circling flight, and, alighting on a conspicuous perch, pours forth his ever-changing song to the delight of all listeners; while his actions in attendance on his mate are playfully demonstrative and equally interest the observer. The mocking-bird is moreover of familiar habits, haunting the neighbourhood of houses, and is therefore a general favourite. The nest is placed with little regard to concealment, and is not distinguished by much care in its construction. The eggs, from three to six in number, are of a pale bluish-green, blotched and spotted with light yellowish-brown. They, as well as the young, are much sought after by snakes, but the parents are often successful in repelling these deadly enemies, and are always ready to wage war against any intruder on their precincts, be it man, cat or hawk. Their food is various, consisting of berries, seeds and insects.

Some twelve or fourteen other species of *Mimus* have been recognized, mostly from South America; but *M. orpheus* seems to be common to some of the Greater Antilles, and *M. hilli* is peculiar to Jamaica, while the Bahamas have a local race in *M. bahamensis.* The so-called mountain mocking-bird (*Oreoscoptes montanus*) is a form not very distant from *Mimus*; but it inhabits exclusively the plains overgrown with sage-brush (*Artemisia*) of the interior tableland of North America, and is not at all imitative in its notes, so that it is an instance of a misnomer. Of the various other genera allied to *Mimus*, the best known are the thrashers (genus *Harporhynchus*) of which six or eight species are found in North America, which are thrush-like and shy in their habits and do not mimic; and the cat-bird (*Galeoscoptes carolinensis*), which in addition to having an attractive song, utters clucks, whistles and mewing sounds. The sooty-grey colour that, deepening into blackish-brown on the crown and quills, pervades the whole of its plumage—the lower tail-coverts, which are of a deep chestnut, excepted—renders it a conspicuous object; and though, for some reason or other, far from being a favourite, it is always willing when undisturbed to become intimate with men's abodes. It has a much wider range on the American continent than the mocking-bird, and is one of the few species that are resident in Bermuda, while on more than one occasion it is said to have appeared in Europe.

The name mocking-bird, or more frequently mock-nightingale, is in England occasionally given to some of the warblers (*q.v.*), especially the blackcap (*Sylvia atricapilla*), and the sedge-bird (*Acrocephalus schoenobaenus*). In India and Australia the same name is sometimes applied to other species. (A. N.)

MODEL (O. Fr. *modelle*, mod. *modèle*; It. *modello*, pattern, mould; from Lat. *modus*, measure, standard), a tangible representation, whether the size be equal, or greater, or smaller, of an object which is either in actual existence, or has to be constructed in fact or in thought. More generally it denotes a thing, whether actually existing or only mentally conceived of, whose properties are to be copied. In foundries, the object of which a cast is to be taken, whether it be for engineering or artistic purposes, is usually first formed of some easily workable material, generally wood. The form of this model is then reproduced in clay or plaster, and into the mould thus obtained the molten metal is poured. The sculptor first makes a model of the object he wishes to chisel in some plastic material such as wax, ingenious and complicated contrivances being employed to transfer this wax model, true to nature, to the stone in which the final work is to be executed. In anatomy and physiology, models are specially employed as aids in teaching and study, and the method of *moulage* or chromoplastic yields excellent impressions of living organisms, and enables anatomical and medical preparations to be copied both in form and colour. A special method is also in use for making plastic models of microscopic and minute microscopic objects. That their internal nature and structure may be more readily studied, these are divided by numerous parallel transverse cuts, by means of a microtome, into exceedingly thin sections. Each of these shavings is then modelled on an enlarged scale in wax or pulp plates, which are fixed together to form a reproduction of the object.

Representation in Thought.

Models in the mathematical, physical and mechanical sciences are of the greatest importance. Long ago philosophy perceived the essence of our process of thought to lie in the fact that we attach to the various real objects around us particular physical attributes—our concepts—and by means of these try to represent the objects to our minds. Such views were formerly regarded by mathematicians and physicists as nothing more than unfertile speculations, but in more recent times they have been brought by J. C. Maxwell, H. v. Helmholtz, E. Mach, H. Hertz and many others into intimate relation with the whole body of mathematical and physical theory. On this view our thoughts stand to things in the same relation as models to the objects they represent. The essence of the process is the attachment of one concept having a definite content to each thing, but without implying complete similarity between thing and thought; for naturally we can know but little of the resemblance of our thoughts to the things to which we attach them. What resemblance there is lies principally in the nature of the connexion, the correlation being analogous to that which obtains between thought and language, language and writing, the notes on the stave and musical sounds, &c. Here, of course, the symbolization of the thing is the important point, though, where feasible, the utmost possible correspondence is sought between the two—the musical scale, for example, being imitated by placing the notes higher or lower. When, therefore, we endeavour to assist our conceptions of space by figures, by the methods of descriptive geometry, and by various thread and object models; our topography by plans, charts and globes; and our mechanical and physical ideas by kinematic models—we are simply extending and continuing the principle by means of which we comprehend objects in thought and represent them in language or writing. In precisely the same way the microscope or telescope forms a continuation and multiplication of the lenses of the eye; and the notebook represents an external expansion of the same process which the memory brings about by purely internal means. There is also an obvious parallelism with representation by means of models when we express longitude, mileage, temperature, &c., by numbers, which should be looked upon as arithmetical analogies. Of a kindred character is the representation of distances by straight lines, of the course of events in time by curves, &c. Still, neither in this case nor in that of maps, charts, musical notes, figures, &c., can we legitimately speak of models, for these always involve a concrete spatial analogy in three dimensions.

So long as the volume of matter to be dealt with in science was insignificant, the need for the employment of models was naturally less imperative; indeed, there are self-evident advantages in comprehending things without resort to complicated models, which are difficult to make, and cannot be altered and adapted to extremely varied conditions so readily as can the easily adjusted symbols of thought, conception and calculation. Yet as the facts of science increased in number, the greatest economy of effort had to be observed in comprehending them and in conveying them to others; and the firm establishment of ocular demonstration was inevitable in view of its enormous superiority over purely abstract symbolism for the rapid and complete exhibition of complicated relations. At the present time it is desirable, on the one hand, that the power of deducing results from purely abstract premisses, without recourse to the aid of tangible models, should be more and more perfected, and on the other that purely abstract conceptions should be helped by objective and comprehensive models in cases where the mass of matter cannot be adequately dealt with directly.

Models in Mathematics and Physics.

In pure mathematics, especially geometry, models constructed of papier-mâché and plaster are chiefly employed to present to the senses the precise form of geometrical figures, surfaces and curves. Surfaces of the second order, represented by equations of the second degree between the rectangular co-ordinates of a point, are very simple to classify, and accordingly all their possible forms can easily be shown by a few models, which, however, become somewhat more intricate when lines of curvature, loxodromics and geodesic lines have to appear on their surfaces. On the other hand, the multiplicity of surfaces of the third order is enormous, and to convey their fundamental types it is necessary to employ numerous models of complicated, not to say hazardous, construction. In the case of more intricate surfaces it is sufficient to present those singularities which exhibit variation from the usual type of surface with synclastic or anticlastic curvatures, such as, for example, a sharp edge or point, or an intersection of the surface with itself; the elucidation of such singularities is of fundamental importance in modern mathematics.

In physical science, again, models that are of unchangeable form are largely employed. For example, the operation of the refraction of light in crystals can be pictured if we imagine a point in the centre of the crystal whence light is dispersed in all directions. The aggregate of the places at which the light arrives at any instant after it has started is called the wave-front. This surface consists of two cups or sheets fitting closely and exactly one inside the other. The two rays into which a single ray is broken are always determined by the points of contact of certain tangent-planes drawn to those sheets. With crystals possessing two axes these wave-surfaces display peculiar singularities in the above sense of the term, in that the inner sheet has four protuberances, while the outer has four funnel-like depressions, the lowest point of each depression meeting the highest point of each protuberance. At each of these funnels there is a tangent-plane that touches not in a single point, but in a circle bounding the depression, so that the corresponding ray of light is refracted, not into two rays, but into a whole cone of light —the so-called conical refraction theoretically predicted by Sir W. R. Hamilton and experimentally detected by Humphrey Lloyd. These conditions, which it is difficult to adequately express in language, are self-evident so soon as the wave-surface formed in plaster lies before our eyes. In thermodynamics, again, similar models serve, among other purposes, for the representation of the surfaces which exhibits the relation between the three thermodynamic variables of a body, *e.g.* between its temperature, pressure and volume. A glance at the model of such a thermodynamic surface enables the behaviour of a particular substance under the most varied conditions to be immediately realized. When the ordinate intersects the surface but once a single phase only of the body is conceivable, but where there is a multiple intersection various phases are possible, which may be liquid or gaseous. On the boundaries between these regions lie the critical phases, where transition occurs from one type of phase into the other. If for one of the elements a quantity which occurs in calorimetry be chosen—for example, entropy—information is also gained about the behaviour of the body when heat is taken in or abstracted.

After the stationary models hitherto considered, come the manifold forms of moving models, such as are used in geometry, to show the origin of geometrical figures from the motion of others—*e.g.* the origin of surfaces from the motion of lines. These include the thread models, in which threads are drawn tightly between movable bars, cords, wheels, rollers, &c. In mechanics and engineering an endless variety of working models are employed to convey to the eye the working either of machines as a whole, or of their component and subordinate parts. In theoretical mechanics models are often used to exhibit the physical laws of motion in interesting or special cases—*e.g.* the motion of a falling body or of a spinning-top, the movement of a pendulum on the rotating earth, the vortical motions of fluids, &c. Akin to these are the models which execute more or less exactly the hypothetical motions by which it is sought to explain various physical phenomena—as, for instance, the complicated wave-machines which present the motion of the particles in waves of sound (now ascertained with fair accuracy), or the more hypothetical motion of the atoms of the aether in waves of light.

Theories of Nature.

The varying importance which in recent times has been attached to models of this kind is intimately connected with the changes which have taken place in our conceptions of nature. The first method by which an attempt was made to solve the problem of the universe was entirely under the influence of Newton's laws. In analogy to his laws of universal gravitation, all bodies were conceived of as consisting of points of matter—atoms or molecules—to which was attributed a direct action at a distance. The circumstances of this action at a distance, however, were conceived as differing from those of the Newtonian law of attraction, in that they could explain the properties not only of solid elastic bodies, but also those of fluids, both liquids and gases. The phenomena of heat were explained by the motion of minute particles absolutely invisible to the eye, while to explain those of light it was assumed that an impalpable medium, called luminiferous aether, permeated the whole universe; to this were attributed the same properties as were possessed by solid bodies, and it was also supposed to consist of atoms, although of a much finer composition. To explain electric and magnetic phenomena the assumption was made of a third species of matter—electric fluids which were conceived of as being more of the nature of fluids, but still consisting of infinitesimal particles, also acting directly upon one another at a distance. This first phase of theoretical physics may be called the direct one, in that it took as its principal object the investigation of the internal structure of matter as it actually exists. It is also known as the mechanical theory of nature, in that it seeks to trace back all natural phenomena to motions of infinitesimal particles, *i.e.* to purely mechanical phenomena. In explaining magnetic and electrical phenomena it inevitably fell into somewhat artificial and improbable hypotheses, and this induced J. Clerk Maxwell, adopting the ideas of Michael Faraday, to propound a theory of electric and magnetic phenomena which was not only new in substance, but also essentially different in form. If the molecules and atoms of the old theory were not to be conceived of as exact mathematical points in the abstract sense, then their true nature and form must be regarded as absolutely unknown, and their groupings and motions, required by theory, looked upon as simply a process having more or less resemblance to the workings of nature, and representing more or less exactly certain aspects incidental to them. With this in mind, Maxwell propounded certain physical theories which were purely mechanical so far as they proceeded from a conception of purely mechanical processes. But he explicitly stated that he did not believe in the existence in nature of mechanical agents so constituted, and that he regarded them merely as means by which phenomena could be reproduced, bearing a certain similarity to those actually existing, and which also served to include larger groups of phenomena in a uniform manner and to determine the relations that held in their case. The question no longer being one of ascertaining the actual internal structure of matter, many mechanical analogies or dynamical illustrations became available, possessing different advantages; and as a matter of fact Maxwell at first employed special and intricate mechanical arrangements, though later these became more general and indefinite. This theory, which is called that of mechanical analogies, leads to the construction of numerous mechanical models. Maxwell himself and his followers devised many kinematic models, designed to afford a representation of the mechanical construction of the ether as a whole as well as of the separate mechanisms at work in it: these resemble the old wave-machines, so far as they represent the movements of a purely hypothetical mechanism. But while it was formerly believed that it was allowable to assume with a great show of probability the actual existence of such mechanisms in nature, yet nowadays philosophers postulate no more than a partial resemblance between the phenomena visible in such mechanisms and those which appear in nature. Here again it is perfectly clear that these models of wood, metal and cardboard are really a continuation and integration of our process of thought; for, according to the view in question, physical theory is merely a mental construction of mechanical models, the working of which we make plain to ourselves by the analogy of mechanisms we hold in our hands, and which have so much in common with natural phenomena as to help our comprehension of the latter.

Although Maxwell gave up the idea of making a precise investigation into the final structure of matter as it actually is, yet in Germany his work, under G. R. Kirchhoff's lead, was carried still further. Kirchhoff defined his own aim as being to describe, not to explain, the world of phenomena; but as he leaves the means of description open his theory differs little from Maxwell's, so soon as recourse is had to description by means of mechanical models and analogies. Now the resources of pure mathematics being particularly suited for the exact description of relations of quantity, Kirchhoff's school laid great stress on description by mathematical expressions and formulae, and the aim of physical theory came to be regarded as mainly the construction of formulae by which phenomena in the various branches of physics should be determined with the greatest approximation to the reality. This view of the nature of physical theory is known as mathematical phenomenology; it is a presentation of phenomena by analogies, though only by such as may be called mathematical.

Another phenomenology in the widest sense of the term, maintained especially by E. Mach, gives less prominence to mathematics, but considers the view that the phenomena of motion are essentially more fundamental than all the others to have been too hastily taken. It rather emphasizes the prime importance of description in the most general terms of the various spheres of phenomena, and holds that in each sphere its own fundamental law and the notions derived from this must be employed. Analogies and elucidations of one sphere by another —*e.g.* heat, electricity, &c.—by mechanical conceptions, this theory regards as mere ephemeral aids to perception, which are necessitated by historical development, but which in course of time either give place to others or entirely vanish from the domain of science.

All these theories are opposed by one called energetics (in the narrower sense), which looks upon the conception of energy, not that of matter, as the fundamental notion of all scientific investigation. It is in the main based on the similarities energy displays in its various spheres of action, but at the same time it takes its stand upon an interpretation or explanation of natural phenomena by analogies which, however, are not mechanical, but deal with the behaviour of energy in its various modes of manifestation.

Experimental Models.

A distinction must be observed between the models which have been described and those experimental models which present on a small scale a machine that is subsequently to be completed on a larger, so as to afford a trial of its capabilities. Here it must be noted that a mere alteration in dimensions is often sufficient to cause a material alteration in the action, since the various capabilities depend in various ways on the linear dimensions. Thus the weight varies as the cube of the linear dimensions, the surface of any single part and the phenomena that depend on such surfaces are proportionate to the square, while other effects—such as friction, expansion and conduction of heat, &c., vary according to other laws. Hence a flying-machine, which when made on a small scale is able to support its own weight, loses its power when its dimensions are increased. The theory, initiated by Sir Isaac Newton, of the dependence of various effects on the linear dimensions, is treated in the article UNITS, DIMENSIONS OF. Under simple conditions it may often be affirmed that in comparison with a large machine a small one has the same capacity, with reference to a standard of time which must be diminished in a certain ratio.

Of course experimental models are not only those in which purely mechanical forces are employed, but also include models of thermal, electro-magnetic and other engines—*e.g.* dynamos and telegraphic machines. The largest collection of such models is to be found in the museum of the Washington Patent Office. Sometimes, again, other than purely mechanical forces are at work in models for purposes of investigation and instruction. It often happens that a series of natural processes—such as motion in liquids, internal friction of gases, and the conduction of heat and electricity in metals—may be expressed by the same differential equations; and it is frequently possible to follow by means of measurements one of the processes in question—*e.g.* the conduction of electricity just mentioned. If then there be shown in a model a particular case of electrical conduction in which the same conditions at the boundary hold as in a problem of the internal friction of gases, we are able by measuring the electrical conduction in the model to determine at once the numerical data which obtain for the analogous case of internal friction, and which could only be ascertained otherwise by intricate calculations. Intricate calculations, moreover, can very often be dispensed with by the aid of mechanical devices, such as the ingenious calculating machines which perform additions and subtractions and very elaborate multiplications and divisions with surprising speed and accuracy, or apparatus for solving the higher equations, for determining the volume or area of geometrical figures, for carrying out integrations, and for developing a function in a Fourier's series by mechanical means. (L. Bo.)

MODELS, ARTISTS', the name given to persons who pose to artists as models for their work. The Greeks, who had the naked body constantly before them in the exercises of the gymnasium, had far less need of professional models than the moderns; but it is scarcely likely that they could have attained to the high level reached by their works without constant study from nature; and the story told of Zeuxis by Valerius Maximus, who had five of the most beautiful virgins of the city of Crotona offered him as models for his picture of Helen, proves their occasional use. The remark of Eupompus, quoted by Pliny, who advised Lysippus, "Let nature be your model, not an artist," directing his attention to the crowd instead of to his own work, also suggests a use of models which the many portrait statues of Greek and Roman times show to have been not unknown. In Egypt, too, although the priesthood had control of both sculpture and painting as used for the decoration of temples and palaces, and imposed a strict conventionalism, there are several statues of the early periods which are so lifelike in their treatment as to make it certain that they must have been worked from life. At the period of the Renaissance, painters generally made use of their relations and friends as models, of which many examples might be quoted from Venice, Florence, Rome and other places, and the stories of Titian and the duchess of Ferrara, and Botticelli and Simonetta Vespucci, go to show that ladies of exalted rank were sometimes not averse from having their charms immortalized by the painter's brush. But paid models were not unknown, as the story of the unfortunate contadino used by Sansovino as model for his statue of the little Bacchus will show. Artists' models as a special class appear when the establishment of schools for the study of the human figure created a regular demand, and since that time the remuneration offered has ensured a continual supply. The prices and the hours of work vary in different art centres. In England seven shillings is generally paid for a day of six hours, but models of exceptional beauty or talent frequently obtain more from successful artists or wealthy amateurs.

MODEL-YACHTING, the pastime of building and racing model-yachts. It has always been customary for ship-builders to make a miniature model of the vessel under construction, which is in every respect a copy of the original on a small scale, whether steam-ship or sailing-vessel (there is a fine collection in the Victoria and Albert Museum, London). Many of these models are of exquisite workmanship, every rope, pulley or portion of the engine being faithfully reproduced. In the case of sailing yachts these models were often pitted against each other on small bodies of water, and hence arose the modern pastime. It was soon seen that elaborate fittings and complicated rigging were a detriment to rapid handling, and that, on account of the comparatively stronger winds in which models were sailed, they needed a greater draught. For these reasons modern model yachts, which usually have fin-keels, are of about 15% or 20% deeper draught than full-sized vessels, while rigging and fittings have been reduced to absolute simplicity. This applies to models built for racing and not to elaborate copies of steamers and ships, made only for show or for "toy cruising."

Model-yacht clubs have existed for many years in Great Britain, Ireland and the United States, most of them holding a number of regattas during each season. The rules do not generally require the owner or skipper of a model to build his own craft, but among model-yachtsmen the designing and the construction of the boats constitute as important and interesting

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