ally rose to special authority, and the rest disappeared. Seven readers are generally reckoned chief authorities, but for practical purposes this number was continually reduced in process of time; so that at present only two "reading-styles" are in actual use,—the common style of Ḥafṣ, and that of Náfi', which prevails in Africa to the west of Egypt. There is, however, a very comprehensive massoretic literature in which a number of other styles are indicated. The invention of vowel-signs, of diacritic points to distinguish similarly formed consonants, and of other orthographic signs, soon put a stop to arbitrary conjectures on the part of the readers. Many zealots objected to the introduction of these innovations in the sacred text, but theological consistency had to yield to practical necessity. In accurate codices, indeed, all such additions, as well as the titles of the súra, etc., are written in coloured ink, while the black characters profess to represent exactly the original of 'Othmán. But there is probably no copy quite faithful in this respect.

In European libraries, besides innumerable modern manuscripts of the Koran, there are also codices, or fragments, of high antiquity, some of them probably dating from the 1st century of the Flight. For the restoration of the text, however, the works of ancient scholars on its readings and modes of writing are more important than the manuscripts; which, however elegantly they may be written and ornamented, proceed from irresponsible copyists. The original, written by 'Othmán himself, has indeed been exhibited in various parts of the Mohammedan world. The library of the India Office contains one such manuscript, bearing the subscription: "Written by 'Othmán the son of 'Affán." These, of course, are barefaced forgeries, although of very ancient date; so are those which profess to be from the hand of 'Alí, one of which is preserved in the same library. In recent times the Koran has been often printed and lithographed, both in the East and the West.

Shortly after Mohammed's death certain individuals applied themselves to the exposition of the Koran. Much of it was obscure from the beginning, other sections were unintelligible apart from a knowledge of the circumstances of their origin. Unfortunately, those who took possession of this field were not very honourable. Ibn 'Abbás, a cousin of Mohammed's, and the chief source of the traditional exegesis of the Koran, has, on theological and other grounds, given currency to a number of falsehoods; and at least some of his pupils have emulated his example. These earliest expositions dealt more with the sense and connexion of whole verses than with the separate words. Afterwards, as the knowledge of the old language declined, and the study of philology arose, more attention began to be paid to the explanation of vocables. A good many fragments of this older theological and philological exegesis have survived from the first two centuries of the Flight, although we have no complete commentary of this period. Most of the expository material will perhaps be found in the very large commentary of the celebrated Ṭabarí (A.D. 839-923), of which an almost complete copy is in the Viceregal library at Cairo. Another very famous commentary is that of Zamakhsharí (A.D. 1075-1144), edited by Nassau-Lees, Calcutta, 1859; but this scholar, with his great insight and still greater subtlety, is too apt to read his own scholastic ideas into the Koran. The favourite commentary of Baiḍáwí (*ob.* A.D. 1286), edited by Fleischer, Leipsic, 1846-1848, is little more than an abridgment of Zamakhsharí's. Thousands of commentaries on the Koran, some of them of prodigious size, have been written by Moslems; and even the number of those still extant in manuscript is by no means small. Although these works all contain much that is useless or false, yet they are invaluable aids to our understanding of the sacred book. An unbiassed European can, no doubt, see many things at a glance more clearly than a good Moslem who is under the influence of religious prejudice; but we should still be helpless without the exegetical literature of the Mohammedans. Nevertheless, a great deal remains to be accomplished by European scholarship for the correct interpretation of the Koran. We want, for example, an exhaustive classification and discussion of all the Jewish elements in the Koran; a praiseworthy beginning has already been made in Geiger's youthful essay: *Was hat Mahomet aus dem Judenthum aufgenommen?* (Bonn, 1833). We want especially a thorough commentary, executed with the methods and resources of modern science. No European language, it would seem, can even boast of a translation which completely satisfies modern requirements. The best are in English; where we have the extremely paraphrastic, but for its time admirable translation of Sale (repeatedly printed), that of Rodwell (1861), which seeks to give the pieces in chronological order, and that of Palmer (1880), who wisely follows the traditional arrangements. The introduction which accompanies Palmer's translation is not in all respects abreast of the most recent scholarship. Considerable extracts from the Koran are well translated in E. W. Lane's *Selections from the Kur-án.*

Besides commentaries on the whole Koran, or on special parts and topics, the Moslems possess a whole literature bearing on their sacred book. There are works on the spelling and right pronunciation of the Koran, works on the beauty of its language, on the number of its verses, words and letters, etc.; nay, there are even works which would nowadays be called "historical and critical introductions." Moreover, the origin of Arabic philology is intimately connected with the recitation and exegesis of the Koran. To exhibit the importance of the sacred book for the whole mental life of the Moslems would be simply to write the history of that life itself; for there is no department in which its all-pervading, but unfortunately not always salutary influence has not been felt.

Eternity of the Koran.

The unbounded reverence of the Moslems for the Koran reaches its climax in the dogma that this book, as the divine word, *i.e.* thought, is immanent in God, and consequently *eternal* and *uncreated*. That dogma has been accepted by almost all Mohammedans since the beginning of the 3d century. Some theologians did indeed protest against it with great energy; it was in fact too preposterous to declare that a book composed of unstable words and letters, and full of variants, was absolutely divine. But what were the distinctions and sophisms of the theologians for, if they could not remove such contradictions, and convict their opponents of heresy?

The following works may be specially consulted: Weil, *Einleitung in den Korán*, 2d ed., 1878; Th. Nöldeke, *Geschichte des Qorân's* (Göttingen, 1860); and the Lives of Mohammed by Muir and Sprenger. (TH. N.)

INDEX.

Note.—Arabic has only three short vowels, ranging between the short sounds of *a* and *e*, *e* and *i*, *o* and *u* respectively. In the transcription adopted these are given by *a* or *e*, *i* and *o* respectively. The corresponding long vowels are *á*, *í*, *ú*. The latter two have the sound of English *ee* and *oo*, and are so written by some English scholars. In the transcription of consonants *th* is as the *th* in *thin*, *dh* the *th* in *the*; dots are put under hard letters which have no exact English equivalent; *kh* (often written *ch*) is nearly the Scottish or German *ch*; ' is a deep breathing, seldom pronounced by Europeans; *gh* a guttural something like modern Greek γ or the Northumberland burr. In a few names the conventional spelling is used. In proper names *b.* stands for *ibn*, "son of."

MOHL, JULES (1800-1876), Orientalist, was born at Stuttgart 25th October 1800, and educated for the Lutheran Church at Tübingen; but his inclinations carried him from theology through Hebrew to Oriental studies, and in 1823 he betook himself to Paris, at that time under De Sacy the great European school of Eastern letters He soon acquired reputation, and from 1826 to 1833 was nominally professor at Tübingen, with permission to continue his studies in France, but he never entered on the duties of this office, Paris having become his second home. In 1826 he was charged by the French Government with the preparation of an edition of the *Sháh Námeh*, the first volume of which appeared in 1838, while the seventh and last was left unfinished at his death; in 1844 he was nominated to the Institut, and in 1847 he became professor of Persian at the Collége de France. But his knowledge and interest extended to all departments of Oriental learning, and this catholicity of taste, united to a singular impartiality of judgment and breadth of view, gave him a quite remarkable personal influence on the course of Eastern learning in France. The chief sphere of this influence was the Société Asiatique, which he served for many years as secretary-adjunct, as secretary, and finally as president. His annual reports on Oriental science, presented to the society from 1840 to 1867, and collected after his death (4th January 1876, at Paris) under the title *Vingt-sept Ans des Études Orientales* (Paris, 1879), are an admirable history of the progress of Eastern learning during these years, and justify the high esteem in which he was held by scholars.

MÖHLER, JOHANN ADAM (1796-1838), Roman Catholic theologian, was born at the village of Igersheim in Würtemberg on 6th May 1796, and, after studying philosophy and theology in the Lyceum at Ellwangen, entered the Wilhelmstift in the university of Tübingen in 1817. Ordained to the priesthood in 1819, he was appointed to a curacy at Riedlingen, but speedily returned as "repetent" to Tübingen, where he became privat-docent in 1822, extraordinary professor of theology in 1826, and ordinary in 1828. The controversies excited by his *Symbolik* (1832) proved so unpleasant that in 1835 he accepted a call to the university of Munich. In 1838 he was appointed to the deanery of Würzburg, but died shortly afterwards (12th April 1838).

Möhler wrote *Die Einheit in der Kirche* (Tübingen, 1825); *Athanasius der Grosse u. d. Kirche seiner Zeit im Kampfe m. d. Arianismus* (2 vols., Mainz, 1827); *Symbolik, oder Darstellung der dogmatischen Gegensätze der Katholiken u. Protestanten nach ihren öffentlichen Bekenntnissschriften* (Mainz, 1832; 8th ed., 1871-72; Eng. transl. by J. B. Robertson, 1843); and *Neue Untersuchungen der Lehrgegensätze zwischen den Katholiken u. Protestanten* (1834). His *Gesammelte Schriften u. Aufsätze* were edited by Döllinger in 1839; his *Patrologie* by Reithmayr, also in 1839; and a *Biographie* by Wörner was published at Ratisbon in 1866. It is with the *Symbolik* that his name is chiefly associated; the interest excited by it in Protestant circles is shown by the fact that within two years of its appearance it had elicited three replies of considerable importance, those namely of Baur, Marheineke, and Nitzsch. But, although characterized by abundant learning and acuteness, as well as by considerable breadth of spiritual sympathy, and thus a stimulative and suggestive work, it cannot be said to have been accepted by Catholics themselves as embodying an accurate objective view of the actual doctrine of their church. The liberal school of thought of which Möhler was a prominent exponent was discouraged in official circles, while Protestants, on the other hand, complain that the author has failed to grasp the vast significance of the Reformation as a great movement in the spiritual history of mankind, while expending needless pains on an exposition of the doctrinal shortcomings, inconsistencies, and contradictions of the individuals who were its leaders.

MOHR, KARL FRIEDRICH (1806-1879), a philosopher whose greatest claims to scientific distinction are as yet, though indubitable, only partially admitted, was the son of a well-to-do druggist in Coblentz, and was born 4th November 1806. Being a delicate child, he received much of his early education at home, in great part in his father's laboratory. To this may be traced much of the skill he showed in devising instruments and methods of analysis which are still in common use in chemical and pharmaceutical laboratories. At the age of 21 he studied chemistry under Gmelin, and, after five years spent in Heidelberg, Berlin, and Bonn, returned with the degree of Ph.D. to join his father's establishment. On the death of his father in 1840 he succeeded to the business, retiring from it for scientific leisure in 1857. Serious pecuniary losses led him at the age of 57 to become a privat-docent in Bonn, where he was soon after appointed, by the direct influence of the emperor, extraordinary professor of pharmacy. In private and domestic life he was a man of singularly winning manners, intensely fond of music and poetry, for the latter of which he showed wonderful memory. But his uncompromising spirit—perhaps we might even in some cases say his wrongheadedness—in matters of scientific and theological authority had raised such a host of enemies that even royal influence could not secure his further advancement. Although he stood at the very head of the scientific pharmacists of Germany, his name was deliberately omitted from the list of the commission entrusted with the preparation of the *Pharmacopœia Germanica.* Yet in that work many of his ideas and processes were incorporated by the very men who had previously denounced them. He died in October 1879.

Mohr's best-known work is his *Lehrbuch der chemisch-analytischen Titrirmethode* (1855), which has already run through many editions, and which was specially commended by Liebig. His improvements in methods of chemical analysis occupy a long series of papers extending over some fifty years. He also published a number of physical papers on subjects such as Hail, St. Elmo's Fire, Ground-ice, &c., and a curious notice of the earliest mention of Ozone. He shows that Homer, on four different occasions, mentions the sulphurous smell produced by lightning, and employs the very word from which the name of Ozone was long afterwards coined. In 1866 appeared his *Geschichte der Erde, eine Geologie auf neuer Grundlage*, which has obtained a wide circulation.

But he will be remembered in future times mainly on account of a paper, *Ueber die Natur der Wärme*, published in 1837, which unfortunately has not yet appeared in full in an English translation. The history of this paper is remarkable. It was refused admission into *Poggendorff's Annalen*, and was then sent to Baumgartner of Vienna, in whose *Zeitschrift für Physik*, &c., it was at once published. As no proof-sheets reached Mohr, he concluded that his paper had been lost or rejected, and contented himself with publishing a short analysis in the *Annalen der Pharmacie*, of which he was an editor. This analysis, it is only fair to say, though probably prepared by the author himself, gives a very inadequate idea of the scope and merit of the paper. In 1864 Dr. Akin unearthed the paper from the forgotten pages of the *Zeitschrift*, and the author was enabled to reprint it, with notes, while the recent discussions as to the history of Conservation of Energy were still being carried on. Along with it he issued a number of other papers of greatly inferior merit.

Unless some still earlier author should be discovered, there can be no doubt that Mohr is to be recognized as the first to enunciate in its generality what we now call "conservation of energy." The thesis of his paper must be stated in his own words,—"Besides the 54 known chemical elements, there is in the physical world one agent only, and this is called Kraft (energy).[1] It may appear, according to circumstances, as motion, chemical affinity, cohesion, electricity, light, and magnetism; and from any one of these forms it can be transformed into any of the others." Even now, after nearly half a century of rapid advance in science, it would be difficult to improve this statement except by inserting, as regards transformation of energy, some such guarding expression as "in whole or in part." But if Mohr had inserted this, he might have had claims to the "dissipation of energy" also. Mohr's starting-point appears to have been the discovery (by Forbes) of the polarization of radiant heat. He goes through the whole of the then range of physics, pointing out the explanation of each experimental result as a transformation of energy, mentioning even the electric currents produced by electro-magnetic induction as a transformation of the energy required to draw the coil from the magnet—one of the earlier methods used by Joule for quantitative determinations. His numerical results, based on data quoted from various books, are, it is

[1] It is to be remembered that even the most accurate authorities in Germany—as, for instance, Von Helmholtz in his *Essay* of 1847—used till quite recently the word Kraft in the sense of Energy.

true, very inaccurate; the correct experimental determinations we owe to Joule. But it must be remembered that these speculations, daring as they were and accurate (on the whole) as they have been found to be, required the confirmation which they received from the experimental work of Colding and Joule, or from the *Essay* of Von Helmholtz, whose basis also is wholly experimental, being the fact that "perpetual motion" is recognized as unattainable.

MOIR, DAVID MACBETH (1798-1851), the "Delta" of *Blackwood's Magazine*, one of its most popular contributors in its early days, was born at Musselburgh 5th January 1798, and was a physician in active practice there from his manhood to his death (6th July 1851). He seems to have been a man of winning manners and noble integrity of character, and the intrinsic value of his poetry has been in consequence somewhat over-estimated by critics of repute who enjoyed his personal acquaintance. He had no independent vein as a writer of serious verse, and his technical qualities as a poet do not bear examination. But his verses were undoubtedly popular with the readers of the magazine at the time. A collection of them was edited by Thomas Aird in 1852. As a kindly humourist "Delta" had a more original turn. His *Autobiography of Mansie Wauch*, published separately in 1828, is a Scotch classic. And some of his satirical squibs on passing events were written with great freshness and spirit. His *Outlines of the Ancient History of Medicine* (1831) evidence his industry and versatility of talent. His *Sketch of the poetical literature of the past Half Century* (1851) is more remarkable for the grace of its rhetorical ornaments than for depth or freshness of insight.

MOIR, GEORGE (1800-1870), author of the treatises on "Poetry" and "Romance" in the seventh edition of the *Encyclopædia Britannica*, and born at Aberdeen in 1800, was an Edinburgh lawyer of very varied accomplishments. He was appointed professor of rhetoric in 1835, professor of Scots law in 1864; he had a considerable success at the Scottish Bar, was successively sheriff of Ross and sheriff of Stirling, and was a frequent contributor to *Blackwood's Magazine*. Moir honourably maintained the literary traditions of Edinburgh law. He was a man of very wide reading, catholic sympathy, and fastidious taste, alive to very various degrees and kinds of excellence in literature, but too critical and hard to please to do justice to his own wealth of ideas. He died in 1870.

MOISSAC, chief town of an arrondissement in the department of Tarn-et-Garonne, France, is situated on the right bank of the Tarn, and on the railway line from Bordeaux to Cette, 17 miles west-north-west of Montauban. The church of St Peter, belonging to the 15th century, has a doorway of the 12th century, remarkable for its elaborate and beautiful sculpture, representing Scriptural scenes. Connected with the choir of the church is a cloister dating from the beginning of the 12th century, and one of the finest specimens of this kind of building in France; the pointed arches are supported by small columns with sculptured capitals. The town has a large trade in corn and flour, and the mills afford employment to a considerable number of persons. The population in 1881 was 9202.

The town owes its origin to an abbey founded between 630 and 640 by St Amand, the friend of Dagobert. After being devastated by the Saracens, the abbey was restored by Louis of Aquitaine, son of Charlemagne. Subsequently it was made dependent on Cluny, but in 1618 it was secularized by Pope Paul V., and replaced by a house of Augustinian monks, which was suppressed at the Revolution. The town, which was erected into a commune in the 13th century, was taken by Richard Cœur de Lion, and by Simon de Montfort.

MOKADDASI. Shams al-Dín Abú Abdalláh Mohammed ibn Aḥmad al-Moḳaddasi, *i.e.*, of Jerusalem, also called al-Bashshari, was the author of a famous description of the lands of Islam, which much surpasses the earlier works of the same kind. His paternal grandfather was an architect of eminence, who constructed many public works in Palestine, and his mother's family was opulent. He was himself a well-educated and talented man, with an exorbitant idea of his own qualities, and some curious affectations, such as that of imitating for each region the dialect of its inhabitants. His descriptions rest on very extensive travels continued through a long series of years. His first pilgrimage was made at the age of twenty, but his book was not published till A.H. 375 (985-6 A.D.), when he was forty years old. The two MSS. (at Berlin and Constantinople) represent a later recension (A.H. 378). The book became known in Europe through the copy brought from India by Sprenger, and was edited by De Goeje in 1877 as the third part of his *Biblioth. Geographorum Arabicorum*.

MOKANNA (*Al-Moḳanna'*, "the veiled") was, as explained above, p. 580, the surname given to Ḥakím, or 'Aṭa, a man of unknown parentage, originally a fuller in Merv, who posed as an incarnation of Deity, and headed a revolt in Khorasán against the caliph Mahdí. Much is related of his magical arts, especially of a moonlike light visible for an enormous distance which he made to rise from a pit near Nakhshab. He died by poison in A.H. 163 (779-80 A.D.).

MOKSHAN, a town of Russia, situated in the government of Penza, 27 miles to the north-west of the capital of the province, and 18 miles from the Ranzay railway station. It has 14,500 inhabitants, who are engaged in agriculture, or work in flour-mills, oil-works, tanneries, and potash-works. A few merchants export corn and flour. Mokshan, which was built in 1535 as a fort to protect the country from the raids of the Tatars and Kalmuks, is supposed to occupy the site of the town of Mescheryaks, Murundza, mentioned as early as the 9th century. It has begun rapidly to increase since the railway between Moscow and Penza was made.

MOLA, or MOLA DI BARI, a seaport town of Italy, in the province of Bari, 13 miles from Bari on the railway to Brindisi. It is an old-fashioned place with irregular streets, but outside of the walls several new districts have grown up. The foreign, and to some extent also the coasting, trade has considerably declined since 1863, and the communal population has decreased from 12,574 in 1861 to 12,435 in 1881. Little is known about the early history of Mola; it was sold by Alphonso I. to Landolfo Maramoldo in 1436, and ten years afterwards to Niccolo Tovaldo.

MOLASSES. See SUGAR.

MOLAY, JACQUES DE, a native of Burgundy, became grand-master of the order of the Temple in 1298, and was the last who held that dignity. He was burned at the stake in 1314. See TEMPLARS.

MOLDAVIA. See ROUMANIA.

MOLE (contracted form of mould-warp, *i.e.*, mould-caster), a term restricted in England to the common mole (*Talpa europæa*), a small, soft-furred, burrowing mammal, with minute eyes, and broad fossorial fore feet, belonging to the order *Insectivora* and family *Talpidæ*, but generally applied elsewhere to any underground burrowing animal of the class Mammalia. Thus, in North America we find, representing the same family, the star-nosed moles (*Condylura*), and the shrew moles (*Scalops* and *Scapanus*); in South Africa, the golden moles of the far-removed family *Chrysochloridæ*; and in South-East Europe, Asia, and South Africa, the rhizophagous rodent moles of the order *Rodentia* and families *Spalacidæ* and *Muridæ* (see MAMMALIA, vol. xv. pp. 405, 419, figs. 64 and 96).

Talpa europæa, the Common Mole, type of the genus *Talpa*,[1] is about six inches in length, of which the tail measures somewhat more than an inch; the body is long and cylindrical, and, owing to the very anterior position of the forelimbs, the head appears to rest between the shoulders; the muzzle is long and obtusely pointed, terminated by the nostrils, which are close together in front; the minute eye is almost hidden by the fur; the ear is without a conch, opening on a level with the surrounding integument; the forelimbs are rather short and very muscular, terminating in broad, naked, shovel-shaped feet, the palms normally directed outwards, each with five subequal digits armed with strong flattened claws; the hind-feet, on the contrary, are long and narrow, and the toes are provided with slender claws. The body is densely covered with soft, erect, velvety fur,—the hairs uniform in length and thickness, except on the muzzle and short tail, the former having some straight vibrissæ on its sides, whilst the latter is clothed with longer and coarser hairs. The fur is generally black, with a more or less greyish tinge, or brownish-black, but various paler shades up to pure white have been observed.

[1] Eight species may be recognized, and arranged, according to their dentition, as follows:—

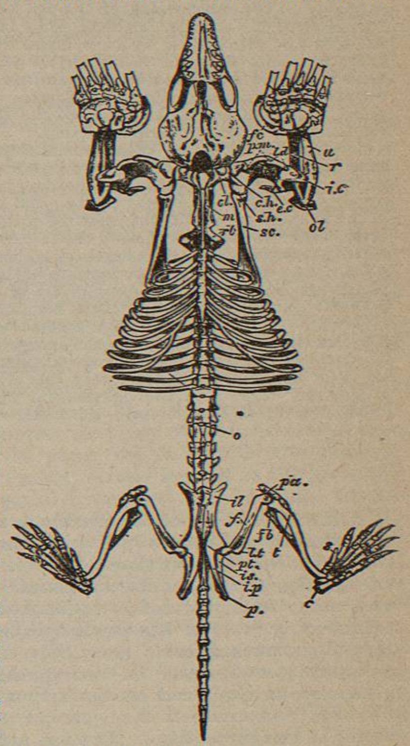
(A.) i. $\frac{3}{3}$, c. $\frac{1}{0}$, prm. $\frac{4}{4}$, m. $\frac{3}{3}$ × 2 (*T. wogura*).
(B.) i. $\frac{3}{3}$, c. $\frac{1}{1}$, prm. $\frac{4}{4}$, m. $\frac{3}{3}$ × 2 (*T. europæa, cæca, longirostris, micrura*).
(C.) i. $\frac{3}{3}$, c. $\frac{1}{1}$, prm. $\frac{3}{4}$, m. $\frac{3}{3}$ × 2 (*T. leucrura, leptura*).
(D.) i. $\frac{3}{3}$, c. $\frac{1}{1}$, prm. $\frac{3}{3}$, m. $\frac{3}{3}$ × 2 (*T. moschata*).

Except in *T. europæa*, the eyes are covered by a membrane. In *T. micrura* the short tail is concealed by the fur. *T. europæa* extends from England to Japan. *T. cæca* is found south of the Alps, the remaining species are all Asiatic, and of them two only—*T. micrura* and *T. leucrura*—occur south of the Himalayas. (See Dobson, *Monograph of the Insectivora*, Part ii., 1883.)

The food of the mole consists chiefly of the common earth-worm, in pursuit of which it forms its well-known underground excavations. Its habits, so difficult to observe, were many years ago most patiently studied and described by M. Henri le Court. Like many other mammals the mole has a lair or fortress to which it may retire for security. This is constructed with much ingenuity. It consists of a central nest formed under a hillock which is placed in some protected situation, as under a bank, or between the roots of trees. The nest, which is lined with dried grass or leaves, communicates with the main-run by four passages, one of which only joins it directly, leading downwards for a short distance and then ascending again; the other three are directed upwards and communicate at regular intervals with a circular gallery constructed in the upper part of the hillock, which in turn communicates by five passages leading downwards and outwards with another much larger gallery placed lower down on a level with the central nest, from which passages proceed outwards in different directions, one only communicating directly with the main-run, while the others, curving round, soon join, or end in culs-de-sac. The main-run is somewhat wider than the animal's body, its walls are smooth, and formed of closely compressed earth, its depth varying according to the nature of the soil, but ordinarily from four to six inches. Along this tunnel the animal passes backwards and forwards several times daily, and here traps are laid by mole-catchers for its capture. From the main-run numerous passages are formed on each side, along which the animal hunts its prey, throwing out the soil in the form of mole-hills. The mole is the most voracious of mammals, and, if deprived of food, is said to succumb in from ten to twelve hours. Almost any kind of flesh is eagerly devoured by captive moles, which have been seen by various observers, as if maddened by hunger, to attack animals nearly as large as themselves, such as birds, lizards, frogs, and even snakes; toads, however, they will not touch, and no form of vegetable food attracts their notice. If two moles be confined together without food, the weaker is invariably devoured by the stronger. They take readily to the water—in this respect, as well as in external form, resembling their representatives on the North American continent. Bruce, writing in 1793, remarks that he saw a mole paddling towards a small island in the Loch of Clunie, 180 yards from land, on which he noticed molehills.

The sexes come together about the second week in March, and the young—generally from four to six in number—which are brought forth in about six weeks, quickly attain their full size.

The mole exhibits in its whole organization the most perfect adaptation to its peculiar mode of life. In the structure of the skeleton very striking departures from the typical mammalian forms are noticeable. The first sternal bone is so much produced anteriorly as to extend forward as far as a vertical line let down from the second cervical vertebra, carrying with it the very short almost quadrate clavicles, which are articulated with its anterior extremity and distally with the humeri, being also connected ligamentously with the scapulæ. The forelimbs are thus brought opposite the sides of the neck, and from this position a threefold advantage is derived:—in the first place, as this is the narrowest part of the body, they add but little to the general width, which, if increased, would lessen the power of movement in a confined space; secondly, this position allows of a longer forelimb than would otherwise be possible, and so increases its lever power; and, thirdly, although the entire limb is relatively very short, its anterior position enables the animal, when burrowing, to thrust the claws so far forward as to be in a line with the end of the muzzle, the importance of which is evident.[1] Posteriorly, we find the hind limbs similarly removed out of the way by approximation of the hip-joints to the centre line of the body. This is effected by inward curvature of the innominate bones at the acetabula to such an extent that they almost meet in the centre, while the pubic bones are widely separated behind.[2] The shortness of the



Skeleton of Mole × $\frac{2}{3}$ (lower jaw removed to show base of skull).

c, calcaneum; *c.h.*, clavicular articulation of the humerus; *cl.*, clavicle; *e.c*, external condyle of humerus; *f.*, femur; *fb*, fibula; *fc*, falciform bone (radial sesamoid); *h*, humerus; *i.c*, internal condyle of humerus; *il*, left iliac bone; *i.p*, ramus of the ilium and pubis; *is.*, ischium; *l.d*, ridge of insertion of latissimus dorsi muscle; *l.t*, lesser trochanter; *m*, manubrium sterni; *o*, fourth hypapophysial sesamoid ossicle; *ol*, olecranon; *p.*, pubic bone widely separated from that of the opposite side, *pa.*, patella; *p.m.*, ridge for insertion of pectoralis major muscle; *pt.*, pectineal eminence; *r*, radius; *rb*, first rib; *s*, plantar sesamoid ossicle corresponding to the radial sesamoid (os falciform) in the manus; *sc.*, scapula; *s.h.*, scapular articulation of the humerus; *t*, tibia; *u*, ulna.

[1] It is most interesting to observe how, in the golden moles (*Chrysochloridæ*) of South Africa, the necessary modifications of the corresponding parts of the body and limbs fitting them for fossorial action and underground progression have been brought about in a totally different manner. In them the manubrium sterni is not anteriorly elongated, neither are the clavicles shortened; but this is made up for by a deep hollowing out of the antero-lateral walls of the thorax, the ribs in these parts and the sternum being convex inwards, the long clavicles have their distal extremities pushed forward, and the concavities on the sides and inferior surface of the thorax lodge the thick muscular arms.

[2] In Jacobs's *Talpæ Europeæ Anatome* (Jena, 1816) this part of the pelvic wall (marked *pt* in the fig.) was identified with the symphysis

forelimb is due to the humerus, which, like the clavicle, is so much reduced in length as to present the appearance of a flattened X-shaped bone, with prominent ridges and deep depressions for the attachments and origins of the powerful muscles connected with it. Its proximal extremity presents two rounded prominences: the smaller, the true head of the bone, articulates as usual with the scapulæ; the larger, which is really the external tuberosity rounded off, forms a separate synovial joint with the end of the clavicle. This double articulation gives to a naturally loose joint the rigidity necessary to support the great lateral pressure sustained by the forelimb in excavating. The forearm bones are normal, but those of the forefeet are much flattened and laterally expanded. The great width of the forefoot is also partly due to the presence of a peculiar falciform bone, lying on the inner side of the palm and articulating by its proximal extremity with the wrist. Into the radial side and under surface of this bone is inserted a tendon derived from that of the palmaris longus muscle, which, acting upon it as an abductor, separates it from the side of the palm, and so increases the width of the latter, at the same time rendering the palmar integument tense.

The muscles acting on these remarkably modified limbs are all homologous with those of the cursorial insectivora, differing only in their relative development. The tendon of the biceps traverses a long osseous tunnel, formed by the great expansion of the margin of the bicipital groove for the insertion of the large pectoralis major muscle; the anterior division of the latter muscle is unconnected with the sternum, extending across as a muscular band between the humeri, and co-ordinating the motions of the forelimbs. The teres major and latissimus dorsi muscles are of immense size, probably relatively larger than in any other mammal, and are inserted together into the prominent ridge below the pectoral attachment; they are the principal agents in the excavating action of the limb. The cervical muscles connecting the slender scapulæ, and through them the forelimbs, with the centre line of the neck and with the occiput are large, and the ligamentum nuchæ between them is ossified (as in all true moles); the latter condition appears to be due to the prolongation forwards of the sternum (described above) preventing all flexion of the head downwards; and, accordingly, the normal office of the ligament being lost, it ossifies, and so affords a more fixed point for the origins of the superficial cervical muscles.

The skull is long, with slender zygomatic arches; the nasal bones are strong and early become united, and in front of them the nostrils are continued forwards in tubes formed of thick cartilage, the septum between which becomes partially or wholly ossified beneath. There are 7 cervical, 13 dorsal, 6 lumbar, 6 sacral, and 10-12 caudal vertebræ; of the dorsal and lumbar there may be one vertebra more or less. The sacral vertebræ are united by their greatly expanded and laterally compressed spinous processes, and all the others, with the exception of the cervical, are very closely and solidly articulated together, so as to support the powerful propulsive and fossorial actions of the limbs. Dentition: i. $\frac{3}{3}$, c. $\frac{1}{1}$, prm. $\frac{4}{4}$, m. $\frac{3}{3}$, $\times 2 = 44$ teeth. The upper incisors are simple chisel-edged teeth; the canine is long and two-rooted; then follow three subequal conical premolars, and a fourth, much larger, and like a canine; these are succeeded by three molars with W-shaped cusps. In the lower jaw the three incisors on each side are slightly smaller, and slant more forwards; close behind them is a tooth which, though quite like them, must, from its position in front of the upper canines when the jaws are closed, be considered as the canine; behind it, but separated by an interval, is a large double-rooted conical tooth, the first premolar; the three following premolars are like the corresponding teeth above, but smaller, and are succeeded, as above, by three molars.

The geographical distribution of the common mole may be said to exceed that of all the other known species of the genus to which it belongs taken together. It extends from England to Japan, and from the Dovre-Fjeld Mountains in Scandinavia and the Middle Dwina region in Russia to southern Europe and the southern slopes of the Himalayas, where it occurs at an elevation of 10,000 feet. In Great Britain it is found as far north as Caithness, but in Ireland and in the Western Isles of Scotland (except Mull) it is altogether unknown.

(G. E. D.)

MOLECULE

IN the conception of the atomic as opposed to the continuous and infinitely divisible constitution of matter, it is supposed that portions of matter called *atoms* exist, which are separated, or are capable of being separated, from each other by empty space. (See ATOM). It may be the case that each atom has unchangeable shape and volume as well as unchangeable mass, but such a conception of an atom is not essential to the hypothesis. It is not even necessary, as explained in the article ATOM (vol. iii., pp. 37, 38), to maintain that no part of space can be in two atoms at the same time. But one attribute of the atom upon which its permanence, or, so to speak, its personal identity, depends, is its constituent mass, and this remains the same, unchanged and unchangeable, through all time.

Boscovich, indeed, goes so far as to regard the atom as a mere centre of force, the result of whose existence is that no two atoms or centres can approach each other within a certain distance, while other physicists regard the atomic volume as a distinct portion of space occupied by that atom to the exclusion of every other, and comprising within it matter ideally infinitely divisible, but the parts of which in fact never have been, and never can be, separated from each other. In this latter mode of viewing the subject, all the conclusions of mechanics which are based on the conception of the continuity and infinite divisibility of matter may be applied to the equilibrium or motion of each individual atom, the atomic theory merely introducing the additional hypothesis that, in fact, these persistent entities called atoms do exist, and that out of them all substances which affect our senses are constructed. The theory of universal gravitation requires us to believe in the existence of forces or actions between every portion of matter and every other portion, determinate in magnitude and direction, and such that, when on the infinitely divisible hypothesis the volumes of these portions are indefinitely diminished, these mutual forces are inversely proportional to the square of the distance between the portions (the distance between any two points, one in the volume of each portion, being in this case taken as the distance between the portions), and directly proportional to the products of the masses, or quantities of the two portions of matter,—such forces being regarded provisionally as ultimate facts, while inviting further analysis and explanation. Chemical and chemico-physical investigations indicate the existence of other actions between portions of matter, following other and for the most part unknown laws, and rapidly becoming inappreciable as the distance between the reacting portions is increased. All these hypotheses are to be retained on the hypothesis of discrete atoms as above enunciated, the mutual actions between atoms being the resultant of the actions between the various portions of their constituent matter. The volumes of the atoms are so small that, for any sensible distances apart, the line of the resultant mutual action between them may be taken as coincident with the line joining any point in the volume of one to any point in the volume of the other, but, for distances or parts comparable with the linear dimensions of the atoms, the size and shape of their bounding surfaces must be taken into consideration, and perhaps also the law of distribution of their constituent matter within that surface. In all respects, unless we accept the Boscovichian hypothesis, we simply regard the atom as made up, so to speak, of infinitely divisible matter, while substances, as we know them, are built up of indestructible and unchangeable atoms.

With this conception of an atom, as thus explained, we might be content to rest, confessing our total ignorance of the mode in which such atoms are built up into actual substances, being satisfied to regard such substances as

pubis, whereas the true pubic bones are widely separated (as shown at *p*). In this mistake he has been followed by most comparative anatomists; and hence the mole is generally believed to present the unique peculiarity that the outlets of the urinary, generative, and digestive organs do not pass through the arch of the pelvis.

composed of these distinct portions of matter separated, or capable of being separated, by empty space from other portions. But the *molecular* hypothesis of the constitution of different kinds of substances aims at analysing this process by which such substances are built up out of their constituent atoms. The *molecule* of any substance is, by some chemists, defined as being the smallest portion of that substance to which can be attributed all the chemical properties of the substance; by others, as the smallest portion which, so long as the substance is chemically unchanged, keeps together without complete separation of its parts. In the language of Clausius's theorem, if the parts of the molecule have internal motion, the kinetic energy of such internal motion is equal to the virial of the mutual attractive forces of the parts. Thus the formation of the molecule of each particular substance is viewed as an essential step in the process of building up that substance out of its constituent atoms. The molecule is first built up out of atoms arranged in its formation according to a definite type, and then the substance itself is constituted of these molecules. Of course molecules may be, and in fact in many particular substances are, supposed to be monatomic; that is to say, the intermediate step of building up the molecule out of the atoms has, in these particular substances, been omitted, the atoms and molecules becoming then identical. The particular arrangement of the formed molecules in the building up of the substance determines the physical state of that substance,—that is, its fluid, solid, gaseous, crystalline, or amorphous state; but the chemical properties of the substance depend upon the constitution of the molecule. As the investigations and theories of chemistry appear to indicate irresistibly the existence of permanent atoms, so do they also lead almost as necessarily to the conception of the molecule as an entity which bears the same relation to special substances that the atoms bear to matter generally. So long as the molecule endures, the substance of which it is the molecule retains its chemical properties; with the dissolution of the molecule, the substance, as that special substance, perishes; the atoms alone continue, and are free to enter into other combinations. The permanence of the molecule is relative, that of the atom absolute. This conception of the molecular constitution of substances suggests physical questions of great interest, such as the shape, volume, and mass of the constituent molecules, and the relative motions of which their parts are susceptible; and the answers to these questions cannot fail to be of great value in chemical and chemico-physical investigations, as well as in the theories of light and electricity.

Now, whatever differences may exist between the properties of different substances in the solid and liquid states, there are certain properties which, in the gaseous state, manifest themselves with no variation whatever in all substances alike. Hence the explanation of these common properties—or gaseous laws, as they are called—has long possessed a peculiar fascination for physicists. The tendency to expand or fill all accessible space, manifested by all gases, proves that on the molecular hypothesis their compound atoms or molecules must be continually tending to fly apart. We must conceive gases as constituted of molecules, not only separable but actually separated by space void of the matter of which these gases consist; and it may be most reasonably expected, therefore, that any general laws to which substances in this state conform may afford us a valuable insight into the constitution of these separate molecules.

Now the general laws to which all gases conform are: (1) *Boyle's law*—that, in a given mass of any gas kept at constant temperature, the pressure per unit of area upon the containing surface increases in the same proportion as the volume occupied by the gas is diminished, or at least with very slight deviation from exact proportionality; (2) *Charles's law*—that, if the temperature be varied while the pressure upon the gas remains the same, the gas increases by $\frac{1}{273}$d of its volume at zero centigrade for every degree of centigrade added to the temperature, or, which in combination with Boyle's law is the same thing, that if the density be constant, the pressure is directly proportional to the temperature measured from the point $-273°$ centigrade, this point being called the zero of absolute temperature; (3) *Avogadro's law*—which asserts that all gases at the same temperature and pressure contain the same number of molecules in the same volume; and (4) *Dalton's law*—that in a mixture of different gases, when there is equilibrium, each gas behaves as a vacuum to all the rest.

It was at one time considered that these phenomena might be explained on the hypothesis of mutual repulsive forces between the parts of which the gas is composed, whether they were regarded as constituted of molecules or of infinitely divisible continuous matter,[1] but it has been shown in the article ATOM (vol. iii. p. 39 *sq.*) that there are at least two absolutely conclusive reasons why this explanation cannot be accepted. These objections, together with the experimental fact proved by Joule that gases, or at any rate atmospheric air, expand into vacuum with scarcely any appreciable change of temperature, must be considered fatal to any mutual-force theory of gaseous action, and, accordingly, physicists have been driven to seek for other methods of explaining these laws. The explanation which has been more developed than any other is that known as the kinetic theory of gases, which regards the intrinsic energy of a gaseous mass as residing, not in the potential energy of intermolecular forces, but mainly in the kinetic energy of the molecules themselves, which are assumed to be in a state of continual relative velocity, admitting at the same time a possible small intermolecular potential energy, and it may be also an interatomic energy, between the atoms of the individual molecules. That some such persistent relative motion does exist in every gaseous mass is evident from the rapidity with which odours penetrate the stillest air where no breath of wind—that is, of absolute motion of translation of the mass as a whole or any portion of finite size—is perceptible. It becomes an interesting question whether the laws of mechanics admit of a mass thus constituted ever arriving at a state of permanence; that is to say, whether, consistently with the hypothesis of infinite irregularities in the directions and magnitudes of velocities of individual molecules, there may be found any properties of the mass in the aggregate which remain

[1] An argument in favour of the molecular constitution of gases, to which attention was first called by Professor Osborne Reynolds (Memoir "On some Dimensional Properties of Matter in the Gaseous State," *Phil. Trans.*, 1879), is derived from certain phenomena observed in highly-rarefied gases, and in the transpiration of gases through porous plates. If, according to this argument, we had in a gas to do with a continuous plenum, such that every portion must possess the same properties, then these properties must exist independently of the amount of gas contained in any space, although their sensible effects might be increased or diminished by a variation in that amount. If, then, we can find properties of a gas depending on the size of the space in which it is enclosed, and on the quantity of gas enclosed in this space, we have proof that gas is not continuous—in other words, possesses dimensional structure. Such properties we do find in highly-rarefied gases, as, for instance, in the phenomena of Crooke's radiometer. The motion of the vanes when one side is heated by incident rays appears to depend on the distance between the vane and the containing walls of the vessel bearing some not very high ratio to the distance between the particles or molecules of the gas. At least no satisfactory explanation of the phenomena consistent with the gas being continuous has yet been suggested.

Again, Professor O. Reynolds, from his experiments on the transpiration of gases through a porous plate, finds a relation between the gas and the coarseness or fineness of the plate, which would not exist were the gas continuous.