of Javans near Surabaya, on the Teugger Hills, numbering about 1200 persons, distributed in about forty villages, and still following the ancient Hindu religion, is endogamous. Good examples of what biologists call “in-and-in breeding” are to be found in various fishing villages in Great Britain, such as Itchinferry, near Southampton, Portland Island, Bentham in Yorkshire, Mousehole and Newlyn in Mountsbay, Cornwall, Boulmer near Alnwick (where almost all the inhabitants are called Stephenson, Stanton or Stewart), Burnmouth, Ross and (to some extent) Eyemouth in Berwickshire, Boyndie in Banffshire, Rathen in Aberdeenshire, Buckhaven in Fifeshire, Portmahomack and Balnabruach in Eastern Ross. In France may be mentioned the commune of Batz, near Le Broisic in Loire-Inférieur, many of the central cantons of Brétagne, and the singular society called Foréatines—supposed to be of Irish descent—living between St Arnaud and Bourges. Many other European examples might be mentioned, such as the Marans of Auvergne, a race of Spanish converted Jews accused of introducing syphilis into France; the Burins and Sermoyers, chiefly cattle-breeders, scattered over the department of Ain and especially in the arrondissement of Bourg-en-Bresse; the Vaquéros, shepherds in the Asturias Mountains; and the Jewish Chuetas of Majorca.

See Gilbert Malcolm Sproat’s *Scenes and Studies of Savage Life*; Westermarck’s *History of Human Marriage* (1894); Lord Avebury’s *Origin of Civilisation* (1902); J.F. McLennan’s *Primitive Marriage* (1865).

ENDOR, an ancient town of Palestine, chiefly memorable as the abode of the sorceress whom Saul consulted on the eve of the battle of Gilboa, in which he perished (1 Sam. xxviii. 5-25). According to a psalmist (Ps. lxxxiii. 9) it was the scene of the rout of Jabin and Sisera. Although situated in the territory of the tribe of Issachar, it was assigned to Manasseh. In the time of Eusebius and Jerome Endor existed as a large village 5 m. south of Mount Tabor; there is still a poor village of the same name on the slope of Jebel Daḥi, near which are numerous caves.

For a description of the locality see Stanley, *Sinai and Palestine*, p. 337.

ENDOSPORA, a natural group or class of the Sporozoa, consisting of the orders Myxosporidia, Actinomyxidia, Sarcosporidia and Haplosporidia, together with various insufficiently-known forms (Sero- and Exosporidia), regarded at present as Sporozoa *incertae sedis*. The distinguishing feature of the group is that the spore-mother-cells (pansporoblasts) arise in the interior of the body of the parent-individual; in other words, sporulation is endogenous. Another very general character—though not so universal—is that the adult trophozoite possesses more than one nucleus, usually many (*i.e.* it is multinucleate). In the majority of forms, though apparently not in all (*e.g.* certain Microsporidia), sporulation goes on coincidently with growth and trophic life. With regard to the origin of the group, the probability is greatly in favour of a Rhizopod ancestry. The entire absence, at any known period, of a flagellate or even gregariniform phase; on the other hand, the amoeboid nature of the trophozoites in very many cases together with the formation of pseudopodia; and, lastly, the simple endogenous spore-formation characteristic of the primitive forms,—are all points which support this view, and exclude any hypothesis of a Flagellate origin, such as, on the contrary, is probably the case in the Ectospora (*q.v.*).

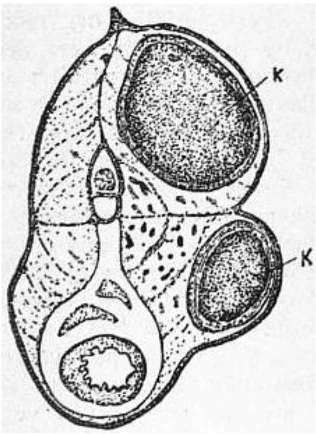
1. Order **Myxosporidia**. The Myxosporidia, or, more correctly, the dense masses formed by their

spores, were well known to the earlier zoological observers. The parasites in fishes were called by Müller “fish-psorosperms,” a name which has stuck to them ever since, although, as is evident from the meaning of the term (“mange-seed”), Müller had little idea of the true nature of the bodies. Other examples, infesting silkworms, have also long been known as “Pèbrine-corpuscles,” from the ravaging disease which they produce in those caterpillars in France, in connexion with which Pasteur did such valuable work. The foundation of our present morphological and biological knowledge of the order was well laid by the admirable researches of Thèlohan in 1895. In spite, however, of the contributions of numerous workers since then (*e.g.* Doflein, Cohn, Stempell and others), there are still one or two very important points, such as the occurrence of sexual conjugation, upon which light is required.

Occurrence and habitat.

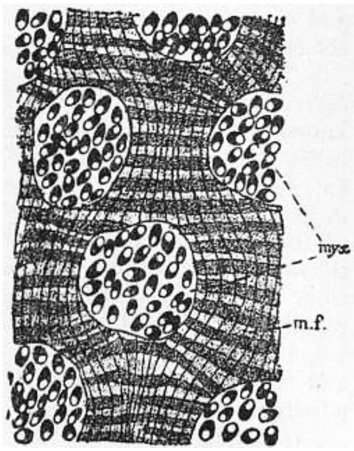
Although pre-eminently parasites of fishes, Myxosporidia also occur, in a few cases, in other Vertebrates (frogs and reptiles); no instance of their presence in a warm-blooded Vertebrate has, however, yet been described. One suborder (the Microsporidia or Cryptocystes) is pretty equally distributed between fishes on the one hand and Invertebrates—chiefly, but not exclusively, Arthropods—on the other. The parasites are frequently the cause of severe and fatal illness in their hosts, and devastating epidemics of 384 myxosporidiosis have often been reported (*e.g.* among carp and barbel in continental rivers, due to a *Myxobolus*, and among crayfish in France, to *Thelohania*).

The seat of the invasion and the mode of parasitism are extremely varied. Practically any organ or tissue may be attacked, excepting, apparently, the testis and cartilage and bone. In one instance at least (that of *Nosema bombycis* of the silkworm) the parasites penetrate into the ova, so that true hereditary infection occurs, the progeny being born with the disease. The parasites may be either free in some lumen, such as that of the gall bladder or urinary bladder (not of the alimentary canal, or the body-cavity itself), when they are known as *coelozoic* forms; or in intimate relation with some tissue, intracellular while young but becoming intercellular in the adult phase (*histozoic* forms); or entirely intracellular (*cytozoic* forms). Among the histozoic and cytozoic types, moreover, two well-defined conditions, *concentration* and *diffuse infiltration*, occur. In the former, the parasitic zone is strictly limited, and well-marked cysts are formed; in the latter, the infection spreads throughout the neighbouring tissue, and the parasitic development becomes inextricably commingled with the host’s cells. Sometimes, as shown by Woodcock (**45**), there may be an attempt on the part of the host’s tissue to circumscribe and check the growth of these parasitic areas, which results in the formation of *pseudocysts*, quite different in character from true cysts.



From Lankester’s *Treatise on Zoology*, vol. Protozoa, from Wasielewski, after Thélohan.

Fig. 1.—Transverse section of a stickle-back (*Gasterosteus aculeatus*), showing two cysts of *Glugea anomala*, Moniez (*kk*), in the body musculature on the right side.



From Lankester’s *Treatise on Zoology*, vol. Protozoa.

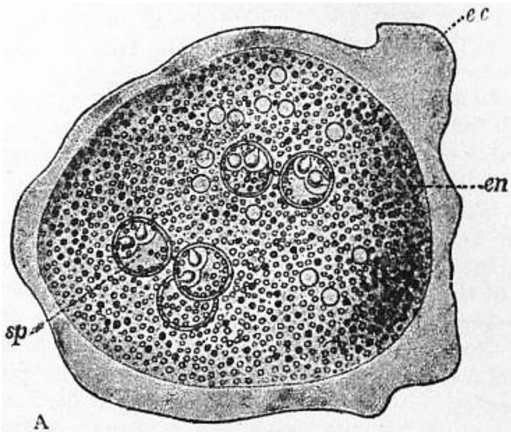
Fig. 2.—Portion of a section through a muscle fibre of *Cottus scorpius* invaded by *Pleistophora typicalis*, Gurley.

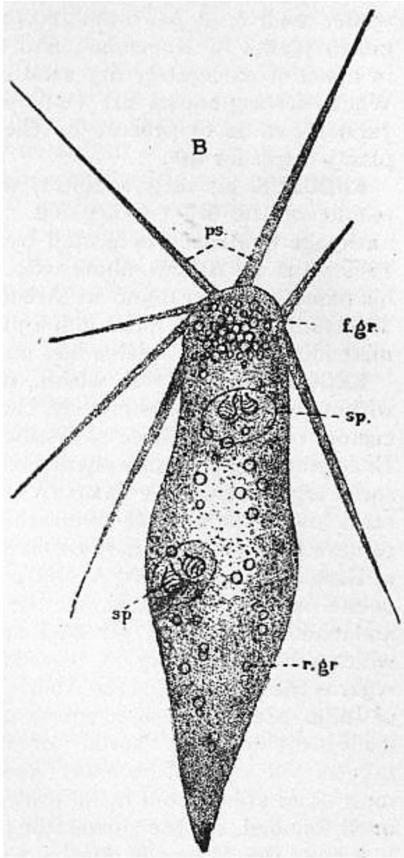
m, f, Muscle fibrils, retaining their striation.

myx, Cysts of the parasite, lying between the fibrils.

Morphology.

The most noticeable feature about the Myxosporidian trophozoite is its amoeboid and Rhizopod-like character. Pseudopodia of various kinds, from long slender ones (fig. 3, B) to short blunt lobose ones, are of general occurrence, being most easily observed, of course, in the free-living forms. The pseudopodia serve chiefly for movement and attachment, and never, it should be noted, for the injection of solid food-particles, as in the case of *Amoebae*. The general protoplasm is divisible into ectoplasm and endoplasm. The former is a clear, finely-granular layer, of which the pseudopodia are mainly constituted (fig. 3, A). In one or two instances (*e.g. Myxidium lieberkühnii*) the ectoplasm shows a vertical striation, and in the older trophozoites breaks down partially, appearing like a fur of delicate, non-motile filaments. A somewhat similar modification is found in *Myxocystis*. The endoplasm is more fluid, and contains numerous inclusions of a granular nature, as well as vacuoles of varying size. In the endoplasm are lodged the nuclei, of which in an adult trophozoite there may be very many; they are all derived by multiplication from the single nucleus with which the young individuals begin life, the number increasing as growth proceeds.





From Wasielewski, *Sporozoenkunde*.

Fig. 3.—A. Trophozoite of *Sphaerospora divergens*, Thél. (par. *Blennius* and *Crenilabrus*), × 750. *ec*, Ectoplasm; *en*, endoplasm; *sp*, spores, each with four pole capsules.

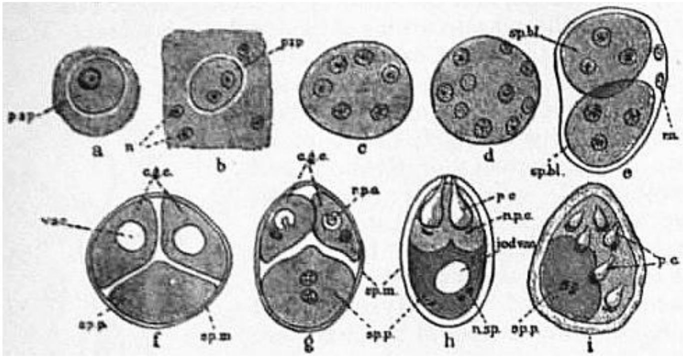
From Lankester's *Treatise on Zoology*, vol. Protozoa.

B. Spore-bearing trophozoite of Leptotheca agilis, Thél. (par. Trygon and Scorpaena), × 750. *ps*, Pseudopodia localized at the anterior end; *f.gr*, fatty granules similarly localized; *r.gr*, refringent granules; *sp*, spores, two in number.

Spore-formation; multiplicative processes.

Spore-formation goes on entirely in the endoplasm. The number of spores formed is very variable. It may be as low as two (as in free-living forms, *e.g. Leptotheca*), in which case a large amount of trophic protoplasm is unconverted into spores; or, on the other hand, the number of spores may be very great (as in tissue-parasites), practically the whole of the parent-body being thus used up. The sporont may or may not encyst at the commencement of sporulation. In the free-living forms there is no cyst-membrane secreted; but in certain *Glugeidae*, on the other hand, the ectoplasm becomes altered into a firm, enclosing layer, the *ectorind*, which forms a thick cyst-wall (fig. 5). The process of sporulation begins by the segregation of small quantities of endoplasm around certain of the nuclei, to form little, rounded bodies, the *pansporoblasts*. There may be either very many or only few pansporoblasts developed; in some cases, indeed, there is only one, the sporont either itself becoming a pansporoblast (certain *Microsporidia*), or giving rise to a solitary one (*Ceratomyxidae*). The pansporoblast constituted, nuclear multiplication goes on preparatory to the formation of sporoblasts, which in their turn become spores (see figs. 4 and 5). Not all the nuclei thus formed, however, are made use of. In the *Phaenocystes* there are always two sporoblasts developed in each pansporoblast; in the *Cryptocystes* there may be from one to several. Around each sporoblast a spore-membrane is secreted, which usually has the form of two valves. It has recently been shown by Léger and Hesse (**29***b*) that, in many Phaenocystes at any rate, each of these valves is formed by a definite nucleated portion of the sporoblast.

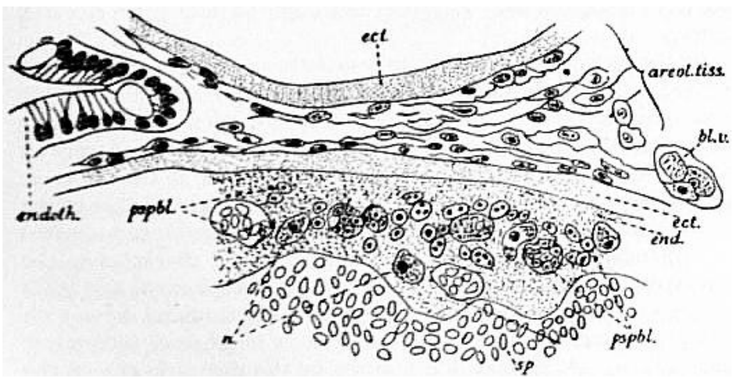
The spores themselves vary greatly in size and shape (figs. 7 and 8). They may be as small as 1.5 µ by 1 µ (as in a species of *Nosema*), or as large as 100 µ by 12 µ (as in *Ceratomyxa*). A conspicuous feature in the structure of a fully-developed spore is the polar-capsules, of which there may be either 1, 2, or 4 to each. In the Phaenocystes the polar-capsules are visible in the fresh condition, but not in the Cryptocystes. The polar-capsule is an organella which recalls the nematocyst of a Hydrozoan, containing a spirally-coiled filament, often of great length, which is shot out on the application of a suitable stimulus. Normally, as was ingeniously shown by Thélohan (**43**), the digestive juices of the fresh host serve this purpose, but various artificial means may suffice. The function of the everted filament is probably to secure the attachment of the spore to the epithelium of the new host. In the Phaenocystes, in connexion with each polar-capsule, a small nuclear body can be generally made out; these two little nuclei are those of the two "capsulogenous" areas of the protoplasm of the pansporoblast, which formed the capsules. The sporoplasm, representing the sporozoite, is always single. Nevertheless, in the Phaenocystes it is invariably binuclear; and, in the Microsporidia, the nucleus, at first single, gives rise later to four nuclei, two of which are regarded by Stempell (**42**) as corresponding to those of two polar-capsules (of which only one is developed in the spore), the remaining two representing germ-nuclei. Hence it is possible that the Myxosporidian sporoplasm really consists of two, incompletely-divided (sister) germs. Moreover, it is supposed by some that these two nuclei fuse together later, this act representing a sexual conjugation; since the earliest known phases of young trophozoites (amoebulae) have been described as uninuclear.



From Lankester’s *Treatise on Zoology*, vol. Protozoa, after Thélohan.

FIG. 4.—Stages in spore-formation. All the figures are from *Myxobolus ellipsoides*, except *a* and *f*, which are from *M. pfeifferi*.

a, Differentiation of the pansporoblast (*p.sp*).
b, Pansporoblast with two nuclei.
c and *d*, Pansporoblasts with six and ten nuclei respectively; in *d*, four of the nuclei are degenerating.
e, Pansporoblast segmented into two definitive sporoblasts, each with three nuclei. In the next four figures the definitive sporoblast, or the spore produced from it, is alone figured.
f, Definitive sporoblast segmented into three masses, the capsulogenous cells (*c.g.c*) and the sporoplasm (*sp.p*), within an envelope, the spore membrane (*sp.m*).
g, More advanced stage.
h, Spore completely developed, with two polar capsules and sporoplasm containing an iodinophilous vacuole.
i, Abnormal spore containing six polar capsules.
n, Nuclei.
sp.bl, Definitive sporoblast.
r.n, Residuary nuclei.
vac, Vacuole.
r.p.c, Rudiment of *p.c*, polar capsule.
n.p.c, Nuclei of polar capsules.
iod.vac, Iodinophilous vacuole.
n.sp, Nuclei of sporoplasm.

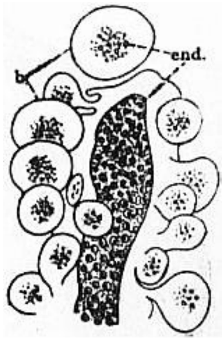


From Woodcock, *Proc. and Trans. of the Liverpool Biological Society*, 1904.

FIG. 5.—Part of the periphery of a cyst of *Glugea stephani*, in the intestinal wall of the plaice, showing sporoblast and spore-formation.

ect, Ectorind.
end, Endoplasm.
endoth, Fold of the mucous membrane, normal in character.
p.sp.bl, Various stages in the development of the pansporoblasts.
sp, Ripe spores, filling the greater part of the cyst.
n, Large (vegetative) nuclei.

In addition to spore-formation, two or three modes of endogenous reproduction, serving for auto-infection, have been made known. One, termed by Doflein *plasmotomy*, consists either in the division of the (multinucleate) trophozoite into two, by more or less equal fission (simple plasmotomy), or in the budding-off, from the parent trophozoite, of several portions (example: *Myxidium lieberkühnii*, fig. 6). A variety of this method has been described by Stempell (**40**) in the case of the young trophozoites (meronts) of *Thelohania mülleri*, which may divide into two while still uninuclear; and by rapid successive divisions chains of meronts may be formed, the different individuals being incompletely separated. Another method, which is probably chiefly responsible for the rapid spread of tissue-parasites and cell-parasites (such as *Myxobolidae* and *Glugeidae*) through their host's tissue in the condition of diffuse infiltration, consists in multiple nuclear division, and the liberation of amoebulae while the parasite is yet quite young and possesses only few nuclei. As Woodcock has pointed out in considering the case of *Glugea stephani*, it is very probable that this "multiplicative reproduction," in diffuse infiltration, is to be looked upon as a separation of the pansporoblast-rudiments as daughter-individuals; *i.e.* that the pansporoblasts are, in certain circumstances, capable of independent existence as little sporonts. A further stage in this direction of evolution is seen, according to Stempell, in *Thelohania*, *Pleistophora* and other types where the whole individual becomes one reproductive organella; such forms are to be considered as examples of a phylogenetic individualization of the pansporoblasts, which now exist as solitary sporonts. An extreme case of this "reduction of the individual" is found, apparently in the genus *Nosema*, as lately characterized by Perez (**34**), where vast numbers of minute entirely independent sporonts (pansporoblasts) are produced, each of which gives rise to only a single spore.



From Lankester's *Treatise on Zoology*, vol. Protozoa.

FIG. 6.—Formation of buds by multiple plasmotomy in *Myxidium lieberkühnii*, Bütschli (par. *Esox* and *Lota*) after Cohn.

b, Buds.
end, Endoplasm; the clear outer portion represents the ectoplasm.

The Myxosporidia are divided into two suborders, the Phaenocystes and the Cryptocystes. Some authors have of late years separated these two divisions and raised each to the rank of a distinct order, considering that they are not more closely related to each other than to other Endosporan orders. We think this is a mistake; and it is very interesting to find that Léger and Hesse (1908) have described (**29***a*) a new genus of Phaenocystes, *Coccomyxa*, which represents a type intermediate between these two suborders, and shows that they are closely connected.

Classification.

Suborder 1: *Phaenocystes*, Gurley. Spores relatively large, with generally two or four polar-capsules, visible in the fresh condition. There are nearly always two spores formed in each pansporoblast.

Section (*a*): *Disporea*. Only two spores (*i.e.* one pansporoblast) produced in each individual trophozoite. The greatest length of the spore is at right angles to the plane of the suture.

One family, *Ceratomyxidae*, including two genera, *Ceratomyxa* (fig. 3, B) and *Leptotheca*, typically "free" parasites, mostly from the gall bladders of fishes. The valves of the spore in the former genus are prolonged into hollow cones. The type-species of this genus is *C. sphaerulosa*, from *Mustelus* and *Galeus*; that of *Leptotheca* is *L. agilis*, from *Trygon*.

Section (*b*): *Polysporea*. More than two spores, generally very many, are produced typically by each individual trophozoite. The greatest length of the spore is usually in the sutural plane.

Family, *Myxidiidae*. Spores with two polar-capsules, and without an iodinophilous vacuole in the sporoplasm. Mostly "free" parasites. Gen. *Sphaerospora*. Four or five species are known, from the kidneys or gall bladder of fishes (fig. 3, A). One, *S. elegans*, is interesting in that it affords a transition between the two sections, being disporous. Gen. *Myxidium*; spores elongated and fusiform, with a polar capsule at each extremity. The best-known species is *M. lieberkühnii*, from the urinary bladder of the pike. One or two species occur in reptiles. Other genera are *Sphaeromyxa*, *Cystodiscus*, *Myxosoma* and *Myxoproteus*. 386

Family, *Chloromyxidae*. Spores with four polar capsules and no iodinophilous vacuole. One genus, *Chloromyxum*, of which several species are known; the type being *C. leydigi*, from the gall bladder of various Elasmobranchs (fig. 7, B).

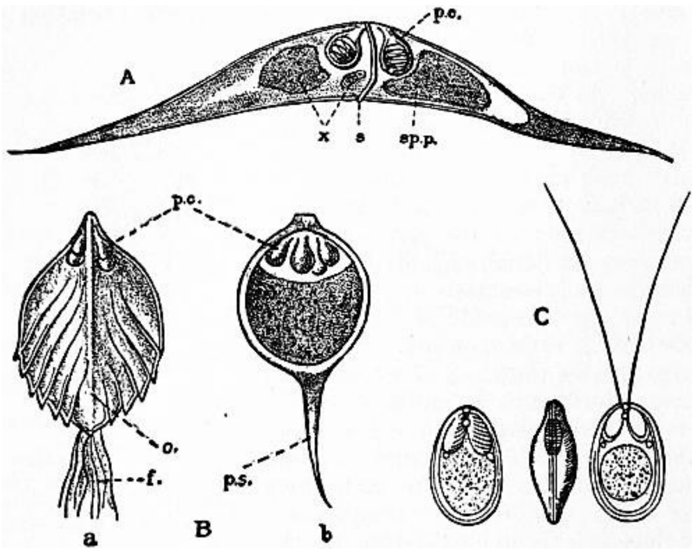


FIG. 7.—A. Spore of *Ceratomyxa sphaerulosa*, Thél. (par. *Mustelus* and *Galeus*), × 750, after Thélohan. *sp.p*, Sporoplasm; *p.c*, polar capsules; *s*, suture; *x*, "irregular, pale masses, of undetermined origin."

From Lankester's *Treatise on Zoology*, vol. Protozoa.

B. Spores of *Chloromyxidae*, after Thélohan. *a*, *Chloromyxum leydigi*, Ming., seen from the sutural aspect, × 2250; *b*, *C. caudatum*, Thél., × 1900. *p.c*, Polar capsules; *s*, suture; *f*, filaments; *p.s*, tail-like process of the spore envelope.

From Wasielewski's *Sporozoenkunde*.

C. Spores of *Myxobolus ellipsoides*, Thél. The spores on the left and right are lying with the sutural plane horizontal, that in the middle with the sutural plane vertical.

Family, *Myxobolidae*. Spores with two polar-capsules (exceptionally one), and with a characteristic iodinophilous vacuole in the sporoplasm. Typically tissue parasites of Teleosteans, often very dangerous. Genus *Myxobolus*. Spores oval or rounded, without a tail-like process. Very many species are known, which are grouped into three subsections: (*a*) forms with only one polar-capsule, such as *M. piriformis*, of the tench; (*b*) forms with two unequal capsules, *e.g. M. dispar* from *Cyprinus* and *Leuciscus*; and (*c*) the great majority of species with two equal polar-capsules, including *M. mülleri*, the type-species, from different fish, *M. cyprini* and *M. pfeifferi*, the cause of deadly disease in carp and barbel respectively and others. Other genera are *Henneguya* and *Hoferellus*, differing from *Myxobolus* in having, respectively, one or two tail-like processes to the spore. *Lentospora*, according to Plehn (**37**), lacks an iodinophilous vacuole.

Family *Coccomyxidae*. The pansporoblasts produce (probably) only one spore. Spore oval, large (14 µ by 5.5 µ), with a single very large polar-capsule. Sporoplasm with no vacuole. Single genus *Coccomyxa*, with the characters of the family. One species, *C. morovi*, Léger and Hesse, from the gall bladder of the sardine. The spore greatly resembles a Cryptocystid spore.

Suborder 2: *Cryptocystes*, Gurley (= *Microsporidia*, Balbiani). Spores minute, usually pear-shaped, with only one polar-capsule, which is visible only after treatment with reagents. The number of spores formed in each pansporoblast varies greatly in different forms.

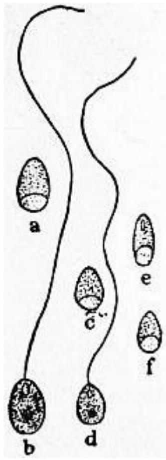
Section (*a*): *Polysporogenea*. The trophozoite produces numerous pansporoblasts, each of which gives rise to many spores. Genus *Glugea*, with numerous species, of which the best-known is *G. anomala*, from the stickleback (fig. 1). The genus *Myxocystis*, which has been shown by Hesse (**24**) to be a true Microsporidian, is placed by Perez in this section, but this is a little premature, as Hesse does not describe the exact character of the sporulation, *i.e.* with regard to the number of pansporoblasts and the spores they produce.

Section (*b*): *Oligosporogenea*. The trophozoite becomes itself the (single) pansporoblast. In *Pleistophora*, the pansporoblast produces many spores; *P. typicalis*, from the muscles of various fishes (fig. 2), is the type-species. In *Thelohania*, eight spores are formed; the different species are parasitic in Crustacea. In *Gurleya*, parasitic in *Daphnia*, only four are formed; and, lastly, in *Nosema* (exs. *N. pulvis*, from *Carcinus*, and, most likely, *N. bombycis*, of the silkworm), each pansporoblast produces only a single spore.

2. Order—**Actinomyxidia.** This order comprises a peculiar group of parasites, first described by A. Stolc in 1899, which are restricted to Oligochaete worms of the family *Tubificidae*. Most forms attack the intestinal wall, often destroying its epithelium over considerable areas; but one genus, *Sphaeractinomyxon*, inhabits the body-cavity of its host. The researches of Caullery and Mesnil (**10**-**12**) and of Léger (**28** and **29**) have shown that the parasites exhibit the typical features of the Endospora, and the spores possess the characteristic polar-capsules of

the Myxosporidian spore, but differ therefrom by their more complicated structure.

The growth and development of an Actinomyxidian have been recently worked out by Caullery and Mesnil in the case of *Sphaeractinomyxon stolci*. A noteworthy point is the differentiation of an external (covering) cellular layer, which affords, perhaps, the nearest approach to distinct tissue-formation known among Protozoa. This envelope is formed soon after nuclear multiplication of the young trophozoite has begun, and is constituted by two nuclei and a thin, peripheral layer of cytoplasm. It remains binuclear throughout the entire period of development, and serves as a delicate cyst-membrane. The multiplication of the internal nuclei is accompanied by a corresponding division of the cytoplasm; so that instead of a multinucleate or plasmodial condition, distinct uninucleate cellules are formed, up to sixteen in number. These cellules, as a matter of fact, are sexual elements or gametes; and eight of them can be distinguished from the other eight by slight differences in the nuclei. The gametes unite in couples, each couple being most probably composed of dissimilar members: in other words, conjugation is slightly anisogamous. Each of these eight copulae gives rise to a spore.



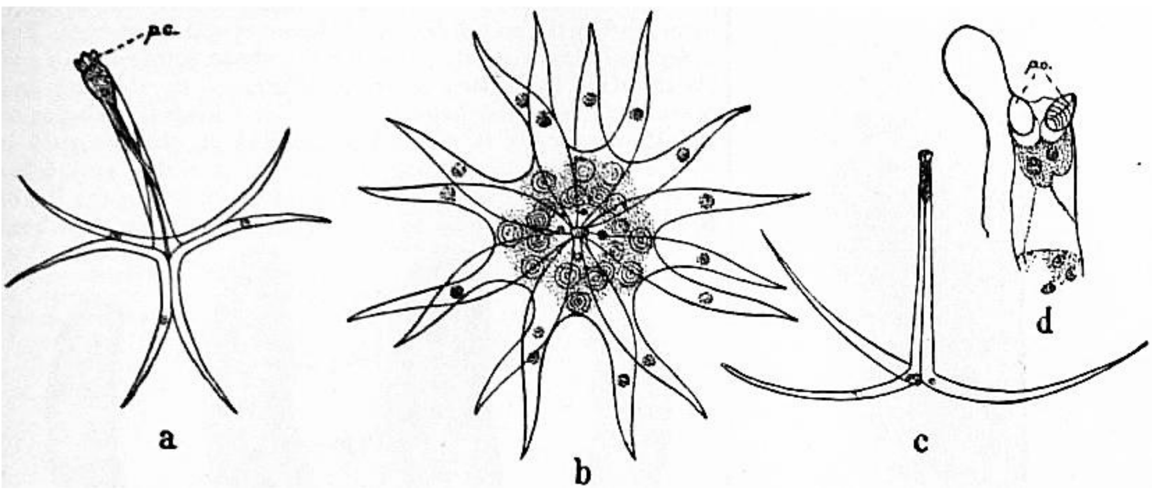
From Lankester’s *Treatise on Zoology*, vol. Protozoa.

FIG. 8.—Spores of various *Glugeidae*, × 1500 (after Thélohan).

a and *b*, *Pleistophora typicalis*, Gurley; *a* in the fresh condition, *b* after treatment with iodine water, causing extrusion of the filament.
c and *d*, *Thelohania octospora*, Henneguy; *c* fresh, *d* treated with ether.
e, *Glugea depressa*, Thél., fresh.
f, *G. acuta*, Thél.

As the name of the order implies, there are always eight spores formed. These differ from other Endosporan spores in having invariably a ternary symmetry and constitution (fig. 9). The wall of the spore is composed of three valves, each formed from an enveloping cell, and three capsular cells, placed at the upper or anterior pole, and containing each a polar-capsule, visible in the fresh condition. The valves are usually prolonged into processes or appendages, whose form and arrangement characterize the genus; but in *Sphaeractinomyxon* the spore is spherical and lacks processes. The sporoplasm may be either a plasmodial mass, with numerous nuclei, or may form a certain number of uninuclear sporozoites. A remarkable feature in the development of the spore is that the germinal tissue (sporoplasm) arises separate from and outside the cellules which give rise to the spore-wall; later, when the envelopes are nearly developed, the sporoplasm penetrates into the spore.

Four genera have been made known. (1) *Hexactinomyxon*, Stolc. Spores having the form of an anchor with six arms; sporoplasm plasmodial, situate near the anterior pole of the spore. One sp. *H. psammoryctis*, from *Psammoryctes*. (2) *Triactinomyxon*, St. Spores having the form of an anchor with three arms; distinct sporozoites, disposed near the anterior pole. *T. ignotum*, with eight spores, from *Tubifex tubifex*, and also from an unspecified Tubificid; another sp., unnamed, with 32 sporozoites, also from *T. t.* (3) *Synactinomyxon*, St. Spores united to one another, each having two aliform appendages; sporoplasm plasmodial. One sp., *S. tubificis*, from *T. rivulorum*. (4) *Sphaeractinomyxon*, C. and M. Spores spherical, without aliform prolongations; sporoplasm gives rise to very many 387
sporozoites, occupying the whole spore. One sp., *S. stolci*, from *Clitellio* and *Hemitubifex*.

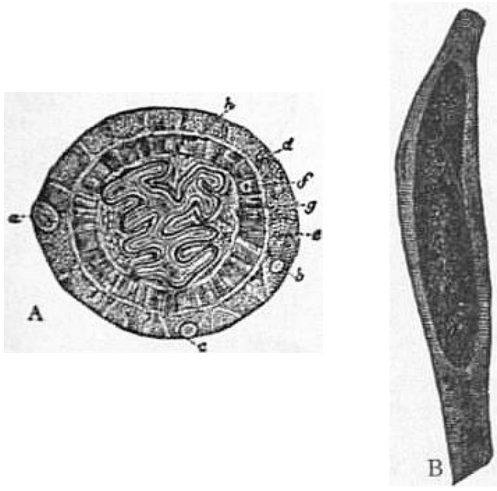


From Lankester’s *Treatise on Zoology*, vol. Protozoa.

FIG. 9.—Spores of Actinomyxidia (after Stolc).

a, *Hexactinomyxon psammoryctis* (par. *Psammoryctes barbatus*).
b, *Synactinomyxon tubificis* (par. *Tubifex rivulorum*); the mass of united spores.
c, *Triactinomyxon ignotum* (par. *Clitellio*, sp.).
d, Upper portion of *Hexactinomyxon*, showing two of the three polar capsules, one with filament discharged.

3. Order—**Sarcosporidia.** With the exception of one or two forms occurring in reptiles, these parasites are always found in warm-blooded Vertebrates, usually Mammals. They are of common occurrence in domestic animals, such as pigs, sheep, horses and (sometimes) cattle. A Sarcosporidian has also been described from man. The characteristic habitat is the striped muscle, generally of the oesophagus (fig. 10, A) and heart, but in acute cases the parasites overrun the general musculature. When this occurs, as often happens in mice, the result is usually fatal. Unless, however, the organisms thus spread throughout the body, the host does not appear to suffer any serious consequences. In addition to the effects produced by the general disturbance to the tissues, the attacked animals have apparently to contend—at any rate in the case of *Sarcocystis tenella* in the sheep—with a poison secreted by the parasite. For Laveran and Mesnil (**27**) have isolated a toxine from this form, which they have termed sarcocystin.



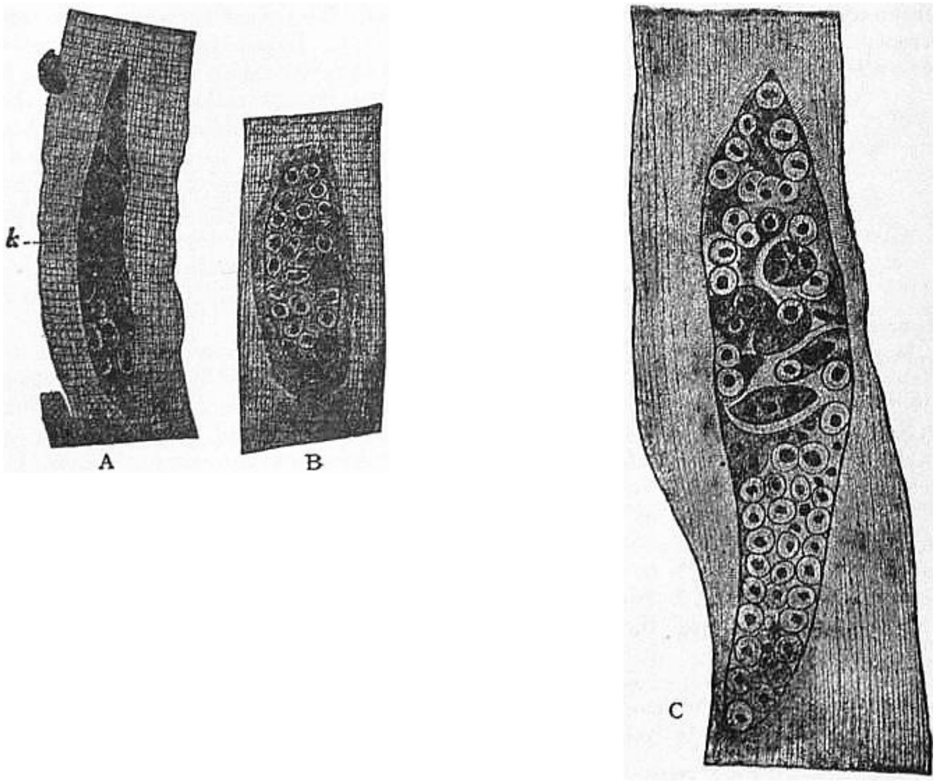
From Wasielewski’s *Sporozoenkunde*.

Fig. 10.—A. Sarcosporidia in the ox; a transverse section of the oesophagus, natural size, showing the parasites in the outer (*a*, *b*, *c*, *d*, *e*) and inner (*f*, *g*, *h*) muscular coats.

B. Longitudinal section of a muscle-fibre containing a Sarcosporidian parasite, × 60.

In the early stages of growth, a Sarcosporidian appears as an elongated whitish body lodged in the substance of a muscle-fibre; this phase has long been known as a “Miescher’s tube,” or *Miescheria*. The youngest trophozoites that have been yet observed (by Bertram, 1) were multinucleate (fig. 11, A), but there is no reason to doubt that they begin life in a uninuclear condition. The protoplasm is limited by a delicate cuticle. With growth, organellae corresponding to the Myxosporidian pansporoblasts are formed by the segregation internally of little uninuclear spheres of protoplasm. At the same time, a thick striated envelope is developed around the parasite, which later comes to look like a fur of fine filaments. The probable explanation of this feature (given by Vuillemin, **44**) is that it is due to the partial breaking down of a stiff, vertically (or radially) striated external layer (fig. 12, A), such as is seen in *Myxidium lieberkühnii*. Immediately internal to this is a thin, homogeneous membrane, which sends numerous partitions or septa inwards; these divide up the endoplasm into somewhat angular chambers or alveoli (fig. 12). In each chamber is a pansporoblast, which divides up to produce many spores; hence the spores formed from different pansporoblasts are kept more or less separate. The pansporoblasts originate, in a growing Sarcosporidian, at the two poles of the body, where the peripheral endoplasm with its nuclei is chiefly aggregated. More internally, spore-formation is in progress; and in the centre, pansporoblasts full of ripe spores are found.

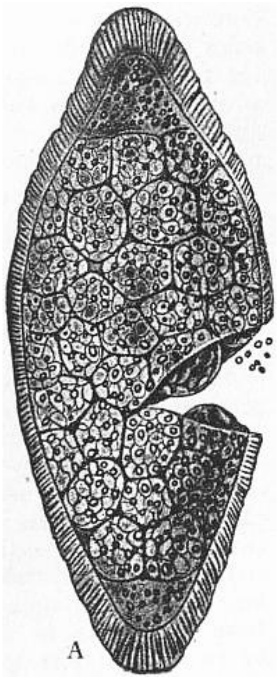
By this time the parasite has greatly distended the muscle-fibre in which it has hitherto lain, absorbing, with its growth, practically all the contractile-substance, until it is surrounded only by the sarcolemma and sarcoplasm. It next passes into the adjacent connective-tissue, and in this phase has been distinguished from *Miescheria* as *Balbiania*, under the impression that the two forms were quite distinct. In the later stages, the parasite may become more rounded, and a cyst may be secreted around it by the host’s tissue. In these older forms, the most centrally placed spores degenerate and die, having become over-ripe and stale.

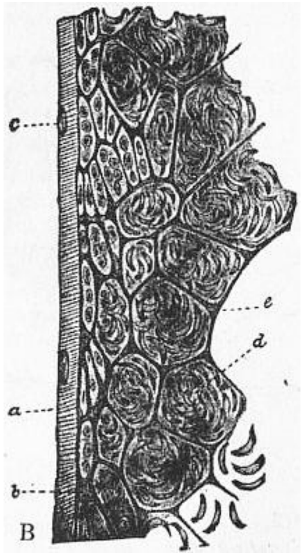


After Bertram, from Wasielewski’s *Sporozoenkunde*.

Fig. 11.—Stages in the growth of *Sarcocystis tenella* of the sheep. A, Youngest observed stage in which the radially striated outer coat has not appeared; the body of the trophozoite is already divided into a number of cells or pansporoblasts (*k*). B and C, Older stages with numerous pansporoblasts and two envelopes, an inner membrane and an outer radially striated layer.

With regard to the spores themselves and what becomes of them, our knowledge is defective. Two kinds of reproductive germ have been described, termed respectively *gymnospores* (so-called sporozoites, “Rainey’s corpuscles”) and *chlamydospores*, or simply spores. It seems probable that the former serve for endogenous or auto-infection, and the latter for infecting fresh hosts. Unfortunately, however, both kinds of germ are not yet known in the case of any one species. The gymnospores, which are the more commonly found (*e.g.* in *S. muris*, *S. miescheriana* of the pig, and other forms), are small sickle-shaped or reniform bodies which are more or less amoeboid, and capable of active 388
movement at certain temperatures. They appear to be naked, and consist of finely granular protoplasm, containing a single nucleus and one or two vacuoles. The chlamydospores, or true spores, occur in *S. tenella* of sheep (fig. 13), and have been described by Laveran and Mesnil (**26**). They also are falciform, but one extremity is rounded, the other pointed. There is a very thin, delicate membrane, most unlike a typical, resistant spore-wall; and the spores themselves are extremely fragile and easily acted upon and deformed by reagents, even by distilled water. The rounded end of the spore contains a large nucleus, while at the other end is an oval, clear space, which, in the fresh condition, shows a distinct spiral striation. The exact significance of this structure has been much debated. In position and appearance it recalls the polar-capsule of a Myxosporidian spore. The proof of this interpretation would be the expulsion of a filament on suitably stimulating the spore; while, however, some investigators have asserted that such a filament is extruded, this cannot be regarded as at all certain. Hence it is still doubtful whether this striated body really corresponds to a polar-capsule.

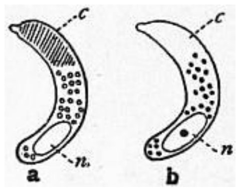




From Wasielewski's *Sporozoenkunde*.

Fig. 12.—A, *Sarcocystis miescheriana* (Kühn) from the pig: late stage in which the body has become divided up into numerous chambers or alveoli, each containing a number of germs.

B, *Sarcocystis* of the ox: section of a stage similar to fig. 12. *a*, Substance of muscle-fibre; *b*, envelope of parasite; *c*, nuclei of the muscle; *d*, parasitic germs (gymnospores); *e*, walls of the alveoli. In the peripheral alveoli are seen immature germs.



(After Laveran and Mesnil, from Lankester's *Treatise on Zoology*, vol. Protozoa.)

Fig. 13.—Spores of *Sarcocystis tenella*, Raill., from the sheep.

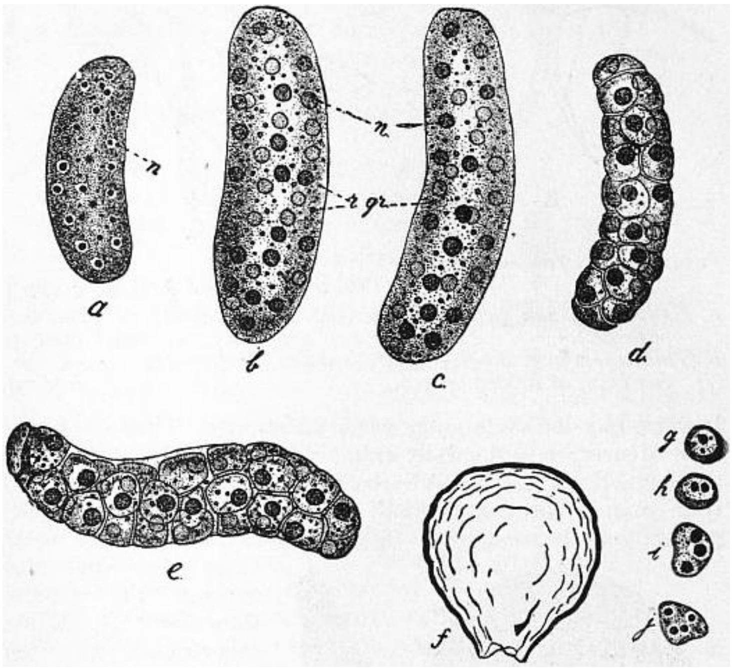
a, Spore in the fresh condition, showing a clear nucleus (*n*) and a striated body or capsule (*c*).

b, Stained spore; the nucleus (*n*) shows a central karyosome; the striations of the polar capsule (*c*) are not visible.

Nothing whatever is known as to the natural means by which infection with Sarcosporidia is brought about. Smith (**39**) showed that mice can be infected with *Sarcocystis muris* by simply feeding them on the flesh of infected mice. It is not very likely, however, that this represents the natural mode, even in the case of mice; and it certainly cannot do so in the case of Herbivora. The difficulty in the way is the delicacy of the spores, which seem totally unfitted to withstand external conditions. It may be that some alternative (intermediate) host is concerned in dispersal; but this has yet to be ascertained.

All known Sarcosporidia are included in a single genus *Sarcocystis*, Lank. (= *Miescheria* + *Balbiania*, Blanchard.) Some of the principal species are: *S. miescheriana*, from pigs; *S. tenella*, from sheep; *S. bertrami*, from horses; *S. blanchardi*, from Bovines; *S. muris*, from mice; *S. platydactyli*, from the gecko; and lastly, *S. lindemanni*, described from man.

4. Order—**Haplosporidia.** The Sporozoa included in this order are characterized by the general simplicity of their development, and by the undifferentiated character of their spores. The order includes a good many forms, whose arrangement and classification have been recently undertaken by Caullery and Mesnil (**15**), to whom, indeed, most of our knowledge relating to the Haplosporidia is due. The habitat of the parasites is sufficiently varied; Rotifers, Crustacea, Annelids and fishes furnishing most of the hosts. A recent addition to the list of Protozoa causing injury to man, a Haplosporidian, has been described by Minchin and Fantham (**29d**), who have termed the parasite *Rhinosporidium*, from its habitat in the nasal septum, where it produces pedunculate tumours.



From Minchin, in Lankester’s *Treatise on Zoology*, vol. Protozoa.

FIG. 14.—*Bertramia Asperospora* (Fritsch) from the body-cavity of *Brachionus*. × 1040.

a, Young form with opaque, evenly-granulated protoplasm and few refringent granules; the nuclei (*n*) are small, and appear to be surrounded each by a clear space.

b and *c*, Full-grown specimens with large nuclei and clearer protoplasm, containing numerous refringent granules (*r. gr.*).

d and *e*, Morula stages, derived from *b* and *c* by division of the body into segments centred round the nuclei, each cell so formed being a spore. Between the spores a certain amount of intercellular substance or residual protoplasm is left, in which the refringent granules seem to be embedded. The morula may break up forthwith and scatter the spores, or may first round itself off and form a spherical cyst with a tough, fairly thick wall.

f, Empty, slightly shrunken cyst, from which the spores have escaped.

g, Free spore or youngest unicellular trophozoite.

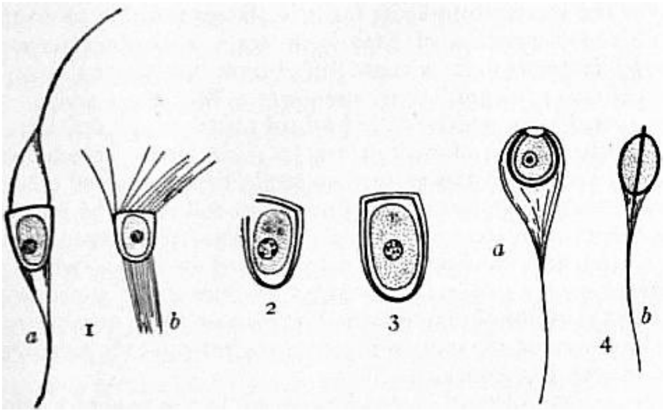
h, *i*, *j*, Commencing growth of the trophozoite, with multiplication of the nuclei, which results ultimately in forms such as *a* and *b*.

Bertramia, a well-known parasite of the body-cavity of Rotifers, will serve very well to give a general idea of the life-cycle so far as it has yet been made out (fig. 14). The trophozoite begins life as a small, rounded uninucleate corpuscle, which as it grows, becomes multinucleate. The multinuclear body generally assumes a definite shape, often that of a sausage. Later, the protoplasm becomes segregated around each of the nuclei, giving the parasite a mulberry-like aspect; hence this stage is frequently known as a morula. The uninuclear cellules thus formed are the spores, which are ultimately liberated by the break-up of the parent body. Each is of quite simple, undifferentiated structure, possesses a large, easily-visible nucleus, and gives rise in due course to another young trophozoite. In some instances, as described by Minchin, the sporulating parasite becomes rounded off and forms a protective cyst, doubtless for the protection of the spores during dissemination.

In some forms (*e.g. Haplosporidium* and *Rhinosporidium*) the spore-mother-cells, instead of becoming each a single spore, as in *Bertramia*, give rise to several, four in the first case, many in the latter. Sometimes, again, the spore, while preserving the essentially simple character of the sporoplasm, may be enclosed in a spore-case; this may have the form of a little box with a lid or operculum, as in some species of *Haplosporidium*, or may possess a long process or tail, as in *Urosporidium* (fig. 15).

The *Haplosporidia* are divided by Caullery and Mesnil into three families, *Haplosporidiidae*, *Bertramiidae* and *Coelosporidiidae*; one or two genera are also included whose exact position is doubtful.

(*a*) *Haplosporidiidae*: 3 genera, *Haplosporidium*, type-species *H. heterocirri*; *Urosporidium*, with one sp., *U. fuliginosum*; all parasitic in various Annelids; and *Anurosporidium*, with the species *A. pelseneeri*, from the sporocysts of a Trematode, parasitic on *Donax*.



From Caullery and Mesnil, *Archives de zoologie expérimentale*, vol. 4, 1905, by permission of Schleicher Frères et Cie, Paris.

FIG. 15.—Spores of various Haplosporidia.

1. *Haplosporidium heterocirri*:
 a, on liberation;
 b, after being in sea-water.
2, *H. scolopli*.
3, *H. vejdovskii*.
4, *Urosporidium fuliginosum*:
 a, surface-view;
 b, side-view. × 1000.

(*b*) *Bertramiidae*: 2 genera, *Bertramia*, with *B. capitellae* from an Annelid and *B. asperospora*, the Rotiferan parasite above described; and *Ichthyosporidium*, with *I. gasterophilum* and *I. phymogenes*, parasitic in various fish.

(*c*) *Coelosporidiiae*: genera *Coelosporidium*, type-species *C. chydoriclola*; and *Polycaryum*, type-species *P. branchiopodianum*. These forms are parasitic in small Crustacea. The genus *Blastulidium* is referred, doubtfully, by Caullery and Mesnil to this family; but certain phases of this organism seem to indicate rather a vegetable nature.

The genus *Rhinosporidium* should probably be placed in a distinct family. The only species so far described is *R. kinealyi* from the nasal septum of man, to which reference has above been made. Another form, *Neurosporidium cephalodisci*, agreeing in some respects with *Rhinosporidium*, has been described by Ridewood and Fantham (**37a**) from the nervous system of *Cephalodiscus*.

A parasite whose affinities are doubtful, but which is regarded by Caullery and Mesnil as allied to the Haplosporidia, is the curious parasite originally described by Schewiakoff as “endoparasitic tubes” of *Cyclops*; it has been named by Caullery and Mesnil, *Scheviakovella*. This organism is remarkable in one or two ways: it possesses a contractile vacuole; the amoeboid trophozoites tend to form plasmodia; and the spores, of the usual simple type, may apparently divide by binary fission.

5. There remain, lastly, certain forms, which are conveniently grouped together as “Sporozoa *incertae sedis*,” either for the reason that it is impossible to place them in any of the well-defined orders, or because their life-cycle is at present too insufficiently known. Serosporidia is the name given by Pfeiffer to certain minute parasites of the body-cavity of Crustacea; they include *Serosporidium*, *Blanchardina* and *Botellus*. *Lymphosporidium*, a form with distributed nucleus, causing virulent epidemics among brook-trout, is considered by Calkins(**3**) to be suitably placed here. Another parasite of lymphatic spaces and channels is the remarkable *Lymphocystis*, described by Woodcock (**46**), from plaice and flounders, which in some respects rather recalls a Gregarine. The group Exosporidia was founded by Perrier to include a peculiar organism, ectoparasitic on Arthropods, to which the name of *Amoebidium* had been given by Cienkowsky. It has recently been shown, however, that this organism is most probably an Alga. Another genus, *Exosporidium*, described by Sand (**38**), is placed at present in this group. For details of the structure of these forms and others like *Siedleckia*, *Toxosporidium*, *Chitonicium Joyeuxella* and *Metschnikovella*, a comprehensive treatise on the Sporozoa, such as that of Minchin, should be consulted.

To complete this article, it will be sufficient to mention various enigmatical bodies, associated with different diseases, which are regarded by their describers as Protozoa. Among such is the “*Histosporidium carcinomatosum*” of Feinberg, which he finds in cancerous growths. *Cytoryctes*, the name given to “Guarnieri’s bodies” in small-pox and vaccinia, has been recently investigated by Calkins (**3a**), who has described a complex life-cycle for the alleged parasite. Other workers, however, such as Siegel, give a quite different account of these bodies, and, moreover, find similar ones in scarlet-fever, syphilis, &c.; while yet others (*e.g.* Prowazek) deny that they are parasitic organisms at all.

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(H. M. Wo.)

ENDYMION, in Greek mythology, son of Aëthlius and king of Elis. He was loved by Selene, goddess of the moon, by whom he had fifty daughters, supposed to represent the fifty moons of the Olympian festal cycle. In other versions, Endymion was a beautiful youth, a shepherd or hunter whom Selene visited every night while he lay asleep in a cave on Mount Latmus in Caria (Pausanias v. 1; Ovid, *Ars am.* iii. 83). Zeus left him free to choose anything he might desire, and he chose an everlasting sleep, in which he might remain youthful for ever (Apollodorus i. 7). According to others, Endymion’s eternal sleep was a punishment inflicted by Zeus upon him because he ventured to fall in love with Hera, when he was admitted to the society of the Olympian gods (Schol. Theocritus iii. 49). The usual form of the legend, however, represents Endymion as having been put to sleep by Selene herself in order that she might enjoy his society undisturbed (Cicero, *Tusc. disp.* i. 38). Some see in Endymion the sun, setting opposite to the rising moon, the Latmian cave being the cave of forgetfulness, into which the sun plunges beneath the sea; others regard him as the personification of sleep or death (see Mayor on Juvenal x. 318).

ENERGETICS. The most fundamental result attained by the progress of physical science in the 19th century was the definite enunciation and development of the doctrine of energy, which is now paramount both in mechanics and in thermodynamics. For a discussion of the elementary ideas underlying this conception see the separate heading Energy.

Ever since physical speculation began in the atomic theories of the Greeks, its main problem has been that of unravelling the nature of the underlying correlation which binds together the various natural agencies. But it is only in recent times that scientific investigation has definitely established that there is a quantitative relation of simple equivalence between them, whereby each is expressible in terms of heat or mechanical power; that there is a certain measurable quantity associated with each type of physical activity which is always numerically identical with a corresponding quantity belonging to the new type into which it is transformed, so that the energy, as it is called, is conserved in unaltered amount. The main obstacle in the way of an earlier recognition and development of this principle had been the doctrine of caloric, which was suggested by the principles and practice of calorimetry, and taught that heat is a substance that can be transferred from one body to another, but cannot be created or destroyed, though it may become latent. So long as this idea maintained itself, there was no possible compensation for the destruction of mechanical power by friction; it appeared that mechanical effect had there definitely been lost. The idea that heat is itself convertible into power, and is in fact energy of motion of the minute invisible parts of bodies, had been held by Newton and in a vaguer sense by Bacon, and indeed long before their time; but it dropped out of the ordinary creed of science in the following century. It held a place, like many other anticipations of subsequent discovery, in the system of Natural Philosophy of Thomas Young (1804); and the discrepancies attending current explanations on the caloric theory were insisted on, about the same time, by Count Rumford and Sir H. Davy. But it was not till the actual experiments of Joule verified the same exact equivalence between heat produced and mechanical energy destroyed, by whatever process that was accomplished, that the idea of caloric had to be definitely abandoned. Some time previously R. Mayer, physician, of Heilbronn, had founded a weighty theoretical argument on the production of mechanical power in the animal system from the food consumed; he had, moreover, even calculated the value of a unit of heat, in terms of its equivalent in power, from the data afforded by Regnault’s determinations of the specific heats of air at constant pressure and at constant volume, the former being the greater on Mayer’s hypothesis (of which his calculation in fact constituted the verification) solely on account of the power required for the work of expansion of the gas against the surrounding constant pressure. About the same time Helmholtz, in his early memoir on the Conservation of Energy, constructed a cumulative argument by tracing the ramifications of the principle of conservation of energy throughout the whole range of physical science.

Mechanical and Thermal Energy.—The amount of energy, defined in this sense by convertibility with mechanical work, which is contained in a material system, must be a function of its physical state and chemical constitution and of its temperature. The change in this amount, arising from a given transformation in the system, is usually measured by degrading the energy that leaves the system into heat; for it is always possible to do this, while the conversion of heat back again into other forms of energy is impossible without assistance, taking the form of compensating degradation elsewhere. We may adopt the provisional view which is the basis of abstract physics, that all these other forms of energy are in their essence mechanical, that is, arise from the motion or strain of material or ethereal media; then their distinction from heat will lie in the fact that these motions or strains are simply co-ordinated, so that they can be traced and controlled or manipulated in detail, while the thermal energy subsists in irregular motions of the molecules or smallest portions of matter, which we cannot trace on account of the bluntness of our sensual perceptions, but can only measure as regards total amount.

Historical: Abstract Dynamics.—Even in the case of a purely mechanical system, capable only of a finite number of definite types of disturbance, the principle of the conservation of energy is very far from giving a complete account of its motions; it forms only one among the equations that are required to determine their course. In its application to the kinetics of invariable systems, after the time of Newton, the principle was emphasized as fundamental by Leibnitz, was then improved and generalized by the Bernoullis and by Euler, and was ultimately expressed in its widest form by Lagrange. It is recorded by Helmholtz that it was largely his acquaintance in early years with the works of those mathematical physicists of the previous century, who had formulated and generalized the principle as a help towards the theoretical dynamics of complex systems of masses, that started him on the track of extending the principle throughout the whole range of natural phenomena. On the other hand, the ascertained validity of this extension to new types of phenomena, such as those of electrodynamics, now forms a main foundation of our belief in a mechanical basis for these sciences.

In the hands of Lagrange the mathematical expression for the manner in which the energy is connected with the geometrical constitution of the material system became a sufficient basis for a complete knowledge of its dynamical phenomena. So far as statics was concerned, this doctrine took its rise as far back as Galileo, who recognized in the simpler cases that the work expended in the steady driving of a frictionless mechanical system is equal to its output. The expression of this fact

was generalized in a brief statement by Newton in the *Principia*, and more in detail by the Bernoullis, until, in the analytical guise of the so-called principle of "virtual velocities" or virtual work, it finally became the basis of Lagrange's general formulation of dynamics. In its application to kinetics a purely physical principle, also indicated by Newton, but developed long after with masterly applications by d'Alembert, that the reactions of the infinitesimal parts of the system against the accelerations of their motions statically equilibrate the forces applied to the system as a whole, was required in order to form a sufficient basis, and one which Lagrange soon afterwards condensed into the single relation of Least Action. As a matter of history, however, the complete formulation of the subject of abstract dynamics actually arose (in 1758) from Lagrange's precise demonstration of the principle of Least 391
Action for a particle, and its immediate extension, on the basis of his new Calculus of Variations, to a system of connected particles such as might be taken as a representation of any material system; but here too the same physical as distinct from mechanical considerations come into play as in d'Alembert's principle. (See Dynamics: *Analytical*.)

It is in the cases of systems whose state is changing so slowly that reactions arising from changing motions can be neglected, that the conditions are by far the simplest. In such systems, whether stationary or in a state of steady motion, the energy depends on the configuration alone, and its mathematical expression can be determined from measurement of the work required for a sufficient number of simple transformations; once it is thus found, all the statical relations of the system are implicitly determined along with it, and the results of all other transformations can be predicted. The general development of such relations is conveniently classed as a separate branch of physics under the name *Energetics*, first invented by W.J.M. Rankine; but the essential limitations of this method have not always been observed. As regards statical change, the complete specification of a mechanical system is involved in its geometrical configuration and the function expressing its mechanical energy in terms thereof. Systems which have statical energy-functions of the same analytical form behave in corresponding ways, and can serve as models or representations of one another.

Extension to Thermal and Chemical Systems.—This dominant position of the principle of energy, in ordinary statical problems, has in recent times been extended to transformations involving change of physical state or chemical constitution as well as change of geometrical configuration. In this wider field we cannot assert that mechanical (or available) energy is never lost, for it may be degraded into thermal energy; but we can use the principle that on the other hand it can never spontaneously increase. If this were not so, cyclic processes might theoretically be arranged which would continue to supply mechanical power so long as energy of any kind remained in the system; whereas the irregular and uncontrollable character of the molecular motions and strains which constitute thermal energy, in combination with the vast number of the molecules, must place an effectual bar on their unlimited co-ordination. To establish a doctrine of *energetics* that shall form a sufficient foundation for a theory of the trend of chemical and physical change, we have, therefore, to impart precision to this motion of available energy.

Carnot's Principle: Entropy.—The whole subject is involved in the new principle contributed to theoretical physics by Sadi Carnot in 1824, in which the far-reaching modern conception of cyclic processes was first scientifically developed. It was shown by Carnot, on the basis of certain axioms, whose theoretical foundations were subsequently corrected and strengthened by Clausius and Lord Kelvin, that a reversible mechanical process, working in a cycle by means of thermal transfers, which takes heat, say H_1, into the material system at a given temperature T_1, and delivers the part of it not utilized, say H_2, at a lower given temperature T_2, is more efficient, considered as a working engine, than any other such process, operating between the same two temperatures but not reversible, could be. This relation of inequality involves a definite law of equality, that the mechanical efficiencies of all reversible cyclic processes are the same, whatever be the nature of their operation or the material substances involved in them; that in fact the efficiency is a function solely of the two temperatures at which the cyclically working system takes in and gives out heat. These considerations constitute a fundamental general principle to which all possible slow reversible processes, so far as they concern matter in bulk, must conform in all their stages; its application is almost coextensive with the scope of general physics, the special kinetic theories in which inertia is involved, being excepted. (See Thermodynamics.) If the working system is an ideal gas-engine, in which a perfect gas (known from experience to be a possible state of matter) is passed through the cycle, and if temperature is measured from the absolute zero by the expansion of this gas, then simple direct calculation on the basis of the laws of ideal gases shows that $H_1/T_1 = H_2/T_2$; and as by the conservation of energy the work done is $H_1 - H_2$, it follows that the efficiency, measured as the ratio of the work done to the supply of heat, is $1 - T_2/T_1$. If we change the sign of H_1 and thus consider heat as positive when it is restored to the system as is H_2, the fundamental equation becomes $H_1/T_1 + H_2/T_2 = 0$; and as any complex reversible working system may be considered as compounded in various ways of chains of elementary systems of this type, *whose effects are additive*, the general proposition follows, that in any reversible complete cyclic change which involves the taking in of heat by the system of which the amount is δH, when its temperature ranges between T_r and $T_r + \delta T$, the equation $\Sigma\delta H_r/T_r$-0 holds good. Moreover, if the changes are not reversible, the proportion of the heat supply that is utilized for mechanical work will be smaller, so that more heat will be restored to the system, and $\Sigma\delta H_r/T_r$ or, as it may be expressed, $\int dH/T$, must have a larger value, and must thus be positive. The first statement involves further, that for all reversible paths of change of the system from one state C to another state D, the value of $\int dH/T$ must be the same, because any one of these paths and any other one reversed would form a cycle; whereas for any irreversible path of change between the same states this integral must have a greater value (and so exceed the difference of entropies at the ends of the path). The definite quantity represented by this integral for a reversible path was introduced by Clausius in 1854 (also adumbrated by Kelvin's investigations about the same time), and was named afterwards by him the increase of the *entropy* of the system in passing from the state C to the state D. This increase, being thus the same for the unlimited number of possible reversible paths involving independent variation of all its finite co-ordinates, along which the system can pass, can depend only on the terminal states. The entropy belonging to a given state is therefore a function of that state alone, irrespective of the manner in which it has been reached; and this is the justification of the assignment to it of a special name, connoting a property of the system depending on its actual condition and not on its previous history. Every reversible change in an isolated system thus maintains the entropy of that system unaltered; no possible spontaneous change can involve decrease of the entropy; while any defect of reversibility, arising from diffusion of matter or motion in the system, necessarily leads to increase of entropy. For a physical or chemical system only those changes are spontaneously possible which would lead to increase of the entropy; if the entropy is already a maximum for the given total energy, and so incapable of further continuous increase under the conditions imposed upon the system, there must be stable equilibrium.

This definite quantity belonging to a material system, its entropy φ, is thus concomitant with its energy E, which is also a definite function of its actual state by the law of conservation of energy; these, along with its temperature T, and the various co-ordinates expressing its geometrical configuration and its physical and chemical constitution, are the quantities with which the thermodynamics of the system deals. That branch of science develops the consequences involved in just two principles: (i.) that the energy of every isolated system is constant, and (ii.) that its entropy can never diminish; any complication that may be involved arises from complexity in the systems to which these two laws have to be applied.

The General Thermodynamic Equation.—When any physical or chemical system undergoes an infinitesimal change of state, we have $\delta E = \delta H + \delta U$, where δH is the energy that has been acquired *as heat* from sources extraneous to the system during the change, and δU is the energy that has been imparted by reversible agencies such as mechanical or electric work. It is, however, not usually possible to discriminate permanently between heat acquired and work imparted, for (unless for isothermal transformations) neither δH nor δU is the exact differential of a function of the constitution of the system and so independent of its previous history, although their sum δE is such; but we can utilize the fact that δH is equal to $T\delta\varphi$ where $\delta\varphi$ is such, as has just been seen. Thus E and φ represent properties of the system which, along with temperature, pressure and other independent 392
data specifying its constitution, must form the variables of an analytical exposition. We have, therefore, to substitute $T\delta\varphi$ for δH; also the *change* of internal energy is determined by the change of constitution, involving a differential relation of type

$$\delta U = -p\delta v + \delta W + \mu_1\delta m_1 + \mu_2\delta m_2 + \dots + \mu_n\delta m_n,$$

when the system consists of an intimate mixture (solution) of masses m_1, m_2, ... m_n of given constituents, which differ physically or chemically but may be partially transformable into each other by chemical or physical action during the changes under consideration, the whole being of volume v and under extraneous pressure p, while W is potential energy arising from physical forces such as those of gravity, capillarity, &c. The variables m_1, m_2, ... m_n may not be all independent; for example, if the system were chloride of ammonium gas existing along with its gaseous products of dissociation, hydrochloric acid and ammonia, only one of the three masses would be independently variable. The sufficient number of these variables (independent components) together with two other variables, which may be v and T, or v and φ, specifies and determines the state of the system, considered as matter in bulk, at each instant. It is usual to include δW in $\mu_1\delta m_1 + \dots$; in all cases where this is possible the single equation

$$\delta E = T\delta\varphi - p\delta v + \mu_1\delta m_1 + \mu_2\delta m_2 + \dots + \mu_n\delta m_n \tag{1}$$

thus expresses the complete variation of the energy-function E arising from change of state; and when the part involving the n constitutive differentials has been expressed in terms of the number of them that are really independent, this equation by itself becomes the unique expression of *all* the thermodynamic relations of the system. These are in fact the various relations ensuring that the right-hand side is an exact differential, and are of the type of reciprocal relations such as $d\mu_r/d\varphi = dT/dm_r$.

The condition that the state of the system be one of stable equilibrium is that $\delta\varphi$, the variation of entropy, be negative for all formally imaginable infinitesimal transformations which make δE vanish; for as $\delta\varphi$ cannot actually be negative for any spontaneous variation, none of these transformations can then occur. From the form of the equation, this condition is the same as that $\delta E - T\delta\varphi$ must be positive for *all possible* variations of state of the system as above defined in terms of co-ordinates representing its constitution in bulk, without restriction.

We can change one of the independent variables expressing the state of the system from φ to T by subtracting $\delta(\varphi T)$ from both sides of the equation of variation: then

$$\delta(E - T\varphi) = -\varphi\delta T - p\delta v + \mu_1\delta m_1 + \dots + \mu_n\delta m_n.$$

It follows that for *isothermal* changes, *i.e.* those for which δT is maintained null by an environment at constant temperature, the condition of stable equilibrium is that the function $E - T\varphi$ shall be a minimum. If the system is subject to an external pressure p, which as well as the temperature is imposed constant from without and thus incapable of variation through internal changes, the condition of stable equilibrium is similarly that $E - T\varphi + pv$ shall be a minimum.

A chemical system maintained at constant temperature by communication of heat from its environment may thus have several states of stable equilibrium corresponding to different minima of the function here considered, just as there may be several minima of elevation on a landscape, one at the bottom of each depression; in fact, this analogy, when extended to space of n dimensions, exactly fits the case. If the system is sufficiently disturbed, for example, by electric shock, it may pass over (explosively) from a higher to a lower minimum, but never (without compensation from outside) in the opposite direction. The former passage, moreover, is often effected by introducing a new substance into the system; sometimes that substance is recovered unaltered at the end of the process, and then its action is said to be purely *catalytic*; its presence modifies the form of the function $E - T\varphi$ so as to obliterate the ridge between the two equilibrium states in the graphical representation.

There are systems in which the equilibrium states are but very slightly dependent on temperature and pressure within wide limits, outside which reaction takes place. Thus while there are cases in which a state of mobile dissociation exists in the system which changes continuously as a function of these variables, there are others in which change does not sensibly occur at all until a certain *temperature of reaction* is attained, after which it proceeds very rapidly owing to the heat developed, and the system soon becomes sensibly permanent in a transformed phase by completion of the reaction. In some cases of this latter type the cause of the delay in starting lies possibly in passive resistance to change, of the nature of viscosity or friction, which is competent to convert an unstable mechanical equilibrium into a moderately stable one; but in most such reactions there seems to be no exact equilibrium at any temperature, short of the ultimate state of dissipated energy in which the reaction is completed, although the velocity of reaction is found to diminish exponentially with change of temperature, and thus becomes insignificant at a small interval from the temperature of pronounced activity.

Free Energy.—The quantity $E - T\varphi$ thus plays the same fundamental part in the thermal statics of general chemical systems at uniform temperature that the potential energy plays in the statics of mechanical systems of unchanging constitution. It is a function of the geometrical co-ordinates, the physical and chemical constitution, and the temperature of the system, which determines the conditions of stable equilibrium *at each temperature*; it is, in fact, the potential energy generalized so as to include temperature, and thus be a single function relating to each temperature but at the same time affording a basis of connexion between the properties of the system at different temperatures. It has been called the *free energy* of the system by Helmholtz, for it is the part of the energy whose variation is connected with changes in the bodily structure of the system represented by the variables $m_1, m_2, \ldots m_n$, and not with the irregular molecular motions represented by heat, so that it can take part freely in physical transformations. Yet this holds good only subject to the condition that the temperature is not varied; it has been seen above that for the more general variation neither δH nor δU is an exact differential, and no line of separation can be drawn between thermal and mechanical energies.

The study of the evolution of ideas in this, the most abstract branch of modern mathematical physics, is rendered difficult in the manner of most purely philosophical subjects by the variety of terminology, much of it only partially appropriate, that has been employed to express the fundamental principles by different investigators and at different stages of the development. Attentive examination will show, what is indeed hardly surprising, that the principles of the theory of free energy of Gibbs and Helmholtz had been already grasped and exemplified by Lord Kelvin in the very early days of the subject (see the paper “On the Thermoelastic and Thermomagnetic Properties of Matter, Part I.” *Quarterly Journal of Mathematics*, No. 1, April 1855; reprinted in Phil. Mag., January 1878, and in *Math. and Phys. Papers*, vol. i. pp. 291, seq.). Thus the striking new advance contained in the more modern work of J. Willard Gibbs (1875-1877) and of Helmholtz (1882) was rather the sustained general application of these ideas to chemical systems, such as the galvanic cell and dissociating gaseous systems, and in general fashion to heterogeneous concomitant phases. The fundamental paper of Kelvin connecting the electromotive force of the cell with the energy of chemical transformation is of date 1851, some years before the distinction between free energy and total energy had definitely crystallized out; and, possibly satisfied with the approximate exactness of his imperfect formula when applied to a Daniell’s cell (*infra*), and deterred by absence of experimental data, he did not return to the subject. In 1852 he briefly announced (*Proc. Roy. Soc. Edin.*) the principle of the dissipation of mechanical (or available) energy, including the necessity of compensation elsewhere when restoration occurs, in the form that “any restoration of mechanical energy, without more than an equivalent of dissipation, is impossible”—probably even in vital activity; but a sufficient specification of available energy (cf. *infra*) was not then developed. In the paper above referred to, where this was done, and illustrated by full application to solid elastic systems, the total energy is represented by c and is named “the intrinsic energy,” the energy taken in during an isothermal transformation is represented by e, of which H is taken in as heat, while the remainder, the change of free (or mechanical or available) energy of the system is the unnamed quantity denoted by the symbol w, which is “the work done by the applied forces” at uniform temperature. It is pointed out that it is w and not e that is the potential energy-function for isothermal change, of which the form can be determined directly by dynamical and physical experiment, and from which alone the criteria of equilibrium and stress are to be derived—simply for the reason that for all *reversible* paths at constant temperature between the same terminal configurations, there must, by Carnot's principle, be the same gain or loss of heat. And a system of formulae are given (5) to (11)—Ex. gr. $e = w - t\, dw/dt + J \int s dt$ for finding the total energy e for any temperature t when w and the thermal capacity s of the system, in a standard state, have thus been ascertained, and another for establishing connexion between the form of w for one temperature and its form for adjacent temperatures—which are identical with those developed by Helmholtz long afterwards, in 1882, except that the entropy appears only as an unnamed integral. The progress of physical science is formally identified with the exploration of this function w for physical systems, with continually increasing exactness and range—except where pure kinetic considerations prevail, in which cases the wider Hamiltonian dynamical formulation is fundamental. Another aspect of the matter will be developed below.

A somewhat different procedure, in terms of entropy as fundamental, has been adopted and developed by Planck. In an isolated system the trend of change must be in the direction which increases the entropy φ, by Clausius' form of the principle. But in experiment it is a system at constant temperature rather than an adiabatic one that usually is involved; this can be attained formally by including in the isolated system (cf. *infra*) a source of heat at that temperature and of unlimited capacity, when the energy of the original system increases by δE this source must give up heat of amount δE, and its entropy therefore diminishes δE/T. Thus for the original system maintained at constant temperature T it is $\delta\varphi - \delta E/T$ that must always be positive in spontaneous change, which is the same criterion as was reached above. Reference may also be made to H.A. Lorentz's *Collected Scientific Papers*, part i.

A striking anticipation, almost contemporaneous, of Gibbs's thermodynamic potential theory (*infra*) was made by Clerk Maxwell in connexion with the discussion of Andrews's experiments on the critical temperature of mixed gases, in a letter published in Sir G.G. Stokes's *Scientific Correspondence* (vol. ii. p. 34).

Available Energy.—The same quantity φ, which Clausius named the entropy, arose in various ways in the early development of the subject, in the train of ideas of Rankine and Kelvin relating to the expression of the *available energy* A of the material system. Suppose there were accessible an auxiliary system containing an *unlimited* quantity of heat at absolute temperature T_0, forming a condenser into which heat can be discharged from the working system, or from which it may be recovered at that temperature: we proceed to find how much of the heat of our system is available for transformation into mechanical work, in a process which reduces the whole system to the temperature of this condenser. Provided the process of reduction is performed reversibly, it is immaterial, by Carnot's principle, in what manner it is effected: thus in following it out in detail we can consider each elementary quantity of heat δH removed from the system as set aside at its actual temperature between T and T + δT for the production of mechanical work δW and the residue of it δH_0 as directly discharged into the condenser at T_0. The principle of Carnot gives $\delta H/T = \delta H_0/T_0$, so that the portion of the heat δH that is not available for work is δH_0, equal to $T_0 \delta H/T$. In the whole process the part not available in connexion with the condenser at T_0 is therefore $T_0 \int \delta H/T$. This quantity must be the same whatever reversible process is employed: thus, for example, we may first transform the system reversibly from the state C to the state D, and then from the state D to the final state of uniform temperature T_0. It follows that the value of $T_0 \int dH/T$, representing the heat degraded, is the same along all reversible paths of transformation from the state C to the state D; so that the function $\int dH/T$ is the excess of a definite quantity φ connected with the system in the former state as compared with the latter.

It is usual to change the law of sign of δH so that gain of heat by the system is reckoned positive; then, relative to a condenser of unlimited capacity at T_0, the state C contains more mechanically *available energy* than the state D by the amount $E_C - E_D + T_0 \int dH/T$, that is, by $E_C - E_D - T_0(\varphi_C - \varphi_D)$. In this way the existence of an entropy function with a definite value for each state of the system is again seen to be the direct analytical equivalent of Carnot's axiom that no process can be more efficient than a reversible process between the same initial and final states. The name *motivity* of a system was proposed by Lord Kelvin in 1879 for this conception of available energy. It is here specified as relative to a condenser of unlimited capacity at an assigned temperature T_0: some such specification is necessary to the definition; in fact, if T_0 were the absolute zero, all the energy would be mechanically available.

But we can obtain an intrinsically different and self-contained comparison of the available energies in a system in two different states at different temperatures, by ascertaining how much energy would be dissipated in each in a reduction to the *same* standard state of the system itself, at a standard temperature T_0. We have only to reverse the operation, and change back this standard state to each of the others in turn. This will involve abstractions of heat δH_0 from the various portions of the system in the standard state, and returns of δH to the state at T_0; if this return were $\delta H_0 T/T_0$ instead of δH, there would be no loss of availability in the direct process; hence there is actual dissipation $\delta H - \delta H_0 T/T_0$, that is $T(\delta\varphi - \delta\varphi_0)$. On passing from state 1 to state 2 through this standard state 0 the difference of these dissipations will represent the energy of the system that has become unavailable. Thus in this sense $E - T\varphi + T\varphi_0 +$ const. represents for each state the amount of energy that is available; but instead of implying an unlimited source of heat at the standard temperature T_0, it implies that there is no extraneous source. The available energy thus defined differs from $E - T\varphi$, the *free energy* of Helmholtz, or the *work function of the applied forces* of Kelvin, which involves no reference to any standard state, by a simple linear function of the temperature alone which is immaterial as regards its applications.

The determination of the available mechanical energy arising from differences of temperature between the parts of the same system is a more complex problem, because it involves a determination of the common temperature to which reversible processes will ultimately reduce them; for the simple case in which no changes of state occur the solution was given by Lord Kelvin in 1853, in connexion with the above train of ideas (cf. Tait’s *Thermodynamics*, §179). In the present exposition the system is sensibly in equilibrium at each stage, so that its temperature T is always uniform throughout; isolated portions at different temperatures would be treated as different systems.

Thermodynamic Potentials.—We have now to develop the relations involved in the general equation (1) of thermodynamics. Suppose the material system includes two coexistent states or phases, with opportunity for free interchange of constituents—for example, a salt solution and the aqueous vapour in equilibrium with it. Then in equilibrium a slight transfer δm of the water-substance of mass m_r constituting the vapour, into the water-substance of mass m_s, existing in the solution, should not produce any alteration of the first order in $\delta E - T\delta\varphi$; therefore μ_r must be equal to μ_s. The quantity μ_r is called by Willard Gibbs the potential of the corresponding substance of mass m_r; it may be defined as its marginal available energy per unit mass at the given temperature. If then a system involves in this way coexistent phases which remain permanently separate, the potentials of any constituent must be the same in all of them in which that constituent exists, for otherwise it would tend to pass from 394
the phases in which its potential is higher to those in which it is lower. If the constituent is non-existent in any phase, its potential when in that phase would have to be higher than in the others in which it is actually present; but as the potential increases logarithmically when the density of the constituent is indefinitely diminished, this condition is automatically satisfied—or, more strictly, the constitutent cannot be entirely absent, but the presence of the merest trace will suffice to satisfy the condition of equality of potential. When the action of the force of gravity is taken into account, the potential of each constituent must include the gravitational potential gh; in the equilibrium state the total potential of each constituent, including this part, must be the same throughout all parts of the system into which it is freely mobile. An example is Dalton’s law of the independent distributions of the gases in the atmosphere, if it were in a state of rest. A similar statement applies to other forms of mechanical potential energy arising from actions at a distance.

When a slight constitutive change occurs in a galvanic element at given temperature, producing available energy of electric current, in a reversible manner and isothermally, at the expense of chemical energy, it is the free energy of the system $E - T\varphi$, not its total intrinsic energy, whose value must be conserved during the process. Thus the electromotive force is equal to the change of this free energy per electrochemical equivalent of reaction in the cell. This proposition, developed by Gibbs and later by Helmholtz, modifies the earlier one of Kelvin—which tacitly assumed all the energy of reaction to be available—except in the cases such as that of a Daniell’s cell, in which the magnitude of the electromotive force does not depend sensibly on the temperature.

The effects produced on electromotive forces by difference of concentrations in dilute solutions can thus be accounted for and traced out, from the knowledge of the form of the free energy for such cases; as also the effects of pressure in the case of gas batteries. The free energy does not sensibly depend on whether the substance is solid or fused—for the two states are in equilibrium at the temperature of fusion—though the total energy differs in these two cases by the heat of fusion; for this reason, as Gibbs pointed out, voltaic potential-differences are the same for the fused as for the solid state of the substances concerned.

Relations involving Constitution only.—The potential of a component in a given solution can depend only on the temperature and pressure of the solution, and the densities of the various components, including itself; as no distance-actions are usually involved in chemical physics, it will not depend on the aggregate masses present. The example above mentioned, of two coexistent phases liquid and vapour, indicates that there may thus be relations between the constitutions of the phases present in a chemical system which do not involve their total masses. These are developed in a very direct manner in Willard Gibbs’s original procedure. In so far as attractions at a distance (a uniform force such as gravity being excepted) and capillary actions at the interfaces between the phases are inoperative, the fundamental equation (1) can be integrated. Increasing the volume k times, and all the masses to the same extent—in fact, placing alongside each other k identical systems at the same temperature and pressure—will increase φ and E in the same ratio k; thus E must be a homogeneous function of the first degree of the independent variables φ, v, m_1, ..., m_n, and therefore by Euler’s theorem relating to such functions

$$E = T\varphi - pv + \mu_1 m_1 + \dots + \mu_n m_n.$$

This integral equation merely expresses the additive character of the energies and entropies of adjacent portions of the system at uniform temperature, and thus depends only on the absence of sensible physical action directly across finite distances. If we form from it the expression for the complete differential δE, and subtract (1), there remains the relation

$$0 = \varphi\delta T - v\delta p + m_1\delta\mu_1 + \dots + m_n\delta\mu_n. \qquad (2)$$

This implies that in each phase the change of pressure depends on and is determined by the changes in T, μ_1, ... μ_n alone; as we know beforehand that a physical property like pressure is an analytical function of the state of the system, it is therefore a function of these n + 1 quantities. When they are all independently variable, the densities of the various constituents and of the entropy in the phase are expressed by the partial fluxions of p with respect to them: thus

$$\frac{\varphi}{v} = \frac{dp}{dT}, \qquad \frac{m_r}{v} = \frac{dp}{d\mu_r}.$$

But when, as in the case above referred to of chloride of ammonium gas existing partially dissociated along with its constituents, the masses are not independent, necessary linear relations, furnished by the laws of definite combining proportions, subsist between the partial fluxions, and the form of the function which expresses p is thus restricted, in a manner which is easily expressible in each special case.

This proposition that the pressure in any phase is a function of the temperature and of the potentials of the independent constituents, thus appears as a consequence of Carnot's axiom combined with the energy principle and the absence of effective actions at a distance. It shows that at a given temperature and pressure the potentials are not all independent, that there is a necessary relation connecting them. This is the *equation of state* or constitution of the phase, whose existence forms one mode of expression of Carnot's principle, and in which all the properties of the phase are involved and can thence be derived by simple differentiation.

The Phase Rule.—When the material system contains only a single phase, the number of independent variations, in addition to change of temperature and pressure, that can spontaneously occur in its constitution is thus one less than the number of its independent constituents. But where several phases coexist in contact in the same system, the number of possible independent variations may be much smaller. The present independent variables $\mu_1, \ldots, \mu_n$ are specially appropriate in this problem, because each of them has the same value in all the phases. Now each phase has its own characteristic equation, giving a relation between δp, δT, and $\delta\mu_1, \ldots \delta\mu_n$, or such of the latter as are independent; if r phases coexist, there are r such relations; hence the number of possible independent variations, including those of v and T, is reduced to $m - r + 2$, where m is the number of independently variable chemical constituents which the system contains. This number of degrees of constitutive freedom cannot be negative; therefore the number of possible phases that can coexist alongside each other cannot exceed $m + 2$. If $m + 2$ phases actually coexist, there is no variable quantity in the system, thus the temperature and pressure and constitutions of the phases are all determined; such is the triple point at which ice, water and vapour exist in presence of each other. If there are $m + 1$ coexistent phases, the system can vary in one respect only; for example, at any temperature of water-substance different from the triple point two phases only, say liquid and vapour, or liquid and solid, coexist, and the pressure is definite, as also are the densities and potentials of the components. Finally, when but one phase, say water, is present, both pressure and temperature can vary independently. The first example illustrates the case of systems, physical or chemical, in which there is only one possible state of equilibrium, forming a point of transition between different constitutions; in the second type each temperature has its own completely determined state of equilibrium; in other cases the constitution in the equilibrium state is indeterminate as regards the corresponding number of degrees of freedom. By aid of this phase rule of Gibbs the number of different chemical substances actually interacting in a given complex system can be determined from observation of the degree of spontaneous variation which it exhibits; the rule thus lies at the foundation of the modern subject of chemical equilibrium and continuous chemical change in mixtures or alloys, and in this connexion it has been widely applied and developed in the experimental investigations of Roozeboom and van 't Hoff and other physical chemists, mainly of the Dutch school.

Extent to which the Theory can be practically developed.—It is only in systems in which the number of independent variables is small that the forms of the various potentials,—or the form of the 395
fundamental characteristic equation expressing the energy of the system in terms of its entropy and constitution, or the pressure in terms of the temperature and the potentials, which includes them all,—can be readily approximated to by experimental determinations. Even in the case of the simple system water-vapour, which is fundamental for the theory of the steam-engine, this has not yet been completely accomplished. The general theory is thus largely confined, as above, to defining the restrictions on the degree of variability of a complex chemical system which the principle of Carnot imposes. The tracing out of these general relations of continuity of state is much facilitated by geometrical diagrams, such as James Thomson first introduced in order to exhibit and explain Andrews' results as to the range of coexistent phases in carbonic acid. Gibbs's earliest thermodynamic surface had for its co-ordinates volume, entropy and energy; it was constructed to scale by Maxwell for water-substance, and is fully explained in later editions of the *Theory of Heat* (1875); it forms a relief map which, by simple inspection, reveals the course of the transformations of water, with the corresponding mechanical and thermal changes, in its three coexistent states of solid, liquid and gas. In the general case, when the substance has more than one independently variable constituent, there are more than three variables to be represented; but Gibbs has shown the utility of surfaces representing, for instance, the entropy in terms of the constitutive variables when temperature and pressure are maintained constant. Such graphical methods are now of fundamental importance in connexion with the phase rule, for the experimental exploration of the trend of the changes of constitution of complex mixtures with interacting components, which arise as the physical conditions are altered, as, for example in modern metallurgy, in the theory of alloys. The study of the phenomena of condensation in a mixture of two gases or vapours, initiated by Andrews and developed in this

manner by van der Waals and his pupils, forms a case in point (see CONDENSATION OF GASES).

Dilute Components: Perfect Gases and Dilute Solutions.—There are, however, two simple limiting cases, in which the theory can be completed by a determination of the functions involved in it, which throw much light on the phenomena of actual systems not far removed from these ideal limits. They are the cases of mixtures of perfect gases, and of very dilute solutions.

If, following Gibbs, we apply his equation (2) expressing the pressure in terms of the temperature and the potentials, to a very dilute solution of substances m_2, m_3, ... m_n in a solvent substance m_1, and vary the co-ordinate m_r alone, p and T remaining unvaried, we have in the equilibrium state

$$m_r \frac{d\mu_r}{dm_r} + m_1 \frac{d\mu_1}{dm_r} + ... + m_n \frac{d\mu_n}{dm_r} = 0,$$

in which every m except m_1 is very small, while $d\mu_1/dm_r$ is presumably finite. As the second term is thus finite, this requires that the total potential of each component m_r, which is $m_r d\mu_r/dm_r$, shall be finite, say k_r, in the limit when m_r is null. Thus for very small concentrations the potential μ_r of a dilute component must be of the form $k_r \log m_r/v$, being proportional to the logarithm of the density of that component; it thus tends logarithmically to an infinite value at evanescent concentrations, showing that removal of the last traces of any impurity would demand infinite proportionate expenditure of available energy, and is therefore practically impossible with finite intensities of force. It should be noted, however, that this argument applies only to fluid phases, for in the case of deposition of a solid m_r is not uniformly distributed throughout the phase; thus it remains possible for the growth of a crystal at its surface in aqueous solution to extrude all the water except such as is in some form of chemical combination.

The precise value of this logarithmic expression for the potential can be readily determined for the case of a perfect gas from its characteristic properties, and can be thence extended to other dilute forms of matter. We have $pv = R/m \cdot T$ for unit mass of the gas, where m is the molecular weight, being 2 for hydrogen, and R is a constant equal to 82×10^6 in C.G.S. dynamical units, or 2 calories approximately in thermal energy units, which is the same for all gases because they have all the same number of molecules per unit volume. The increment of heat received by the unit mass of the gas is $\delta H = p\delta v + \kappa\delta T$, κ being thus the specific heat at constant volume, which can be a function only of the temperature. Thus

$$\varphi = \int dH/T = R/m \cdot \log v + \int \kappa T^{-1} dT;$$

and the available energy A per unit mass is $E - T\varphi + T\varphi_0$ where $E = \varepsilon + \int \kappa dT$, the integral being for a standard state, and ε being intrinsic energy of chemical constitution; so that

$$A = \varepsilon + \varphi_0 T + \int \kappa dT - T \int \kappa T^{-1} dT - R/m \cdot T \log v.$$

If there are ν molecules in the unit mass, and N per unit volume, we have $m\nu = Nmv$, each being 2 ν′, where ν′ is the number of molecules per unit mass in hydrogen; thus the free energy per molecule is $a' + R'T \log bN$, where $b = m/2\nu'$, $R' = R/2\nu'$, and a′ is a function of T alone. It is customary to avoid introducing the unknown molecular constant ν′ by working with the available energy per "gramme-molecule," that is, for a number of grammes expressed by the molecular weight of the substance; this is a constant multiple of the available energy per molecule, and is $a + RT \log\rho$, ρ being the density equal to bN where $b = m/2\nu'$. This formula may now be extended by simple summation to a mixture of gases, on the ground of Dalton's experimental principle that each of the components behaves in presence of the others as it would do in a vacuum. The components are, in fact, actually separable wholly or partially in reversible ways which may be combined into cycles, for example, either (i.) by diffusion through a porous partition, taking account of the work of the pressures, or (ii.) by utilizing the modified constitution towards the top of a long column of the mixture arising from the action of gravity, or (iii.) by reversible absorption of a single component.

If we employ in place of available energy the form of characteristic equation which gives the pressure in terms of the temperature and potentials, the pressure of the mixture is expressed as the sum of those belonging to its components: this equation was made by Gibbs the basis of his analytical theory of gas mixtures, which he tested by its application to the only data then available, those of the equilibrium of dissociation of nitrogen peroxide ($2NO_2 \leftrightarrows N_2O_4$) vapour.

Van 't Hoff's Osmotic Principle: Theoretical Explanation.—We proceed to examine how far the same formulae as hold for gases apply to the available energy of matter in solution which is so dilute that each molecule of the dissolved substance, though possibly the centre of a complex of molecules of the solvent, is for nearly all the time beyond the sphere of direct influence of the other molecules of the dissolved substance. The available energy is a function only of the co-ordinates of the matter in bulk and the temperature; its change on further dilution, with which alone we are concerned in the transformations of dilute solutions, can depend only on the further separation of these molecular complexes in space that is thereby produced, as no one of them is in itself altered. The change is therefore a function only of the number N of the dissolved molecules per unit volume, and of the temperature, and is, per molecule, expressible in a form entirely independent of their constitution and of that of the medium in which they are dissolved. This suggests that the expression for the change on dilution is the same as the known one for a gas, in which the same molecules would exist free and in the main outside each other's spheres of influence; which confirms and is verified by the experimental principle of van 't Hoff, that osmotic pressure obeys the laws of gaseous pressure with identically the same physical constants as those of gases. It can be held, in fact, that this suggestion does not fall short of a demonstration, on the basis of Carnot's principle, and independent of special molecular theory, that in all cases where the molecules of a component, whether it be of a gas or of a solution, are outside each other's spheres of influence, the available energy, so far as regards dilution, must have a common form, and the physical constants must therefore be the known gas-constants. The customary exposition derives this principle, by an argument involving cycles, from Henry's law of solution of gases; it is sensibly restricted to such solutes as appear concomitantly in the free gaseous state, but theoretically it becomes general when it is remembered that no solute can be absolutely non-volatile.

Source of the Idea of Temperature.—The single new element that thermodynamics introduces into the ordinary dynamical specification of a material system is temperature. This conception is akin to that of potential, except that it is given to us directly by our sense of heat. But if that were not so, we could still demonstrate, on the basis of Carnot's principle, that there is a definite function of the state of a body which must be the same for all of a series of connected bodies, when thermal equilibrium has become established so that there is no tendency for heat to flow from one to another. For we can by mere geometrical displacement change the order of the bodies so as to bring different ones into direct contact. If this disturbed the thermal equilibrium, we could construct cyclic processes to take advantage of the resulting flow of heat to do mechanical work, and such processes might be carried on without limit. Thus it is proved that if a body A is in temperature-equilibrium with B, and B with C, 396
then A must be in equilibrium with C directly. This argument can be applied, by aid of adiabatic partitions, even when the bodies are in a field of force so that mechanical work is required to change their geometrical arrangement; it was in fact employed by Maxwell to extend from the case of a gas to that of any other system the proposition that the temperature is the same all along a vertical column in equilibrium under gravity.

It had been shown from the kinetic theory by Maxwell that in a gas-column the mean kinetic energy of the molecules is the same at all heights. If the only test of equality of temperature consisted in bringing the bodies into contact, this would be rather a proof that thermal temperature is of the same physical nature in all parts of the field of force; but temperature can also be equalized across a distance by radiation, so that this law for gases is itself already necessitated by Carnot's general principle, and merely confirmed or verified by the special gas-theory. But without introducing into the argument the existence of radiation, the uniformity of temperature throughout all phases in equilibrium is necessitated by the doctrine of energetics alone, as otherwise, for example, the raising of a quantity of gas to the top of the gravitational column in an adiabatic enclosure together with the lowering of an equal mass to the bottom would be a source of power, capable of unlimited repetition.

Laws of Chemical Equilibrium based on Available Energy.—The complete theory of chemical and physical equilibrium in gaseous mixtures and in very dilute solutions may readily be developed in terms of available energy (cf. *Phil. Trans.*, 1897, A, pp. 266-280), which forms perhaps the most vivid and most direct procedure. The available energy per molecule of any kind, in a mixture of perfect gases in which there are N molecules of that kind per unit volume, has been found to be $a' + R'T \log bN$ where R' is the universal physical constant connected with R above. This expression represents the marginal increase of available energy due to the introduction of one more molecule of that kind into the system as actually constituted. The same formula also applies, by what has already been stated, to substances in dilute solution in any given solvent. In any isolated system in a mobile state of reaction or of internal dissociation, the condition of chemical equilibrium is that the available energy at constant temperature is a minimum, therefore that it is stationary, and slight change arising from fresh reaction would not sensibly alter it. Suppose that this reaction, per molecule affected by it, is equivalent to introducing n_1 molecules of type N_1, n_2 of type N_2, &c., into the system, n_1, n_2, ... being the numbers of molecules of the different types that take part in the reaction, as shown by its chemical equation, reckoned positive when they appear, negative when they disappear. Then in the state of equilibrium

$$n_1 (a'_1 + R'T \log b_1N_1) + n_2 (a'_2 + R'T \log b_2N_2) + \dots$$

must vanish. Therefore $N_1^{n_1} N_2^{n_2} \dots$ must be equal to K, a function of the temperature alone. This law, originally based by Guldberg and Waage on direct statistics of molecular interaction, expresses for each temperature the relation connecting the densities of the interacting substances, in dilution comparable as regards density with the perfect gaseous state, when the reaction has come to the state of mobile equilibrium.

All properties of any system, including the heat of reaction, are expressible in terms of its available energy A, equal to $E - T\varphi + \varphi_0 T$. Thus as the constitution of the system changes with the temperature, we have

$$\frac{dA}{dT} = \frac{dE}{dT} - T\frac{d\varphi}{dT} - (\varphi - \varphi_0)$$

where

$$\delta E = \delta H + \delta W,\ \delta H = T\delta\varphi,$$

δH being heat and δW mechanical and chemical energy imparted to the system at constant temperature; hence

$$\frac{d(A - W)}{dT} = -(\varphi - \varphi_0), \text{ so that } A = E + T\frac{d(A - W)}{dT},$$

which is equivalent to

$$E - W = -T^2 \frac{d}{dT} \left(\frac{A - W}{T} \right).$$

This general formula, applied differentially, expresses the heat $\delta E - \delta W$ absorbed by a reaction in terms of δA, the change produced by it in the available energy of the system, and of δW, the mechanical and electrical work done on the system during its progress.

In the problem of reaction in gaseous systems or in very dilute solution, the change of available energy per molecule of reaction has just been found to be

$$\delta A = \delta A_0 + R'T \log K', \text{ where } K' = b_1^{n1} b_2^{n2} \ldots K;$$

thus, when the reaction is spontaneous without requiring external work, the heat absorbed per molecule of reaction is

$$-T^2 \frac{d}{dT} \frac{\delta A_0}{T}, \text{ or } -R'T^2 \frac{d}{dT} \log K.$$

This formula has been utilized by van ’t Hoff to determine, in terms of the heat of reaction, the displacement of equilibrium in various systems arising from change of temperature; for K, equal to $N_1^{n1} N_2^{n2} \ldots$, is the reaction-parameter through which alone the temperature affects the law of chemical equilibrium in dilute systems.

Interfacial Phenomena: Liquid Films.—The characteristic equation hitherto developed refers to the state of an element of mass in the interior of a homogeneous substance: it does not apply to matter in the neighbourhood of the transition between two adjacent phases. A remarkable analysis has been developed by J.W. Gibbs in which the present methods concerning matter in bulk are extended to the phenomena at such an interface, without the introduction of any molecular theory; it forms the thermodynamic completion of Gauss’s mechanical theory of capillarity, based on the early form of the principle of total energy. The validity of the fundamental doctrine of available energy, so far as regards all mechanical actions in bulk such as surface tensions, is postulated, even when applied to interfacial layers so thin as to be beyond our means of measurement; the argument from perpetual motions being available here also, as soon as we have experimentally ascertained that the said tensions are definite physical properties of the state of the interface and not merely accidental phenomena. The procedure will then consist in assuming a definite excess of energy, of entropy, and of the masses of the various components, each per unit surface, at the interface, the potential of each component being of necessity, in equilibrium, the same as it is in the adjacent masses. The interfacial transition layer thus provides in a sense a new surface-phase coexistent with those on each side of it, and having its own characteristic equation. It is only the extent of the interface and not its curvatures that need enter into this relation, because any slight influence of the latter can be eliminated from the equation by slightly displacing the position of the surface which is taken to represent the interface geometrically. By an argument similar to one given above, it is shown that one of the forms of the characteristic equation is a relation expressing the surface tension as a function of the temperature and the potentials of the various components present on the two sides of the interface; and from the differentiation of this the surface densities of the superficial distributions of these components (as above defined) can be obtained. The conditions that a specified new phase may become developed when two other given ones are brought into contact, *i.e.* that a chemical reaction may start at the interface, are thence formally expressed in terms of the surface tensions of the three transition layers and the pressures in the three phases. In the case of a thin soap-film, sudden extension of any part reduces the interfacial density of each component at each surface of the film, and so alters the surface tension, which requires time to recover by the very slow diffusion of dissolved material from other parts of the thin film; the system being stable, this change must be an increase of tension, and constitutes a species of elasticity in the film. Thus in a vertical film the surface tension must be greater in the higher parts, as they have to sustain the weight of the lower parts; the upper parts, in fact, stretch until the superficial densities of the components there situated are reduced to the amounts that correspond to the tension required for this purpose. Such a film could not therefore 397 consist of pure water. But there is a limit to these processes: if the film becomes so thin that there is no water in bulk between its surfaces, the tensions cannot adjust themselves in this slow way by migration of components from one part of the film to another; if the film can survive at all after it has become of molecular thickness, it must be as a definite molecular structure all across its thickness. Of such type are the black spots that break out in soap-films (suggested by Gibbs and proved by the measures of Reinold and Rücker): the spots increase in size because their tension is less than that of the surrounding film, but their indefinite increase is presumably stopped in practice by some clogging or viscous agency at their boundary.

Transition to Molecular Theory.—The subject of energetics, based on the doctrine of available energy, deals with matter in bulk and is not concerned with its molecular constitution, which it is expressly designed to eliminate from the problem. This analysis of the phenomena of surface tension shows how far the principle of negation of perpetual motions can carry us, into regions which at first sight might be classed as molecular. But, as in other cases, it is limited to pointing out the general scheme of relations within which the phenomena can have their play. There is now a considerable body of knowledge correlating surface tension with chemical constitution, especially to a certain extent with the numerical density of the distribution of molecules; thus R. Eötvös has shown that a law of proportionality exists for wide classes of substances between the temperature-gradient of the surface tension and the density of the molecules over the surface layer, which varies as the two-thirds power of the number per unit volume (see CHEMISTRY: *Physical*). This takes us into the sphere of molecular science, where at present we have only such indications largely derived from experiment, if we except the mere notion of inter-atomic forces of unknown character on which the older theories of capillarity, those of Laplace and Poisson, were constructed.

In other topics the same restrictions on the scope of the simple statical theory of energy appear. From the ascertained behaviour in certain respects of gaseous media we are able to construct their characteristic equation, and correlate their remaining relations by means of its consequences. Part of the experimental knowledge required for this purpose is the values of the gas-constants, which prove to be the same for all nearly perfect gases. The doctrine of energetics by itself can give no clue as to why this should be so; it can only construct a scheme for each simple or complex medium on the basis of its own experimentally determined characteristic equation. The explanation of uniformities in the intrinsic constitutions of various media belongs to molecular theory, which is a distinct and in the main more complex and more speculative department of knowledge. When we proceed further and find, with van 't Hoff, that these same universal gas-constants reappear in the relations of very dilute solutions, our demand for an explanation such as can only be provided by molecular theory (as *supra*) is intensely stimulated. But except in respects such as these the doctrine of energetics gives a complete synthesis of the course and relations of the chemical reactions of matter in bulk, from which we can eliminate atomism altogether by restating the merely numerical atomic theory of Dalton as a principle of equivalent combining proportions. Of recent years there has been a considerable school of chemists who insist on this procedure as a purification of their science from the hypothetical ideas as to atoms and molecules, in terms of which its experimental facts have come to be expressed. A complete system of doctrine can be developed in this manner, but its scope will be limited. It makes use of one principle of correlation, the doctrine of available energy, and discards another such principle, the atomic theory. Nor can it be said that the one principle is really more certain and definite than the other. This may be illustrated by what has sometimes by German writers been called Gibbs's paradox: the energy that is available for mechanical effect in the inter-diffusion of given volumes of two gases depends only on these volumes and their pressures, and is independent of what the gases are; if the gases differed only infinitesimally in constitution it would still be the same, and the question arises where we are to stop, for we cannot suppose the inter-diffusion of two identical gases to be a source of power. This then looks like a real failure, or rather limitation, of the principle; and there are other such, that can only be satisfactorily explained by aid of the complementary doctrine of molecular theory. That theory, in fact, shows that the more nearly identical the gases are, the slower will be the process of inter-diffusion, so that the mechanical energy will indeed be available, but only after a time that becomes indefinitely prolonged. It is a case in which the simple doctrine of energetics becomes inadequate before the limit is reached. The phenomena of highly rarefied gases provide other cases. And in fact the only reason hitherto thought of for the invariable tendency of available energy to diminish, is that it represents the general principle that in the kinetic play of a vast assemblage of independent molecules individually beyond our control, the normal tendency is for the regularities to diminish and the motions to become less correlated: short of some such reason, it is an unexplained empirical principle. In the special departments of dynamical physics on the other hand, the molecular theory, there dynamical and therefore much more difficult and less definite, is an indispensable part of the framework of science; and even experimental chemistry now leans more and more on new physical methods and instruments. Without molecular theory the clue which has developed into spectrum analysis, bringing with it stellar chemistry and a new physical astronomy, would not have been available; nor would the laws of diffusion and conduction in gases have attained more than an empirical form; nor would it have been possible to weave the phenomena of electrodynamics and radiation into an entirely rational theory.

The doctrine of available energy, as the expression of thermodynamic theory, is directly implied in Carnot's Essai of 1824, and constitutes, in fact, its main theme; it took a fresh start, in the light of fuller experimental knowledge regarding the nature of heat, in the early memoirs of Rankine and Lord Kelvin, which may be found in their Collected Scientific Papers; a subsequent exposition occurs in Maxwell's *Theory of Heat*; its most familiar form of statement is Lord Kelvin's principle of the dissipation of available energy. Its principles were very early applied by James Thomson to a physico-chemical problem, that of the influence of stress on the growth of crystals in their mother liquor. The "thermodynamic function" introduced by Rankine into its development is the same as the "entropy" of the material system, independently defined by Clausius about the same time. Clausius's form of the principle, that in an adiabatic system the entropy tends continually to increase, has been placed by Professor Willard Gibbs, of Yale University, at the foundation of his magnificent but complex and difficult development of the theory. His monumental memoir "On the Equilibrium of Heterogeneous Substances," first published in *Trans. Connecticut Academy* (1876-1878), made a clean sweep of the subject; and workers in the modern experimental science of physical chemistry have returned to it again and again to find their empirical principles forecasted in the light of pure theory, and to derive fresh inspiration for new departures. As specially preparatory to Gibbs's general discussion may be mentioned Lord Rayleigh's memoir on the thermodynamics of gaseous diffusion (*Phil. Mag.*, 1876), which was expounded by Maxwell in the 9th edition of the *Ency. Brit.* (art. DIFFUSION). The fundamental importance of the doctrine of dissipation of energy for the theory of chemical reaction had already been insisted on in general terms by Rayleigh; subsequent to, but independently of, Gibbs's work it had been elaborated by von Helmholtz (*Gesamm. Abhandl.* ii. and iii.) in connexion with the thermodynamics of voltaic cells, and more particularly in the calculation of the free or available energy of solutions from data of vapour-pressure, with a view to the application to the theory of concentration cells, therein also coming close to the doctrine of osmotic pressure. This form of the general theory has here been traced back substantially to Lord Kelvin under date 1855. Expositions and developments on various lines will be found in papers by Riecke and by Planck in *Annalen der Physik* between 1890 and 1900, in the course of a memoir by Larmor, Phil. Trans., 1897, A, in Voigt's *Compendium der Physik* and his more recent *Thermodynamik*, in Planck's *Vorlesungen über Thermodynamik*, in Duhem's elaborate *Traité de mécanique chimique* and *Le Potential thermodynamique*, in Whetham's *Theory of Solution* and in Bryan's *Thermodynamics*. Numerous applications to special problems are expounded in van't Hoff's *Lectures on Theoretical and Physical Chemistry*. 398

The theory of energetics, which puts a diminishing limit on the amount of energy available for mechanical purposes, is closely implicated in the discovery of natural radioactive substances by H. Becquerel, and their isolation in the very potent form of radium salts by M. and Mme Curie. The slow degradation of radium has been found by the latter to be concomitant with an evolution of heat, in amount enormous compared with other chemical changes. This heat has been shown by E. Rutherford to be about what must be due to the stoppage of the α and β particles, which are emitted from the substance with velocities almost of the same scale as that of light. If they struck an ideal rigid target, their lost kinetic energy must all be sent away as radiation; but when they become entangled among the molecules of actual matter, it will, to a large extent, be shared among them as heat, with availability reduced accordingly. In any case the particles that escape into the surrounding space are so few and their velocity so uniform that we can, to some extent, treat their energy as directly available mechanically, in contradistinction to the energy of individual molecules of a gas (cf. Maxwell's "demons"), *e.g.* for driving a vane, as in Crookes's experiment with the cathode rays. Indeed, on account of the high velocity of projection of the particles from a radium salt, the actions concerned would find their equilibrium at such enormously high temperatures that any influence of actually available differences of temperature is not sensibly a feature of the phenomena. Such actions, however, like explosive actions in general, are beyond our powers of actual *direct* measurement as regards the degradation of availability of the energy. It has been pointed out by Rutherford, R.J. Strutt and others, that the energy of degradation of even a very minute admixture of active radium would entirely dominate and mask all other cosmical modes of transformation of energy; for example, it far outweighs that arising from the exhaustion of gravitational energy, which has been shown by Helmholtz and Kelvin to be an ample source for all the activities of our cosmical system, and to be itself far greater than the energy of any ordinary chemical rearrangements consequent on a fall of temperature: a circumstance that makes the existence and properties of this substance under settled cosmic conditions still more anomalous (see Radioactivity). Theoretically it is possible to obtain unlimited concentration of availability of energy at the expense of an equivalent amount of degradation spread over a wider field; the potency of electric furnaces, which have recently opened up a new department of chemistry, and are limited only by the refractoriness of the materials of which they are constituted, forms a case in point. In radium we have the very remarkable phenomenon of far higher concentration occurring naturally in very minute permanent amounts, so that merely chemical sifting is needed to produce its aggregation. Even in pitchblende only one molecule in 10^9 seems to be of radium, renewable, however, when lost, by internal transformation.

The energetics of Radiation is treated under that heading. See also Thermodynamics.

(J. L.*)

ENERGICI, or Energumens (Gr. "possessed by a spirit"), the name given in the early Church to those suffering from different forms of insanity, who were popularly supposed to be under the control of some indwelling spirit other than their own. Among primitive races everywhere disease is explained in this way, and its removal supposed to be effected by priestly prayers and incantations. They were sometimes called χειμαζόμενοι, as being "tossed by the waves" of uncontrollable impulse. Persons afflicted in this way were restricted from entering the church, but might share the shelter of the porch with lepers and persons of offensive life (Hefele, *Conciliengeschichte*, vol. i. § 16). After the prayers, if quiet, they might come in to receive the bishop's blessing (*Apost. Const.* viii. 6, 7, 32) and listen to the sermon. They were daily fed and prayed over by the exorcists, and, in case of recovery, after a fast of from 20 to 40 days, were admitted to the eucharist, and their names and cures entered in the church records.

A note on the New Testament use of the word ἐνεργεῖν and its cognates will be found in J.A. Robinson's edition of *The Epistle to the Ephesians*, pp. 241-247; an excursus on "The Conflict with Demons" in A. Harnack, *The Expansion of Christianity*, i. 152-180. Cf. Exorcism.

ENERGY (from the Gr. ἐνέργεια; ἐν, in, ἔργον, work), in physical science, a term which may be defined as accumulated mechanical work, which, however, may be only partially available for use. A bent spring possesses energy, for it is capable of doing work in returning to its natural form; a charge of gunpowder possesses energy, for it is capable of doing work in exploding; a Leyden jar charged with electricity possesses energy, for it is capable of doing work in being discharged. The motions of bodies, or of the ultimate parts of bodies, also involve energy, for stopping them would be a source of work.

All kinds of energy are ultimately measured in terms of work. If we raise 1 ℔ of matter through a foot we do a certain amount of work against the earth’s attraction; if we raise 2 ℔ through the same height we do twice this amount of work, and so on. Also, the work done in raising 1 ℔ through 2 ft. will be double of that done in raising it 1 ft. Thus we recognize that the work done varies as the resistance overcome and the distance through which it is overcome conjointly.

Now, we may select any definite quantity of work we please as our unit, as, for example, the work done in lifting a pound a foot high from the sea-level in the latitude of London, which is the unit of work generally adopted by British engineers, and is called the “foot-pound.” The most appropriate unit for scientific purposes is one which depends only on the fundamental units of length, mass and time, and is hence called an absolute unit. Such a unit is independent of gravity or of any other quantity which varies with the locality. Taking the centimetre, gramme and second as our fundamental units, the most convenient unit of force is that which, acting on a gramme for a second, produces in it a velocity of a centimetre per second; this is called a Dyne. The unit of work is that which is required to overcome a resistance of a dyne over a centimetre, and is called an Erg. In the latitude of Paris the dyne is equal to the weight of about $1/981$ of a gramme, and the erg is the amount of work required to raise $1/981$ of a gramme vertically through one centimetre.

Energy is the capacity for doing work. The unit of energy should therefore be the same as that of work, and the centimetre-gramme-second (C.G.S.) unit of energy is the erg.

The forms of energy which are most readily recognized are of course those in which the energy can be most directly employed in doing mechanical work; and it is manifest that masses of matter which are large enough to be seen and handled are more readily dealt with mechanically than are smaller masses. Hence when useful work can be obtained from a system by simply connecting visible portions of it by a train of mechanism, such energy is more readily recognized than is that which would compel us to control the behaviour of molecules before we could transform it into useful work. This leads up to the fundamental distinction, introduced by Lord Kelvin, between “available energy,” which we can turn to mechanical effect, and “diffuse energy,” which is useless for that purpose.

The conception of work and of energy was originally derived from observation of purely mechanical phenomena, that is to say, phenomena in which the relative positions and motions of visible portions of matter were all that were taken into consideration. Hence it is not surprising that, in those more subtle forms in which energy cannot be readily or completely converted into work, the universality of the principle of energy, its conservation, as regards amount, should for a long while have escaped recognition after it had become familiar in pure dynamics.

If a pound weight be suspended by a string passing over pulley, in descending through 10 ft. it is 399
capable of raising nearly a pound weight attached to the other end of the string, through the same height, and thus can do nearly 10 foot-pounds of work. The smoother we make the pulley the more nearly does the amount of useful work which the weight is capable of doing approach 10 foot-pounds, and if we take into account the work done against the friction of the pulley, we may say that the work done by the descending weight is 10 foot-pounds, and hence when the weight is in its elevated position we have at disposal 10 foot-pounds more energy than when it is in the lower position. It should be noticed, however, that this energy is possessed by the system consisting of the earth and pound together, in virtue of their separation, and that neither could do work without the other to attract it. The system consisting of the earth and the pound therefore possesses an amount of energy which depends on the relative positions of its two parts, on account of the latent physical connexion existing between them. In most mechanical systems the working stresses acting between the parts can be determined when the relative positions of all the parts are known; and the energy which a system possesses in virtue of the relative positions of its parts, or its *configuration*, is classified as “potential energy,” to distinguish it from energy of motion which we shall presently consider. The word potential does not imply that this energy is not real; it exists in potentiality only in the sense that it is stored away in some latent manner; but it can be drawn upon without limit for mechanical work.

It is a fundamental result in dynamics that, if a body be projected vertically upwards *in vacuo*, with a velocity of v centimetres per second, it will rise to a height of $v^2/2g$ centimetres, where g represents the numerical value of the acceleration produced by gravity in centimetre-second units. Now, if m represent the mass of the body in grammes its weight will be mg dynes, for it will require a force of mg dynes to produce in it the acceleration denoted by g. Hence the work done in raising the mass will be represented by $mg \cdot v^2/2g$, that is, $\frac{1}{2}mv^2$ *ergs*. Now, whatever be the direction in which a body is moving, a frictionless constraint, like a string attached to the body, can cause its velocity to be changed into the vertical direction without any change taking place in the magnitude of the velocity. Thus it is merely in virtue of the velocity that the mass is capable of rising against the resistance of gravity, and hence we recognize that on account of its motion the body possessed $\frac{1}{2}mv^2$ units of energy. Energy of motion is usually called “kinetic energy.”

A simple example of the transformation of kinetic energy into potential energy, and vice versa, is afforded by the pendulum. When at the limits of its swing, the pendulum is for an instant at rest, and all the energy of the oscillation is static or potential. When passing through its position of equilibrium, since gravity can do no more work upon it without changing its fixed point of support, all the energy of oscillation is kinetic. At intermediate positions the energy is partly kinetic and partly potential.

Available kinetic energy is possessed by a system of two or more bodies in virtue of the relative motion of its parts. Since our conception of velocity is essentially relative, it is plain that any property possessed by a body in virtue of its motion can be effectively possessed by it only in relation to those bodies with respect to which it is moving. If a body whose mass is m grammes be moving with a velocity of v centimetres per second relative to the earth, the available kinetic energy possessed by the system is $\frac{1}{2}mv^2$ ergs if m be small relative to the earth. But if we consider two bodies each of mass m and one of them moving with velocity v relative to the other, only $\frac{1}{4}mv^2$ units of work is available from this system alone. Thus the estimation of kinetic energy is intimately affected by the choice of our base of measurement.

When the stresses acting between the parts of a system depend *only* on the relative positions of those parts, the sum of the kinetic energy and potential energy of the system is always the same, provided the system be not acted upon by anything outside it. Such a system is called "conservative," and is well illustrated by the swinging pendulum above referred to. But there are stresses which depend on the relative *motion* of the visible bodies between which they appear to act. When work is done against these forces no full equivalent of potential energy may be produced; this applies especially to frictional forces, for if the motion of the system be reversed the forces will be also reversed and will still oppose the motion. It was long believed that work done against such forces was lost, and it was not till the 19th century that the energy thus transformed was traced; the conservation of energy has become the master-key to unlock the connexions in inanimate nature.

It was pointed out by Thomson (Lord Kelvin) and P.G. Tait that Newton had divined the principle of the conservation of energy, so far as it belongs purely to mechanics. But what became of the work done against friction and such non-conservative forces remained obscure, while the chemical doctrine that heat was an indestructible substance afterwards led to the idea that it was lost. There was, however, even before Newton's time, more than a suspicion that heat was a form of energy. Francis Bacon expressed his conviction that heat consists of a kind of motion or "brisk agitation" of the particles of matter. In the *Novum Organum*, after giving a long list of the sources of heat, he says: "From these examples, taken collectively as well as singly, the nature whose limit is heat appears to be motion.... It must not be thought that heat generates motion or motion heat (though in some respects this is true), but the very essence of heat, or the substantial self of heat, is motion and nothing else."

After Newton's time the first vigorous effort to restore the universality of the doctrine of energy was made by Benjamin Thompson, Count Rumford, and was published in the *Phil. Trans*. for 1798. Rumford was engaged in superintending the boring of cannon in the military arsenal at Munich, and was struck by the amount of heat produced by the action of the boring bar upon the brass castings. In order to see whether the heat came out of the chips he compared the capacity for heat of the chips abraded by the boring bar with that of an equal quantity of the metal cut from the block by a fine saw, and obtained the same result in the two cases, from which he concluded that "the heat produced could not possibly have been furnished at the expense of the latent heat of the metallic chips."

Rumford then turned up a hollow cylinder which was cast in one piece with a brass six-pounder, and having reduced the connexion between the cylinder and cannon to a narrow neck of metal, he caused a blunt borer to press against the hollow of the cylinder with a force equal to the weight of about 10,000 ℔, while the casting was made to rotate in a lathe. By this means the mean temperature of the brass was raised through about 70° Fahr., while the amount of metal abraded was only 837 grains.

In order to be sure that the heat was not due to the action of the air upon the newly exposed metallic surface, the cylinder and the end of the boring bar were immersed in 18.77 ℔ of water contained in an oak box. The temperature of the water at the commencement of the experiment was 60° Fahr., and after two horses had turned the lathe for 2½ hours the water boiled. Taking into account the heat absorbed by the box and the metal, Rumford calculated that the heat developed was sufficient to raise 26.58 ℔ of water from the freezing to the boiling point, and in this calculation the heat lost by radiation and conduction was neglected. Since one horse was capable of doing the work required, Rumford remarked that one horse can generate heat as rapidly as nine wax candles burning in the ordinary manner.

Finally, Rumford reviewed all the sources from which the heat might have been supposed to be derived, and concluded that it was simply produced by the friction, and that the supply was inexhaustible. "It is hardly necessary to add," he remarks, "that anything which any insulated body or system of bodies can continue to furnish *without limitation* cannot possibly be a *material substance*; and it appears to me to be extremely difficult, if not quite impossible, to form any distinct idea of anything capable of being excited and communicated in the manner that heat was excited and communicated in these experiments, except it be *motion*."

About the same time Davy showed that two pieces of ice could be melted by rubbing them together in a vacuum, although everything surrounding them was at a temperature below the freezing point.
He did not, however, infer that since the heat could not have been supplied by the ice, for ice absorbs

heat in melting, this experiment afforded conclusive proof against the substantial nature of heat.

Though we may allow that the results obtained by Rumford and Davy demonstrate satisfactorily that heat is in some way due to motion, yet they do not tell us to what particular dynamical quantity heat corresponds. For example, does the heat generated by friction vary as the friction and the time during which it acts, or is it proportional to the friction and the distance through which the rubbing bodies are displaced—that is, to the work done against friction—or does it involve any other conditions? If it can be shown that, however the duration and all other conditions of the experiment may be varied, the same amount of heat can in the end be always produced when the same amount of *energy* is expended, then, and only then, can we infer that heat is a form of energy, and that the energy consumed has been really transformed into heat. This was left for J.P. Joule to achieve; his experiments conclusively prove that heat and energy are of the same nature, and that all other forms of energy can be transformed into an equivalent amount of heat.

The quantity of energy which, if entirely converted into heat, is capable of raising the temperature of the unit mass of water from 0° C. to 1° C. is called the mechanical equivalent of heat. One of the first who took in hand the determination of the mechanical equivalent of heat was Marc. Séguin, a nephew of J.M. Montgolfier. He argued that, if heat be energy, then, when it is employed in doing work, as in a steam-engine, some of the heat must itself be consumed in the operation. Hence he inferred that the amount of heat given up to the condenser of an engine when the engine is doing work must be less than when the same amount of steam is blown through the engine without doing any work. Séguin was unable to verify this experimentally, but in 1857 G.A. Hirn succeeded, not only in showing that such a difference exists, but in measuring it, and hence determining a tolerably approximate value of the mechanical equivalent of heat. In 1839 Séguin endeavoured to determine the mechanical equivalent of heat from the loss of heat suffered by steam in expanding, *assuming* that the whole of the heat so lost was consumed in doing external work against the pressure to which the steam was exposed. This assumption, however, cannot be justified, because it neglected to take account of work which might possibly have to be done *within the steam itself* during the expansion.

In 1842 R. Mayer, a physician at Heilbronn, published an attempt to determine the mechanical equivalent of heat from the heat produced when air is compressed. Mayer made an assumption the converse of that of Séguin, asserting that the whole of the work done in compressing the air was converted into heat, and neglecting the possibility of heat being consumed in doing work within the air itself or being produced by the transformation of internal potential energy. Joule afterwards proved (see below) that Mayer's assumption was in accordance with fact, so that his method was a sound one as far as experiment was concerned; and it was only on account of the values of the specific heats of air at constant pressure and at constant volume employed by him being very inexact that the value of the mechanical equivalent of heat obtained by Mayer was very far from the truth.

Passing over L.A. Colding, who in 1843 presented to the Royal Society of Copenhagen a paper entitled "Theses concerning Force," which clearly stated the "principle of the perpetuity of energy," and who also performed a series of experiments for the purpose of determining the heat developed by the compression of various bodies, which entitle him to be mentioned among the founders of the modern theory of energy, we come to Dr James Prescott Joule of Manchester, to whom we are indebted more than to any other for the establishment of the principle of the conservation of energy on the broad basis on which it has since stood. The best-known of Joule's experiments was that in which a brass paddle consisting of eight arms rotated in a cylindrical vessel of water containing four fixed vanes, which allowed the passage of the arms of the paddle but prevented the water from rotating as a whole. The paddle was driven by weights, and the temperature of the water was observed by thermometers which could indicate $\frac{1}{200}$th of a degree Fahrenheit. Special experiments were made to determine the work done against resistances outside the vessel of water, which amounted to about .006 of the whole, and corrections were made for the loss of heat by radiation, the buoyancy of the air affecting the descending weights, and the energy dissipated when the weights struck the floor with a finite velocity. From these experiments Joule obtained 72.692 foot-pounds in the latitude of Manchester as equivalent to the amount of heat required to raise 1 ℔ of water through 1° Fahr, from the freezing point. Adopting the centigrade scale, this gives 1390.846 foot-pounds.

With an apparatus similar to the above, but smaller, made of iron and filled with mercury, Joule obtained results varying from 772.814 foot-pounds when driving weights of about 58 ℔ were employed to 775.352 foot-pounds when the driving weights were only about 19½ ℔. By causing two conical surfaces of cast-iron immersed in mercury and contained in an iron vessel to rub against one another when pressed together by a lever, Joule obtained 776.045 foot-pounds for the mechanical equivalent of heat when the heavy weights were used, and 774.93 foot-pounds with the small driving weights. In this experiment a great noise was produced, corresponding to a loss of energy, and Joule endeavoured to determine the amount of energy necessary to produce an equal amount of sound from the string of a violoncello and to apply a corresponding correction.

The close agreement between the results at least indicates that "the amount of heat produced by friction is proportional to the work done and independent of the nature of the rubbing surfaces." Joule inferred from them that the mechanical equivalent of heat is probably about 772 foot-pounds, or, employing the centigrade scale, about 1390 foot-pounds.

Previous to determining the mechanical equivalent of heat by the most accurate experimental method at his command, Joule established a series of cases in which the production of one kind of energy was accompanied by a disappearance of some other form. In 1840 he showed that when an electric current was produced by means of a dynamo-magneto-electric machine the heat generated in the conductor, when no external work was done by the current, was the same as if the energy employed in producing the current had been converted into heat by friction, thus showing that electric currents conform to the principle of the conservation of energy, since energy can neither be created nor destroyed by them. He also determined a roughly approximate value for the mechanical equivalent of heat from the results of these experiments. Extending his investigations to the currents produced by batteries, he found that the total voltaic heat generated in any circuit was proportional to the number of electrochemical equivalents electrolysed in each cell multiplied by the electromotive force of the battery. Now, we know that the number of electrochemical equivalents electrolysed is proportional to the whole amount of electricity which passed through the circuit, and the product of this by the electromotive force of the battery is the work done by the latter, so that in this case also Joule showed that the heat generated was proportional to the work done.

In 1844 and 1845 Joule published a series of researches on the compression and expansion of air. A metal vessel was placed in a calorimeter and air forced into it, the amount of energy expended in compressing the air being measured. Assuming that the whole of the energy was converted into heat, when the air was subjected to a pressure of 21.5 atmospheres Joule obtained for the mechanical equivalent of heat about 824.8 foot-pounds, and when a pressure of only 10.5 atmospheres was employed the result was 796.9 foot-pounds.

In the next experiment the air was compressed as before, and then allowed to escape through a long lead tube immersed in the water of a calorimeter, and finally collected in a bell jar. The amount of heat absorbed by the air could thus be measured, while the work done by it in expanding could be readily calculated. In allowing the air to expand from a pressure of 21 atmospheres to that of 1 [401]
atmosphere the value of the mechanical equivalent of heat obtained was 821.89 foot-pounds. Between 10 atmospheres and 1 it was 815.875 foot-pounds, and between 23 and 14 atmospheres 761.74 foot-pounds.

But, unlike Mayer and Séguin, Joule was not content with assuming that when air is compressed or allowed to expand the heat generated or absorbed is the equivalent of the work done and of that only, no change being made in the internal energy of the air itself when the temperature is kept constant. To test this two vessels similar to that used in the last experiment were placed in the same calorimeter and connected by a tube with a stop-cock. One contained air at a pressure of 22 atmospheres, while the other was exhausted. On opening the stop-cock no work was done by the expanding air against external forces, since it expanded into a vacuum, and it was found that no heat was generated or absorbed. This showed that Mayer’s assumption was true. On repeating the experiment when the two vessels were placed in different calorimeters, it was found that heat was absorbed by the vessel containing the compressed air, while an equal quantity of heat was produced in the calorimeter containing the exhausted vessel. The heat absorbed was consumed in giving motion to the issuing stream of air, and was reproduced by the impact of the particles on the sides of the exhausted vessel. The subsequent researches of Dr Joule and Lord Kelvin (*Phil. Trans.*, 1853, p. 357, 1854, p. 321, and 1862, p. 579) showed that the statement that no *internal work* is done when a gas expands or contracts is not quite true, but the amount is very small in the cases of those gases which, like oxygen, hydrogen and nitrogen, can only be liquefied by intense cold and pressure.

For a long time the final result deduced by Joule by these varied and careful investigations was accepted as the standard value of the mechanical equivalent of heat. Recent determinations by H.A. Rowland and others, necessitated by modern requirements, have shown that it is in error, but by less than 1%. The writings of Joule, which thus occupy the place of honour in the practical establishment of the conservation of energy, have been collected into two volumes published by the Physical Society of London. On the theoretical side the greatest stimulus came from the publication in 1847, without knowledge of Mayer or Joule, of Helmholtz’s great memoir, *Über die Erhaltung der Kraft*, followed immediately (1848-1852) by the establishment of the science of thermodynamics (*q.v.*), mainly by R. Clausius and Lord Kelvin on the basis of “Carnot’s principle” (1824), modified in expression so as to be consistent with the conservation of energy (see Energetics).

Though we can convert the whole of the energy possessed by any mechanical system into heat, it is not in our power to perform the inverse operation, and to utilize the whole of the heat in doing mechanical work. Thus we see that different forms of energy are not equally valuable for conversion into work. The ratio of the portion of the energy of a system which can under given conditions be converted into mechanical work to the whole amount of energy operated upon may be called the “availability” of the energy. If a system be removed from all communication with anything outside of itself, the whole amount of energy possessed by it will remain constant, but will of its own accord tend to undergo such transformations as will diminish its availability. This general law, known as the principle of the “dissipation of energy,” was first adequately pointed out by Lord Kelvin in 1852; and was applied by him to some of the principal problems of cosmical physics. Though controlling all phenomena of which we have any experience, the principle of the dissipation of energy rests on a very different foundation from that of the conservation of energy; for while we may conceive of no means of circumventing the latter principle, it seems that the actions of intelligent beings are subject to the former only in consequence of the rudeness of the machinery which they have at their disposal for controlling the behaviour of those ultimate portions of matter, in virtue of the motions or positions of which the energy with which they have to deal exists. If we have a weight capable of falling through a certain distance, we can employ the mutual forces of the system consisting of the earth and weight to do an amount of useful work which is less than the full amount of potential energy possessed by the system only in consequence of the friction of the constraints, so that the limit of availability in this case is determined only by the friction which is unavoidable. Here we have to deal with a transformation with which we can grapple, and which can be controlled for our purposes. If, on the other hand, we have to deal with a system of molecules of whose motions in the aggregate we become conscious only by indirect means, while we know absolutely nothing either of the motions or positions of any individual molecule, it is obvious that we cannot grasp single molecules and control their movements so as to derive the full amount of work from the system. All we can do in such cases is to place the system under certain conditions of transformation, and be content with the amount of work which it is, as it were, willing to render up under those conditions. Thus the principle of Carnot involves the conclusion that a greater proportion of the heat possessed by a body at a high temperature can be converted into work than in the case of an equal quantity of heat possessed by a body at a low temperature, so that the availability of heat increases with the temperature.

Clerk Maxwell supposed two compartments, A and B, to be filled with gas at the same temperature, and to be separated by an ideal, infinitely thin partition containing a number of exceedingly small trap-doors, each of which could be opened or closed without any expenditure of energy. An intelligent creature, or "demon," possessed of unlimited powers of vision, is placed in charge of each door, with instructions to open the door whenever a particle in A comes towards it with more than a certain velocity V, and to keep it closed against all particles in A moving with less than this velocity, but, on the other hand, to open the door whenever a particle in B approaches it with less than a certain velocity v, which is not greater than V, and to keep it closed against all particles in B moving with a greater velocity than this. By continuing this process every unit of mass which enters B will carry with it more energy than each unit which leaves B, and hence the temperature of the gas in B will be raised and that of the gas in A lowered, while no heat is lost and no energy expended; so that by the application of intelligence alone a portion of gas of uniform pressure and temperature may be sifted into two parts, in which both the temperature and the pressure are different, and from which, therefore, work can be obtained at the expense of heat. This shows that the principle of the dissipation of energy has control over the actions of those agents only whose faculties are too gross to enable them to grapple individually with the minute portions of matter which are the seat of energy.

In 1875 Lord Rayleigh published an investigation on "the work which may be gained during the mixing of gases." In the preface he states the position that "whenever, then, two gases are allowed to mix without the performance of work, there is dissipation of energy, and an opportunity of doing work at the expense of low temperature heat has been for ever lost." He shows that the amount of work obtainable is equal to that which can be done by the first gas in expanding into the space occupied by the second (supposed vacuous) together with that done by the second in expanding into the space occupied by the first. In the experiment imagined by Lord Rayleigh a porous diaphragm takes the place of the partition and trap-doors imagined by Clerk Maxwell, and the molecules sort themselves automatically on account of the difference in their average velocities for the two gases. When the pressure on one side of the diaphragm thus becomes greater than that on the other, work may be done at the expense of heat in pushing the diaphragm, and the operation carried on with continual gain of work until the gases are uniformly diffused. There is this difference, however, between this experiment and the operation imagined by Maxwell, that when the gases have diffused the experiment cannot be repeated; and it is no more contrary to the dissipation of energy than is the fact that work may be derived at the expense of heat when a gas expands into a vacuum, for the working substance is not finally restored to its original condition; while Maxwell's "demons" may operate without limit.

In such experiments the molecular energy of a gas is converted into work only in virtue of the molecules being separated into classes in which their velocities are different, and these classes then allowed to act upon one another through the intervention of a suitable heat-engine. This sorting can occur spontaneously to a limited extent; while if we could carry it out as far as we pleased we might transform the whole of the heat of a body into work. The theoretical availability of heat is limited only by our power of bringing those particles whose motions constitute heat in bodies to rest relatively to one another; and we have precisely similar practical limits to the availability of the energy due to the motion of visible and tangible bodies, though theoretically we can then trace all the stages. 402

If a battery of electromotive force E maintain a current C in a conductor, and no other electromotive force exist in the circuit, the whole of the work done will be converted into heat, and the amount of work done per second will be EC. If R denote the resistance of the whole circuit, E = CR, and the heat generated per second is C^2R. If the current drive an electromagnetic engine, the reaction of the engine will produce an electromotive force opposing the current. Suppose the current to be thus reduced to C′. Then the work done by the battery per second will be EC′ or CC′R, while the heat generated per second will be C'^2R, so that we have the difference (C - C′)C′R for the energy consumed in driving the engine. The ratio of this to the whole work done by the battery is (C - C′)/C, so that the efficiency is increased by diminishing C′. If we could drive the engine so fast as to reduce C′ to zero, the whole of the energy of the battery would be available, no heat being produced in the wires, but the horse-power of the engine would be indefinitely small. The reason why the whole of the energy of the current is not available is that heat must always be generated in a wire in which a finite current is flowing, so that, in the case of a battery in which the whole of the energy of chemical affinity is employed in producing a current, the availability of the energy is limited only on account of the resistance of the conductors, and may be increased by diminishing this resistance. The availability of the energy of electrical separation in a charged Leyden jar is also limited only by the resistance of conductors, in virtue of which an amount of heat is necessarily produced, which is greater the less the time occupied in discharging the jar. The availability of the energy of magnetization is limited by the coercive force of the magnetized material, in virtue of which any change in the intensity of magnetization is accompanied by the production of heat.

In all cases there is a general tendency for other forms of energy to be transformed into heat on account of the friction of rough surfaces, the resistance of conductors, or similar causes, and thus to lose availability. In some cases, as when heat is converted into the kinetic energy of moving machinery or the potential energy of raised weights, there is an ascent of energy from the less available form of heat to the more available form of mechanical energy, but in all cases this is accompanied by the transfer of other heat from a body at a high temperature to one at a lower temperature, thus losing availability to an extent that more than compensates for the rise.

It is practically important to consider the rate at which energy may be transformed into useful work, or the horse-power of the agent. It generally happens that to obtain the greatest possible amount of work from a given supply of energy, and to obtain it at the greatest rate, are conflicting interests. We have seen that the *efficiency* of an electromagnetic engine is greatest when the current is indefinitely small, and then the rate at which it works is also indefinitely small. M.H. von Jacobi showed that for a given electromotive force in the battery the horse-power is greatest when the current is reduced to one-half of what it would be if the engine were at rest. A similar condition obtains in the steam-engine, in which a great rate of working necessitates the dissipation of a large amount of energy.

(W. G.; J. L.*)

ENFANTIN, BARTHÉLEMY PROSPER (1796-1864), French social reformer, one of the founders of Saint-Simonism, was born at Paris on the 8th of February 1796. He was the son of a banker of Dauphiny, and after receiving his early education at a lyceum, was sent in 1813 to the École Polytechnique. In March 1814 he was one of the band of students who, on the heights of Montmartre and Saint-Chaumont, attempted resistance to the armies of the allies then engaged in the investment of Paris. In consequence of this outbreak of patriotic enthusiasm, the school was soon after closed by Louis XVIII., and the young student was compelled to seek some other career instead of that of the soldier. He first engaged himself to a country wine merchant, for whom he travelled in Germany, Russia and the Netherlands. In 1821 he entered a banking-house newly established at St Petersburg, but returned two years later to Paris, where he was appointed cashier to the Caisse Hypothécaire. At the same time he became a member of the secret society of the Carbonari. In 1825 a new turn was given to his thoughts and his life by the friendship which he formed with Olinde Rodriguez, who introduced him to Saint-Simon. He embraced the new doctrines with ardour, and by 1829 had become one of the acknowledged heads of the sect (see Saint-Simon).

After the Revolution of 1830 Enfantin resigned his office of cashier, and devoted himself wholly to his cause. Besides contributing to the *Globe* newspaper, he made appeals to the people by systematic preaching, and organized centres of action in some of the principal cities of France. The headquarters in Paris were removed from the modest rooms in the Rue Taranne, and established in large halls near the Boulevard Italien. Enfantin and Bazard (*q.v.*) were proclaimed “Pères Suprêmes.” This union of the supreme fathers, however, was only nominal. A divergence was already manifest, which rapidly increased to serious difference and dissension. Bazard had devoted himself to political reform, Enfantin to social and moral change; Bazard was organizer and governor, Enfantin was teacher and consoler; the former attracted reverence, the latter love. A hopeless antagonism arose between them, which was widened by Enfantin’s announcement of his theory of the relation of man and woman, which would substitute for the “tyranny of marriage” a system of “free love.” Bazard now separated from his colleague, and in his withdrawal was followed by all those whose chief aim was philosophical and political. Enfantin thus became sole “father,” and the few who were chiefly attracted by his religious pretensions and aims still adhered to him. New converts joined them, and Enfantin assumed that his followers in France numbered 40,000. He wore on his breast a badge with his title of “Père,” was spoken of by his preachers as “the living law,” declared, and probably believed, himself to be the chosen of God, and sent out emissaries in a quest of a woman predestined to be the “female Messiah,” and the mother of a new Saviour. The quest was very costly and altogether fruitless. No such woman was discoverable. Meanwhile believers in Enfantin and his new religion were multiplying in all parts of Europe. His extravagances and success at length brought down upon him the hand of the law. Public morality was in peril, and in May 1832 the halls of the new sect were closed by the government, and the father, with some of his followers, appeared before the tribunals. He now retired to his estate at Menilmontant, near Paris, where with forty disciples, all of them men, he continued to carry out his socialistic views. In August of the same year he was again arrested, and on his appearance in court he desired his defence to be undertaken by two women who were with him, alleging that the matter was of special concern to women. This was of course refused. The trial occupied two days and resulted in a verdict of guilty, and a sentence of imprisonment for a year with a small fine.

This prosecution finally discredited the new society. Enfantin was released in a few months, and then, accompanied by some of his followers, he went to Egypt. He stayed there two years, and might have entered the service of the viceroy if he would have professed himself, as a few of his friends did, a Mahommedan. On his return to France, a sadder and practically a wiser man, he settled down to very prosaic work. He became first a postmaster near Lyons, and in 1841 was appointed, through the influence of some of his friends who had risen to posts of power, member of a scientific commission on Algeria, which led him to engage in researches concerning North Africa and colonization in general. in 1845 he was appointed a director of the Paris & Lyons railway. Three years later he established, in conjunction with Duveyrier, a daily journal, entitled *Le Crédit*, which was discontinued in 1850. He was afterwards attached to the administration of the railway from Lyons to the Mediterranean. Father Enfantin held fast by his ideal to the end, but he had renounced the hope of giving it a local habitation and a name in the degenerate obstinate world. His personal influence over those who associated with him was immense. “He was a man of a noble presence, with finely formed and expressive features. He was gentle and insinuating in manner, and possessed a calm, graceful and winning delivery” (*Gent. Mag.*, Jan. 1865). His evident sincerity, his genuine enthusiasm, gave him his marvellous ascendancy. Not a few of his disciples ranked afterwards amongst the most distinguished men of France. He died suddenly at Paris on the 1st of September 1864. 403

Amongst his works are—Doctrine de Saint-Simon (written in conjunction with several of his followers), published in 1830, and several times republished; *Économie politique et politique Saint-Simonienne* (1831); *Correspondance politique* (1835-1840); *Corresp. philos. et religieuse* (1843-1845); and *La Vie éternelle passée, présente, future* (1861). A large number of articles by his hand appeared in *Le Producteur, L’Organisateur, Le Globe,* and other periodicals. He also wrote in 1832 *Le Livre nouveau*, intended as a substitute for the Christian Scriptures, but it was not published.

See G. Weill, *L’École Saint-Simonienne, son histoire, son influence, jusqu’ à nos jours* (Paris, 1896).

ENFIDAVILLE [*Dar-el-Bey*], a town of Tunisia, on the railway between Tunis and Susa, 30 m. N.E. of the last-named place and 5 m. inland from the Gulf of Hammamet. Enfidaville is the chief settlement on the Enfida estate, a property of over 300,000 acres in the Sahel district of Tunisia, forming a rectangle between the towns of Hammamet, Susa, Kairawan and Zaghwan. On this estate, devoted to the cultivation of cereals, olives, vines and to pasturage, are colonies of Europeans and natives. At Enfidaville, where was, as its native name indicates, a palace of the beys of Tunis, there is a large horse-breeding establishment and a much-frequented weekly market. About 5 m. N. of Enfidaville is Henshir Fraga (anc. *Uppenna*), where are ruins of a large fortress and of a church in which were found mosaics with epitaphs of various bishops and martyrs.

The Enfida estate was granted by the bey Mahommed-es-Sadok to his chief minister Khaireddin Pasha (*q.v.*) in return for the confirmation by the sultan of Turkey in 1871, through the instrumentality of the pasha, of the right of succession to the beylik of members of Es-Sadok’s family. When, some years later, Khaireddin left Tunisia for Constantinople he sold the estate to a Marseilles company, which resold it to the Société Franco-africaine.

ENFIELD, a township of Hartford county, Connecticut, U.S.A., in the N. part of the state, on the E. bank of the Connecticut river, 20 m. N. of Hartford. It has an area of 35 sq. m., with three villages—Thompsonville, Hazardville and Enfield. Pop. (1890) 7199; (1900) 6699 (1812 foreign-born); (1910) 9719. Its principal manufactures are gunpowder, carpets, brick, cotton press machinery, and coffin hardware. In Enfield and its vicinity much tobacco is grown. First settled in 1679, Enfield was a part of the township of Springfield, Massachusetts, until 1683, when it was made a separate township; in 1749 it became a part of Connecticut. At a town meeting on the 11th of July 1774 it was resolved that “a firm and inviolable union of our colonies is absolutely necessary for the defence of our civil rights,” and that “the most effectual measures to defeat the machinations of the enemies of His Majesty’s government and the liberties of America is to break off all commercial intercourse with Great Britain and the West Indies until these oppressive acts for raising a revenue in America are repealed.” A Shaker community was established in the township in 1781, at what is now called Shaker Station.

See Francis Olcutt Allen, *History of Enfield* (Lancaster, Pa., 1900).

ENFIELD, a market town in the Enfield parliamentary division of Middlesex, England, 11 m. N. of London Bridge, on the Great Northern and Great Eastern railways. Pop. of urban district, (1891) 31,536, (1901) 42,738. It is picturesquely situated on the western slope of the Lea valley, with a considerable extension towards the river, mainly consisting of artisans’ dwellings (Churchbury, Ponder’s End, and Enfield Highway on the Old North Road). Great numbers of villas occupied by those whose work lies in London have grown up; and many of the inhabitants are employed in the Royal Small Arms factory at Enfield Lock. The church of St Andrew is mainly Perpendicular, but has Early English portions; it contains several ancient monuments and brasses, and flanks the market-place, with its modern cross. Enfield Palace fronts the High Street; it retains portions of the building of Edward VI., but has been greatly altered. The grammer school, near the church, was founded in 1557. The New River flows through the parish, and Sir Hugh Myddleton, its projector, was for some time resident here. Middleton House, named after him, is one of several fine mansions in the vicinity. Of these, Forty Hall, in splendidly timbered grounds, is from the designs of Inigo Jones; and a former mansion occupying the site of White Webbs House was suspected as the scene of the hatching of Gunpowder Plot. The parish is of great extent (12,653 acres).

An Anglo-Saxon derivation, signifying “forest clearing,” is indicated for the name. Enfield Chase was a royal preserve, disafforested in 1777. The principal manor of Enfield, which was held by Asgar, Edward the Confessor’s master of horse, was in the hands of the Norman baron Geoffrey de Mandeville at the time of Domesday, and belonged to the Bohun family in the 12th and 13th centuries. It came, by succession and marriage, into the possession of the crown under Henry IV., and was included in the duchy of Lancaster. There were, however, seven other manors, and of these one, Worcesters, came to the crown in the time of Henry VIII., whose children resided at the manor-house, Elsynge Hall. Edward VI., settling both manors upon the princess Elizabeth, rebuilt Enfield Palace for her. She was a frequent resident here not only before but after her accession to the throne. About 1664 the palace was occupied as a school by Robert Uvedale (1642-1722), who was also an eminent horticulturist, planted the magnificent cedar still standing in the palace grounds, and formed a herbarium now in the Sloane collection at the British Museum. The town received grants of markets from Edward I. and James I.

ENFILADE (a French word, from *enfiler*, to thread, and so to pass through from end to end), a military term used to express the direction of fire along an enemy’s line, or parapet. This species of fire is most demoralizing and destructive, since, from its direction, very few guns or rifles can be brought to bear to meet it. If any considerable body of men changes front, it immediately lays itself open to enfilade from the enemy whom it originally faced. Against entrenchments, or the parapets of fortifications, enfilade is still more effective, as the enemy is deprived of the protection given by his works and is no better covered than if he were in the open. Banks of earth, built perpendicular to the line of defence (called *traverses*), are usually employed to protect parapets or trenches against enfilade.

ENGADINE (Ger. *Engadin*; Ital. *Engadina*; Ladin, *Engiadina*), the name of the upper or Swiss portion of the valley of the Inn, which forms part of the Swiss canton of the Grisons. Its length by carriage road from the Maloja plateau (5935 ft.) at its south-western end to Martinsbruck (3406 ft.) at its north-eastern extremity is about 59 m. It is to be noted that up to and including St Moritz (6037 ft., the highest) all the villages (save Sils-Baseglia) at its south-western end are higher than the Maloja plateau itself. The uppermost portion of the valley contains several lakes, which, as one descends, gradually diminish in size, those of Sils, Silvaplana and St Moritz. But both the Maloja plateau and the south-western half of the lake of Sils belong to the commune of Stampa in the Val Bregaglia, and are included in the Bregaglia administrative district, so that, from a political point of view, Sils is the first village that is included in the Engadine. The rest of the Engadine forms the districts of the Upper Engadine with eleven communes, and of the Inn (*i.e.* the Lower Engadine), subdivided into the Ob Tasna, Remüs, and Unter Tasna circles, and containing twelve communes.

In 1900 the total population of the Engadine was 11,712, of whom 5429 were in the Upper Engadine and 6283 in the Lower Engadine. In point of religion 8594 were Protestants (4923 in the Lower Engadine and 3671 in the Upper Engadine), and 3086 Romanists (1728 in the Upper Engadine and 1358 in the Lower Engadine), while there were 12 Jews in the Upper Engadine and 2 in the Lower Engadine: in the Upper Engadine the majority in each commune was Protestant (the Romanists strongest in St Moritz), as also in the case of the Lower Engadine, save Tarasp and Samnaun, where the Romanists prevail. In point of language 7609 inhabitants (5010 in the Lower Engadine and 2599 in the Upper Engadine) spoke the curious Ladin dialect (a survival of a primitive Romance tongue), and 2221 German (1265 in the Upper Engadine and 956 in the Lower Engadine). The capital of the Upper 404

Engadine is Samaden (967 inhabitants), and that of the Lower Engadine, Schuls (1117 inhabitants). In 1908 there were no railways in the Engadine, save about 8 m. (from the mouth of the tunnel past Bevers and Samaden to St Moritz village) of the railway pierced (1898-1902) beneath (5987 ft.) the Albula Pass (7595 ft.), which now affords the easiest means of access from Coire to St Moritz (56 m.); but many railways in and to the Engadine have been planned. The valley is reached by many passes (over which excellent carriage roads were constructed 1820-1872). The Maloja (5935 ft.) is the route from Chiavenna and the Lake of Como to the Upper Engadine, which is also reached from Coire by the Julier (7504 ft.) and the Albula Passes (7595 ft.) as well as from Tirano in the Valtellina by the Bernina Pass (7645 ft.). On the other hand, the Lower Engadine is accessible from Davos over the Flüela Pass (7838 ft.) and from Mals at the head of the Adige valley (or the Vintschgau) by the Ofen Pass (7071 ft.), while from Martinsbruck, the last Swiss village, a carriage road leads up to Nauders (5 m.), whence it is 27 m. by road down the Inn valley to Landeck on the Arlberg railway, or 17½ m. over the Reschen Scheideck Pass (4902 ft.) to Mals in the Vintschgau.

The Upper Engadine consists of a long, straight, nearly level trough of 26 m., varying from a mile to half a mile in breadth, through which flows the Inn. On the south-east this trough is limited by the lofty glacier-clad Bernina group (culminating in the Piz Bernina, 13,304 ft.) and the range rising between the Inn valley and that of Livigno to the south-east, while on the north-west the boundary is the extensive Albula group (culminating in Piz Kesch, 11,228 ft.). The Lower Engadine is far more picturesque and romantic than the Upper Engadine, the Inn valley being here much narrower and the fall greater. On its north-west rises the last bit of the Albula group (culminating in Piz Vadret, 10,584 ft.), and on the north the Silvretta group (culminating in Piz Linard, 11,201 ft.), while to the east and south are the ranges on either side of the Ofen Pass (culminating in Piz Sesvenna, 10,568 ft.). In the Upper Engadine the villages are on the floor of the valley, but in the Lower Engadine many are perched high above the bed of the river on terraces, and are cut off from each other by deep ravines.

The Upper Engadine is far better known to foreign visitors than the Lower Engadine, and is consequently much richer and more prosperous. The mineral waters of St Moritz (*q.v.*) were known and employed in the 16th century, and long formed the great attraction of the region. But about the middle of the 19th century the Upper Engadine came into fashion as a great “air-cure,” and now Maloja, Sils, Silvaplana, Campfer and St Moritz are all well known; those who desire to explore the glaciers of the Bernina group mostly resort to Pontresina, on the Flatzbach, the stream descending from the Bernina Pass. Yet, owing to its great elevation, the scenery of the Upper Engadine has a bleak, northern aspect. Pines and larches alone flourish, garden vegetables are grown only in sunny spots, and there is no tillage. The Alpine flora is very rich and varied. But snow falls even in August, and the climate is well described in the proverb, “nine months winter, and three months cold weather.” The villages are built entirely of stone (as also in the Lower Engadine), chiefly to guard against destructive fires that were formerly frequent in this narrow, wind-swept valley. The wealth of the inhabitants consists in their hay meadows and pastures. The lower pastures support large herds of cows, while the higher are let out (in both parts of the valley) to Bergamasque shepherds, who come thither every summer with their flocks. In the Lower Engadine the chief attraction is formed by the mineral springs at Schuls below Tarasp, which are much frequented during the summer. The wild gorge of Finstermünz separates the last Swiss village, Martinsbruck, from the first Tirolese village, Pfunds, the gorge being passable only on foot, while the carriage road makes a great detour by way of Nauders, so that the two villages named are 13 m. by road from each other. The earliest full description of the country by an English traveller is that by Archdeacon W. Coxe, in *Travels in Switzerland* (London, 1789).

The Upper Engadine is not mentioned in authentic documents till 1139, the bishop of Coire being then the great lord, and, from the 13th century, having as his bailiffs the family of Planta, the original seat of which was at Zuz. The valley obtained its freedom from both in 1486 (Planta) and in 1526, when the temporal powers of the bishop were abolished. In 1367 it (as well as the bishop’s vassals in the Lower Engadine) joined the newly founded League of God’s House or *Gotteshausbund* (see Grisons), one of the 3 Raetian Leagues, which lasted till 1799-1801, when the whole Engadine became part of Canton Raetia of the Helvetic Republic, which, in 1803, altered its name to that of Grisons or Graubünden, and then first entered the Swiss Confederation. In the Upper Engadine the “Referendum” existed as between the different villages composing a bailiwick (*Hochgericht*). The history of the Lower Engadine is for long quite different. Though always comprised in the diocese of Coire, it formed from the early 9th century onwards (with the Vintschgau) a separate county, which was gradually absorbed in that which, later, took the name of the county of Tirol. The limit between the Upper Engadine and the Tirolese Lower Engadine was definitively fixed in 1282 at the Punt’ Ota (the high bridge) just above Brail, and mentioned in 1139 already. In 1363 Tirol came into the possession of the Habsburgers, who were troublesome neighbours both to the Upper Engadine and to the League of God’s House. Their power was stemmed in 1499 at the battle of the Calven gorge (above Mals), though it was only in 1652 that the Lower Engadine bought up the remaining rights of the Habsburgers. But the castle of Tarasp (acquired by them in 1464) was excepted: the lordship was given by them in 1687 to the Dietrichstein family, and held by it till 1801, when Austria ceded it to France, which, in 1803, handed it over to the Swiss Confederation, by which it was incorporated in 1809 with the Canton of the Grisons. This long connexion with Tirol accounts for the fact that Tarasp is still mainly Romanist, while the lonely Swiss valley of Samnaun (above Martinsbruck) has given up its Protestantism and its Ladin speech owing to communications with Tirol being easier than with Switzerland. The bears in the bear pit at Bern come from the forests in the lower Spöl valley, above

Zernez, in the Lower Engadine, on the way to the Ofen Pass. The upper Spöl valley (Livigno) is Italian (see VALTELLINA).

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(W. A. B. C.)

ENGAGED COLUMN, in architecture, a form of column, sometimes defined as semi or three-quarter detached according to its projection; the term implies that the column is partly attached to a pier or wall. It is rarely found in Greek work, and then only in exceptional cases, but it exists in profusion in Roman architecture. In the temples it is attached to the cella walls. repeating the 405
columns of the peristyle, and in the theatres and amphitheatres, where they subdivided the arched openings: in all these cases engaged columns are utilized as a decorative feature, and as a rule the same proportions are maintained as if they had been isolated columns. In Romanesque work the classic proportions are no longer adhered to; the engaged column, attached to the piers, has always a special function to perform, either to support subsidiary arches, or, raised to the vault, to carry its transverse or diagonal ribs. The same constructional object is followed in the earlier Gothic styles, in which they become merged into the mouldings. Being virtually always ready made, so far as their design is concerned, they were much affected by the Italian revivalists.

ENGEL, ERNST (1821-1896), German political economist and statistician, was born in Dresden on the 21st of March 1821. He studied at the famous mining academy of Freiberg, in Saxony, and on completing his curriculum travelled in Germany and France. Immediately after the revolution of 1848 he was attached to the royal commission in Saxony appointed to determine the relations between trade and labour. In 1850 he was directed by the government to assist in the organization of the German Industrial Exhibition of Leipzig (the first of its kind). The success which crowned his efforts was so great that in 1854 he was induced to enter the government service, as chief of the newly instituted statistical department. He retired, however, from the office in 1858. He founded at Dresden the first Mortgage Insurance Society (Hypotheken-Versicherungsgesellschaft), and as a result of the success of his work was summoned in 1860 to Berlin as director of the statistical department, in succession to Karl Friedrich Wilhelm Dieterici (1790-1859). In his new office he made himself a name of world-wide reputation. Raised to the rank of *Geheimer Regierungsrat*, he retired in 1882 and lived henceforward in Radebeul near Dresden, where he died on the 8th of December 1896. Engel was a voluminous writer on the subjects with which his name is connected, but his statistical papers are mostly published in the periodicals which he himself established, viz. *Preuss. Statistik* (in 1861); *Zeitschrift des Statistischen Bureaus*, and *Zeitschrift des Statistischen Bureaus des Königreichs Sachsen*.

ENGEL, JOHANN JAKOB (1741-1802), German author, was born at Parchim, in Mecklenburg, on the 11th of September 1741. He studied theology at Rostock and Bützow, and philosophy at Leipzig, where he took his doctor's degree. In 1776 he was appointed professor of moral philosophy and belles-lettres in the Joachimstal gymnasium at Berlin, and a few years later he became tutor to the crown prince of Prussia, afterwards Frederick William III. The lessons which he gave his royal pupil in ethics and politics were published in 1798 under the title *Fürstenspiegel*, and are a favourable specimen of his powers as a popular philosophical writer. In 1787 he was admitted a member of the Academy of Sciences of Berlin, and in the same year he became director of the royal theatre, an office he resigned in 1794. He died on the 28th of June 1802.

Besides numerous dramas, some of which had a considerable success, Engel wrote several valuable books on aesthetic subjects. His *Anfangsgründe einer Theorie der Dichtungsarten* (1783) showed fine taste and acute critical faculty if it lacked imagination and poetic insight. The same excellences and the same defects were apparent in his *Ideen zu einer Mimik* (1785), written in the form of letters. His most popular work was *Der Philosoph für die Welt* (1775), which consists chiefly of dialogues on men and morals, written from the utilitarian standpoint of the philosophy of the day. His last work, a romance entitled *Herr Lorenz Stark* (1795), achieved a great success, by virtue of the marked individuality of its characters and its appeal to middle-class sentiment.

Engel's *Sämtliche Schriften* were published in 12 volumes at Berlin in 1801-1806; a new edition appeared at Frankfort in 1851. See K. Schröder, *Johann Jakob Engel* (Vortrag) (1897).

ENGELBERG, an Alpine village and valley in central Switzerland, much frequented by visitors in summer and to some extent in winter. It is 14 m. by electric railway from Stansstad, on the Lake of Lucerne, past Stans. The village (3343 ft.) is in a mountain basin, shut in on all sides by lofty mountains (the highest is the Titlis, 10,627 ft. in the south-east), so that it is often hot in summer. It communicates by the Surenen Pass (7563 ft.) with Wassen, on the St Gotthard railway, and by the Joch Pass (7267 ft.) past the favourite summer resort of the Engstlen Alp (6034 ft.), with Meiringen in the Bernese Oberland. The village has clustered round the great Benedictine monastery which gives its name to the valley, from the legend that its site was fixed by angels, so that the spot was named “Mons Angelorum.” The monastery was founded about 1120 and still survives, though the buildings date only from the early 18th century. Its library suffered much at the hands of the French in 1798. From 1462 onwards it was under the protectorate of Lucerne, Schwyz, Unterwalden and Uri. In 1798 the abbot lost all his temporal powers, and his domains were annexed to the Obwalden division of Unterwalden, but in 1803 were transferred to the Nidwalden division. However, in 1816, in consequence of the desperate resistance made by the Nidwalden men to the new Federal Pact of 1815, they were punished by the fresh transfer of the valley to Obwalden, part of which it still forms. As the pastures forming the upper portion of the Engelberg valley have for ages belonged to Uri, the actual valley itself is politically isolated between Uri and Nidwalden. The monastery is still directly dependent on the pope. In 1900 the valley had 1973 inhabitants, practically all German-speaking and Romanists.

(W. A. B. C.)

ENGELBRECHTSDATTER, DORTHE (1634-1716), Norwegian poet, was born at Bergen on the 16th of January 1634; her father, Engelbrecht Jörgensen, was originally rector of the high school in that city, and afterwards dean of the cathedral. In 1652 she married Ambrosius Hardenbech, a theological writer famous for his flowery funeral sermons, who succeeded her father at the cathedral in 1659. They had five sons and four daughters. In 1678 her first volume appeared, *Sjaelens aandelige Sangoffer* (“The Soul's Spiritual Offering of Song”) published at Copenhagen. This volume of hymns and devotional pieces, very modestly brought out, had an unparalleled success. The fortunate poetess was invited to Denmark, and on her arrival at Copenhagen was presented at Court. She was also introduced to Thomas Kingo, the father of Danish poetry, and the two greeted one another with improvised couplets, which have been preserved, and of which the poetess's reply is incomparably the neater. In 1683 her husband died, and before 1698 she had buried all her nine children. In the midst of her troubles appeared her second work, the *Taareoffer* (“Sacrifice of Tears”), which is a continuous religious poem in four books. This was combined with the Sangoffer, and no fewer than three editions of the united works were published before her death, and many after it. In 1698 she brought out a third volume of sacred verse, *Et kristeligt Valet fra Verden* (“A Christian Farewell to the World”), a very tame production. She died on the 19th of February 1716. The first verses of Dorthe Engelbrechtsdatter are the best; her *Sangoffer* was dedicated to Jesus, the Taareoffer to Queen Charlotte Amalia; this is significant of her changed position in the eyes of the world.

ENGELHARDT, JOHANN GEORG VEIT (1791-1855), German theologian, was born at Neustadt-on-the-Aisch on the 12th of November 1791, and was educated at Erlangen, where he afterwards taught in the gymnasium (1817), and became professor of theology in the university (1821). His two great works were a *Handbuch der Kirchengeschichte* in 4 vols. (1833-1834), and a *Dogmengeschichte* in 2 vols. (1839). He died at Erlangen on the 13th of September 1855.

ENGHIEN, LOUIS ANTOINE HENRI DE BOURBON CONDÉ, Duc d’ (1772-1804), was the only son of Henri Louis Joseph, prince of Condé, and of Louise Marie Thérèse Mathilde, sister of the duke of Orleans (Philippe Égalité), and was born at Chantilly on the 2nd of August 1772. He was educated privately by the abbé Millot, and received a military training from the commodore de Virieux. He early showed the warlike spirit of the house of Condé, and began his military career in 1788. On the outbreak of the French Revolution he “emigrated” with very many of the nobles a few days after the fall of the Bastille, and remained in exile, seeking to raise forces for the invasion of France and the restoration of the old monarchy. In 1792, on the outbreak of war, he held a command in the force of *émigrés* (styled the “French royal army”) which shared in the duke of Brunswick’s unsuccessful invasion of France. He continued to serve under his father and grandfather in what was known as the Condé army, and on several occasions distinguished himself by his bravery and ardour in the vanguard. On the dissolution of that force after the peace of Lunéville (February 1801) he married privately the princess Charlotte, niece of Cardinal de Rohan, and took up his residence at Ettenheim in Baden, near the Rhine. Early in the year 1804 Napoleon, then First Consul of France, heard news which seemed to connect the young duke with the Cadoudal-Pichegru conspiracy then being tracked by the French police. The news ran that the duke was in company with Dumouriez and made secret journeys into France. This was false; the acquaintance was Thuméry, a harmless old man, and the duke had no dealings with Cadoudal or Pichegru. Napoleon gave orders for the seizure of the duke. French mounted gendarmes crossed the Rhine secretly, surrounded his house and brought him to Strassburg (15th of March 1804), and thence to the castle of Vincennes, near Paris. There a commission of French colonels was hastily gathered to try him. Meanwhile Napoleon had found out the true facts of the case, and the ground of the accusation was hastily changed. The duke was now charged chiefly with bearing arms against France in the late war, and with intending to take part in the new coalition then proposed against France. The colonels hastily and most informally drew up the act of condemnation, being incited thereto by orders from Savary (*q.v.*), who had come charged with instructions. Savary intervened to prevent all chance of an interview between the condemned and the First Consul; and the duke was shot in the moat of the castle, near a grave which had already been prepared. With him ended the house of Condé. In 1816 the bones were exhumed and placed in the chapel of the castle. It is now known that Josephine and Mme de Rémusat had begged Napoleon for mercy towards the duke; but nothing would bend his will. The blame which the apologists of the emperor have thrown on Talleyrand or Savary is undeserved. On his way to St Helena and at Longwood he asserted that, in the same circumstances, he would do the same again; he inserted a similar declaration in his will. 406

See H. Welschinger, *Le Due d’Enghien 1772-1804* (Paris, 1888); A. Nougaret de Fayet, *Recherches historiques sur le procès et la condamnation du duc d’Enghien*, 2 vols. (Paris, 1844); Comte A. Boulay de la Meurthe, *Les Dernières Années du due d’Enghien 1801-1804* (Paris, 1886). For documents see *La Catastrophe du duc d’Enghien* in the edition of *Mémoires* edited by M.F. Barrière, also the edition of the duke’s letters, &c., by Count Boulay de la Meurthe (tome i., Paris, 1904; tome ii., 1908).

(J. Hl. R.)

ENGHIEN, a town in the province of Hainaut, Belgium, lying south of Grammont. Pop. (1904) 4541. It is the centre of considerable lace, linen and cotton industries. There is a fine park outside the town belonging to the duke of Arenberg, whose ancestor, Charles de Ligne, bought it from Henry IV. in 1607, but the château in which the duke of Arenberg of the 18th century entertained Voltaire no longer exists. Curiously enough the cottage, a stone building, built by the same duke for Jean Jacques Rousseau, still stands in the park, while the ducal residence was burnt down by the *sans-culottes*. A fine pavilion or kiosk, named de l’Étoile, has also survived. The great Condé was given, for a victory gained near this place, the right to use the style of Enghien among his subsidiary titles.

ENGINE (Lat. *ingenium*), a term which in the time of Chaucer had the meaning of “natural talent” or “ability,” corresponding to the Latin from which it is derived (cf. “A man hath sapiences thre, Memorie, engin, and intellect also,” *Second Nun’s Tale*, 339); in this sense it is now obsolete. It also denoted a mechanical tool or contrivance, and especially a weapon of war; this use may be compared with that of *ingenium* in classical Latin to mean a clever idea or device, and in later Latin, as in Tertullian, for a warlike instrument or machine. In the 19th century it came to have, when employed alone, a specific reference to the steam-engine (*q.v.*), but it is also used of other prime movers such as the air-engine, gas-engine and oil-engine (*qq.v.*).

ENGINEERING, a term for the action of the verb "to engineer," which in its early uses referred specially to the operations of those who constructed engines of war and executed works intended to serve military purposes. Such military engineers were long the only ones to whom the title was applied. But about the middle of the 18th century there began to arise a new class of engineers who concerned themselves with works which, though they might be in some cases, as in the making of roads, of the same character as those undertaken by military engineers, were neither exclusively military in purpose nor executed by soldiers, and those men by way of distinction came to be known as civil engineers. No better definition of their aims and functions can be given than that which is contained in the charter (dated 1828) of the Institution of Civil Engineers (London), where civil engineering is described as the "art of directing the great sources of power in nature for the use and convenience of man, as the means of production and of traffic in states, both for external and internal trade, as applied in the construction of roads, bridges, aqueducts, canals, river navigation and docks for internal intercourse and exchange, and in the construction of ports, harbours, moles, breakwaters and lighthouses, and in the art of navigation by artificial power for the purposes of commerce, and in the construction and adaptation of machinery, and in the drainage of cities and towns." Wide as is this enumeration, the practice of a civil engineer in the earlier part of the 19th century might cover many or even most of the subjects it contains. But gradually specialization set in. Perhaps the first branch to be recognized as separate was *mechanical* engineering, which is concerned with steam-engines, machine tools, mill-work and moving machinery in general, and it was soon followed by *mining* engineering, which deals with the location and working of coal, ore and other minerals. Subsequently numerous other more or less strictly defined groups and subdivisions came into existence, such as *naval architecture* dealing with the design of ships, *marine* engineering with the engines for propelling steamers, *sanitary* engineering with water-supply and disposal of sewage and other refuse, *gas* engineering with the manufacture and distribution of illuminating gas, and chemical engineering with the design and erection of the plant required for the manufacture of such chemical products as alkali, acids and dyes, and for the working of a wide range of industrial processes. The last great new branch is *electrical* engineering, which touches on the older branches at so many points that it has been said that all engineers must be electricians.

ENGINEERS, MILITARY. From the earliest times engineers have been employed both in the field of war and on field defences. In modern times, however, the application of numerous scientific and engineering devices to warfare has resulted in the creation of many minor branches of military engineering, some of them almost rivalling in importance their primary duty of fortification and siegecraft, such as the field telegraph, the balloon service, nearly all demolitions, the building of pontoon and other bridges, and the construction and working of military roads, railways, piers, &c. All these branches requiring special knowledge, the modern tendency is to divide a corps of engineers in accordance with such requirements. The "field companies" and "fortress companies" of the R.E. represent the traditional tactical application of their arm to works of offence and defence in field and siege warfare. The balloon, telegraph, and other branches, also organized on a permanent footing, represent the modern application of scientific aids in warfare. (See Fortification and Siegecraft; Tactics; Infantry, &c.)

History.—It is difficult to distinguish between military and civil engineers in the earlier ages of modern history, for all engineers acted as builders of castles and defensible strongholds, as well as manufacturers and directors of engines of war with which to attack or defend them. The annals of fortification show professors, artists, &c., as well as soldiers and architects, as designers and builders of innumerable systems of fortification. By the middle of the 13th century there was in England an organized body of skilled workmen employed under a "chief engineer." At the siege of Calais in 1347 this corps consisted of masons, carpenters, smiths, tentmakers, miners, armourers, gunners and artillerymen. At the siege of Harfleur in 1415 the chief engineer was designated Master of the King's Works, Guns and Ordnance, and the corps under him numbered 500 men, including 21 foot-archers. Headquarters of engineers existed at the Tower of London before 1350, and a century later developed into the Office of Ordnance (afterwards the Board of Ordnance), whose duty was to administer all matters connected with fortifications, artillery and ordnance stores. 407

Henry VIII. employed many engineers (of whom Sir Richard Lee is the best known) in constructing coast defences from Penzance to the Thames and thence to Berwick-on-Tweed, and in strengthening the fortresses of Calais and Guînes in France. He also added to the organization a body of pioneers under trench-masters and a master trenchmaster. Charles II. increased the peace establishment of engineers and formed a separate one for Ireland, with a chief engineer who was also surveyor-general of the King’s Works. In both countries only a small permanent establishment was maintained, a special ordnance train being enrolled in war-time for each expedition and disbanded on its termination. The commander of an ordnance train was frequently, but not necessarily, an engineer, but there was always a chief engineer of each train. At Blenheim (1704) Marlborough’s ordnance train was commanded by Holcroft Blood, a distinguished engineer. But after the rebellion of 1715 it was decided to separate the artillery from the engineers, and the royal warrant of 26th May 1716 established two companies of artillery as a separate regiment, and an engineer corps composed of 1 chief engineer, 3 directors, 6 engineers-in-ordinary, 6 engineers extraordinary, 6 sub-engineers and 6 practitioner engineers.

Until the 14th of May 1757 officers of engineers frequently held, in addition to their military rank in the corps of engineers, commissions in foot regiments; but on and after that date all engineer officers were gazetted to army as well as engineer rank—the chief engineer as colonel of foot, directors as lieutenant-colonel, and so forth down to practitioners as ensigns. On the 18th of November 1782 engineer grades, except that of chief engineer, were abolished, and the establishment was fixed at 1 chief engineer and colonel, 6 colonels commandant, 6 lieutenant-colonels, 9 captains, 9 captain lieutenants (afterwards second captains), 22 first lieutenants, and 22 second lieutenants. Ten years later a small invalid corps was formed. In 1787 the designation “Royal” was conferred upon the engineers, and its precedence settled to be on the right of the army, with the royal artillery.

In 1802 the title of chief engineer was changed to inspector-general of fortifications. From this time to the conclusion of the Crimean War various augmentations took place, consequent on the increasing and widely extending duties thrown upon the officers. These, in addition to ordinary military duties, comprised the construction and maintenance of fortifications, barrack and ordnance store buildings, and all engineering services connected with them. The cadastral survey of the United Kingdom (called the “Ordnance Survey”) had been entrusted to the engineers as far back as 1784, and absorbed many officers in its execution.

In 1772 the formation at Gibraltar of “The Company of Soldier Artificers,” officered by Royal Engineers, was authorized, and a second company was added soon afterwards. In 1787 by royal warrant “The Corps of Royal Military Artificers” was established at home, consisting of six companies, with which the Gibraltar companies were amalgamated. In 1806 this corps was doubled, and in 1811 increased to 32 companies. In 1813 its title was changed to “The Royal Sappers and Miners.” In 1856, at the close of the Crimean War, it was incorporated with “The Corps of Royal Engineers,” by whom it had always been officered. At that date the corps numbered about 340 officers and 4000 non-commissioned officers and men, in 1 troop and 32 companies.

In 1770 the East India Company reorganized the engineer corps of the three presidencies, composed of officers only. Native corps of sappers or pioneers were formed later, and officered principally by engineers. The officers of engineers were employed in peacetime on the public works of the country, their services when required being placed at the disposal of the military authorities. The Indian Engineers have not only distinguished themselves in the operations of war, but have left monuments of engineering skill in the irrigation works, railways, surveys, roads, bridges, public buildings and defences of the country. When Indian administration was transferred to the crown (1862) the Indian Engineers became “Royal,” so that there now exists but one corps, the Royal Engineers. This is composed of about 1000 officers and 7700 warrant and non-commissioned officers and men. Of the officers some 220 are attached to units, about 400 employed either at home or in the colonies on engineering duties in military commands, on the staff, or on special duty, and about 370 on the Indian establishment. The supreme technical control of the Royal Engineers is exercised from the War Office. See also United Kingdom; Army.

The history of the French engineers shows a somewhat similar line of development. Originally selected officers of infantry were given brevets as engineers, and these men performed military and also civil duties for the king’s service by the aid of companies of workmen enlisted and discharged from time to time. Vauban (*q.v.*) was the founder of the famous *corps de Génie* (1690). Its members were selected officers and civilians, employed in all branches of military and naval services, and it soon achieved its European reputation as the first school of fortification and siegecraft. It received a special uniform in 1732. About 1755 it was for a time merged in the artillery. In 1766 the title of *Génie* was conferred upon the officers, and the same name (*troupes de Génie*) was given to the previously existing companies of sappers and miners in 1801.

In the United States the separate Corps of Engineers (since 1794 there had been a Corps of Artillerists and Engineers) was organized in 1802, starting with a small body stationed at West Point, which in 1838 and 1846 was gradually increased, and in 1861 given three additional companies. In 1866 they were formed into a battalion and stationed at Willets Point, N.Y. In 1901 they were reorganized in three battalions, with a total strength of 1282. The U.S. Engineer School, formerly at Willets Point, was transferred in 1901 to Washington. Until 1866 the military academy at West Point was under the supervision of the Corps of Engineers, but from that time its direction was thrown open; but the highest branch at West Point is still regarded as that of the engineers. The Corps of Engineers has done a great deal of highly important work in the United States, notably in building forts, and improving rivers and harbours for navigation.

See Maj.-Gen. R.W. Porter, *Hist, of the Corps of Royal Engineers* (Chatham, 1889); C. Lecomte, *Les Ingénieurs militaires de la France* (Paris, 1903); H. Frobenius, *Geschichte der K. preuss. Ingenieur-*

und Pioneer-Korps (Berlin, 1906).

ENGIS, a cave on the banks of the Meuse near Liége, Belgium, where in 1832 Dr P.C. Schmerling found human remains in deposits belonging to the Quaternary period. Bones of the cave-bear, mammoth, rhinoceros and hyena were discovered in association with parts of a man's skeleton and a human skull. This, known as "the Engis Skull," gave rise to much discussion among anthropologists, since it has characteristics of both high and low development, the forehead, low and narrow, indicating slight intelligence, while the abnormally large brain cavity contradicts this conclusion. Of it Huxley wrote: "There is no mark of degradation about any part of its structure. It is a fair average human skull, which might have belonged to a philosopher, or might have contained the thoughtless brains of a savage." Dr Schmerling concluded that the human remains were those of man who had been contemporary with the extinct mammals. As, however, fragments of coarse pottery were found in the cave which bore other evidence of having been used by neolithic man, by whom the cave-floor and its contents might have been disturbed and mixed, his arguments have not been regarded as conclusive. There is, however, no doubt as to the great age of the Engis Skull. Discoveries of a like nature were made by Dr Schmerling in the neighbourhood in the caves of Engihoul, Chokier and others.

See P.C. Schmerling, *Recherches sur les ossements découverts dans les cavernes de la province Liège* (1833); Huxley, *Man's Place in Nature*, p. 156; Lord Avebury, *Prehistoric Times*, p. 317 (1900).