other eye of the same patient. Euphthalmin acts more rapidly in young than in old people, causes no smarting or discomfort, weakens accommodation but little, has no appreciable effect on the conjunctival vessels or the corneal epithelium, and increases intra-ocular tension but slightly or not at all. The mydriasis is more complete in strong sunlight than that of cocaine or homatropine, yet there is such slight effect on accommodation that reading and writing are not materially interfered with. Jackson found no case in which the pupil was entirely without response to light, and noted that during the maximum effect about one-fourth of the total accommodation was lost. He prefers cocaine for ordinary ophthalmoscopic work, using euphthalmin for testing vision with strong light in cataract, or as a rapid mydriatic where iritis is suspected but still uncertain. He recommends a solution containing one per cent. each of euphthalmin and cocaine hydrochlorates. Knapp uses a ten-per-cent. solution for ordinary ophthalmoscopic examinations, stating, however, that it dilates the pupil less powerfully than atropine. Sneguiroff increased the speed of its action by a prior instillation of one per cent. holocain, this hastening the diffusion of fluids from the conjunctival sac into the anterior chamber. Some observers have used euphthalmin in glaucoma, claiming that its brief mydriasis does not allow of increased tension, yet its safety in this condition has not been proven. In glaucoma and in the aged, cocaine is a more suitable agent. As yet toxic effects from the drug have not been reported. Euphthalmin will act in one-per-cent. solution, but it requires repeated instillations to produce mydriasis.

W. A. Bastedo.

EUPYRIN.—Vanillin - ethyl - carbonate - p - phenetidin. This substance belongs to the paraphenetidin group which includes phenacetin, being a compound of paraphenetidin with vanillin. It forms pale, greenish-yellow needles of vanilla-like odor and without taste. It is freely soluble in alcohol, ether, and chloroform, but with difficulty in water. This is an antipyretic, which, according to Overbach, possesses stimulating properties, as evidenced by the sensation of well-being which follows its ingestion. It is of no use in neuralgia, but is recommended as a mild, non-toxic antipyretic, especially suitable for old people or children, or in cases of fever with great weakness.

W. A. Bastedo.

EUQUININE, or Quinine-carbonic-ether ($CO.OC_2H_5.OC_{20}H_{23}N_2O$), is the ethyl carbonic ester of quinine produced by the action of quinine on ethyl carbonyl chloride. It forms white needle-like crystals in fleecy masses which melt at 95° C. Its reaction is alkaline, and its taste flat with a slightly bitterish after-taste. It dissolves with difficulty in water, but readily in alcohol, ether, chloroform, and dilute acids, the acid solutions fluorescing like those of other quinine compounds. The hydrochlorate is the most soluble salt, the sulphate slightly soluble, and the tannate almost insoluble. Euquinine gives the thalleoquin reaction, but not the herapathite reaction of quinine.

Euquinine is a quinine compound which clinical reports show to possess all the valuable properties of the mother substance, without causing, in therapeutic dosage, ringing of the ears, nausea, headache, or other symptoms of cinchonism. As it is also practically tasteless, it can be administered to children with ease. It is said also to be borne well by those having an idiosyncrasy against quinine. Bernheim uses it in solution with ferric chloride for lavage in gastritis with dilatation, and as an enema in the stubborn diarrhœa of colitis. Goliner prefers it to quinine, acetanilid, antipyrin, or phenacetin in la grippe. For malaria it is best preceded by a mercurial laxative and combined with ginger or other aromatic. It is highly recommended in whooping-cough and the fevers of phthisis. The dose up to 2 or 3 gm. (gr. xxx.–xlv.) is slightly larger than that of quinine sulphate, and it can be administered in soup, gruel, milk, cocoa, or flavored syrup.

W. A. Bastedo.

EUREKA SPRINGS.—Carroll County, Arkansas.

Post-Office.—Eureka Springs. Hotels: Crescent and Southern, and numerous smaller houses.

Access.—Viâ Eureka Springs, branch of the St. Louis and San Francisco Railroad.

The development of Eureka Springs affords a forcible object-lesson of the progress of civilization in the Western wilds of America. Where a few years ago was an uninhabited sterile mountain glen, now nestles a bright little city of more than 6,000 inhabitants, which number is greatly increased by the large floating population of visitors, tourists, business men, and invalids constantly coming and going. The city is lighted by gas and electricity, contains an electric railway system, and excellent schools, hotels, etc. The Interstate Summer Normal and Educational Assembly have erected a building with a seating capacity of five thousand persons, in which annual summer sessions are held and attended by visitors from all parts of the Union. The State District Normal School of Arkansas is also located here. The springs are sixty in number, the best known being as follows: The "Crescent," "Dairy," "Basin," "Magnetic," "Harding," "Little Eureka," "Sweet," "Grotto," "Mystic," "Oil," "Arsenic," "Cave," and "Cold" springs. The waters contain mainly carbonates of lime and magnesia, with a small proportion of sulphates and chlorides. They are not strongly mineralized, and differ but slightly from each other. The following table from the report of F. W. Clarke, Chief of Division of Chemistry, United States Geological Survey, and R. R. Riggs,* shows the proportion of solids in four of the principal springs:

	Grains per United States gallon.
Crescent Spring	5.36
Dairy Spring	6.29
Basin Spring	6.97
Magnetic Spring	10.99

The following table sent us by Dr. John D. Jordan, of Eureka Springs, shows some of the climatic advantages of the resort:

Eureka Springs.	Altitude above sea level		2,000 ft.
	Annual average precipitation		32.79 in.
	Mean temperature (Fahr.)	Spring	60.85°
		Summer	74.79°
		Autumn	58.01°
		Winter	42.08°
	Annual average		58.93°
	Relative humidity (per cent.)		58.93
	Average number of days per annum	Clear weather	209
		Fair weather	90
		Cloudy weather.	66
	Death rate per annum		10.33 per 1,000

The city is picturesquely located on the headwaters of the White River in the Ozark Mountains. A sojourn at Eureka Springs and the free use of its waters are stated to be beneficial in a wide range of affections, including rheumatism, skin, nervous, renal and bladder disorders, dyspepsia, hay fever, and general debility.

James K. Crook.

EUREKA SPRINGS.—Humboldt County, California.

Post-Office.—Eureka.

These springs are located near the town of Eureka. The waters belong to the muriated-sulphureted class, and were analyzed by Prof. W. D. Johnson in 1885, with the following result:

One United States Gallon Contains:

Solids.	Grains.
Sodium chloride	1,403.00
Sodium carbonate	10.10
Sodium bromide	14.00
Potassium sulphate	12.20
Magnesium chloride	101.00
Magnesium sulphate	211.30
Calcium carbonate	3.80
Calcium sulphate	42.50
Alumina	1.30
Silica	.95
Ferrous carbonate	.12

* February 15th, 1877.

Solids.	Grains.
Manganese	Trace.
Boric acid	Trace.
Iodine	Trace.
Lithium	Trace.
Total	1800.27
Carbonic acid gas	Small amount.
Sulphureted hydrogen	Saturated.

This water is now used extensively by the residents of the neighboring districts. It is also shipped to San Francisco. The action of the water is laxative and diuretic.

James K. Crook.

EURESOL, or resorcin monoacetate [$C_6H_3(OH)_2.CH_3CO$], is a viscid, transparent mass of pleasant odor, and easily reduced to a powder. Kromayer has obtained good results in the treatment of over sixty cases of acne vulgaris, rosacea, sycosis, seborrhœa, seborrhœic eczema, etc. It is used in acetone solution as a varnish, leaving a coating on the skin when dry.

W. A. Bastedo.

EUROBIN, or chrysarobin triacetate, is a dark powder, insoluble in water, but soluble in chloroform, acetone, ether, or acetic acid. Kromayer finds that it causes more reaction than chrysarobin on chronically inflamed skin, as in chronic eczema. He uses it in one to twenty per cent. acetone solution as a varnish. Eugallol or saligallol may be added with advantage.

W. A. Bastedo.

EUROPHEN.—This is one of the many compounds containing iodine and devoid of any disagreeable odor, that have been introduced as substitutes for iodoform. Chemically it is di-isobutylortho-cresol iodide, its formula being $\left(\begin{matrix}C_4H_9\\CH_3\end{matrix} > C_6H_3O\right)_2HI$. Its relation to cresol and iodine is much the same as that of aristol to thymol and iodine.

It is an extremely light amorphous yellow powder, being about five times as bulky as iodoform, with an aromatic odor resembling saffron. It contains 27.6 per cent. of iodine. It is insoluble in water and glycerin, soluble in alcohol up to thirty per cent., and in ether, chloroform, collodion, and fatty oils up to twenty-five per cent. It must be excluded from light and heat, as it is readily decomposed. In contact with water it is slowly decomposed, yielding free iodine.

The use of europhen is indicated in all cases in which iodoform is employed in wounds and ulcers and ulcerated surfaces, and in diseased conditions of the nasal and pharyngeal cavities of the vagina and uterus and all mucous surfaces. In various forms of skin disease it has proved beneficial, especially the acute and chronic eczemas. It is also administered internally in all stages of syphilitic disease, but is recommended as being most active in the third stage, and is thought to replace the iodide of potassium as a specific. The dose to commence with should be one-quarter of a grain, gradually to be increased to one or two grains. If it is administered too rapidly there is a danger of iodism manifesting itself. The same amount may be used hypodermically, a ten-per-cent. solution in oil being prepared for this purpose. For external use as an ointment the following has been selected as an excellent combination: Europhen, 3 parts; olive oil, 7 parts; vaseline, 60 parts; lanolin, 30 parts.

Beaumont Small.

EUSTRONGYLUS GIGAS. See *Nematodes*.

EVOLUTION.—(L. *evolutio*, an unrolling, from *evolvere*, to unroll or unfold.) The term *evolution* has been employed with various meanings:

1. It was used at first in its true etymological meaning of unrolling or unfolding to describe a supposed method of the individual development of organisms.

2. Later it was applied in a metaphorical sense to the origin of species, where it means simply continuous descent with modification, or the origin of species by the alteration of pre-existing species.

3. Finally, we have the metaphysical sense of the word when used as the designation of a system of philosophy that attempts to explain the origin of all things by continuous change. The great exponent of the evolutionary philosophy is Herbert Spencer. The central points in his philosophy are the laws of the indestructibility of matter and the conservation of energy. According to Spencer, the result of these laws is rhythmic motion, manifested everywhere from the dance of molecules to gyrations of planets, and this produces an alternation of evolution and dissolution throughout the universe. Spencer defines this evolution as "change from an indefinite, incoherent homogeneity to a definite, coherent heterogeneity, through continuous differentiations and integrations."

Metaphysics being beyond the scope of the present work, we will confine our attention to the two biological meanings of *evolution*.

Evolution in Ontogeny.—Modern embryology may be said to have begun with the work on the development of the chick which Harvey described in his "Treatise on Generation" in 1651. By means of a hand lens he was able to trace the development of the chick in a general way back to the beginning of the second day. He found that the embryo arises from the light-colored spot in the yolk, called by Fabricius the *cicatricula*. Harvey saw this dilate and become divided into circles, forming what we now call the *area embryonalis*, and this he compared to the iris of the eye and called the *oculum ovi*. At the end of the third day he discovered a fine line of red around the edge of the spot, "and nearly in its centre there appears," he says, "a leaping point of the color of blood so small that when it contracts it almost entirely escapes the eye, when it dilates it shows like the smallest spark of fire. Such is the outset of animal life which the plastic force of nature puts in motion from the most insignificant beginnings." He was unable to distinguish any other parts of the embryo until the fifth day, and he describes in a very interesting way the gradual appearance of the various organs of the embryo as he saw them from that time until the perfect chick is formed.

One of the great generalizations that Harvey made as a result of his observations is known as the theory of *epigenesis*. This is, briefly, that the embryo is built up gradually from a simple beginning by the addition of part to part in a definite order. Harvey regarded the blood as "the first engendered part . . . the source and origin of all other parts . . . which thence obtain their vital heat and become subservient to it in its duties."

It was in opposition to this theory of epigenesis that the theory of *evolution* arose.

Malpighi, working a little later than Harvey, and probably having a better microscope, found that the blood is not the "first engendered part," for he could see an outline of the embryo before the appearance of the "*punctum sanguineum*." This small detail of observation led Malpighi to reject Harvey's whole theory of epigenesis. He asserted, instead, that the embryo as a whole is present in the egg before incubation, that it is *predelineated*. This led to a great discussion which lasted for more than a hundred years. Of course, if the whole embryo is predelineated in the egg, epigenesis is an impossibility; and development must be a process of *evolution*, an unfolding of the pre-existing embryo. The chief exponent of this theory was Bonnet, who carried it out to its logical conclusion (1762), and asserted that development is not only a process of evolution, but also that all germs have existed since the day of creation, and that each embryo contains in similar form the germs of all subsequent generations.

The theory of evolution seems, on the whole, to have prevailed as the generally accepted explanation of development until 1812, when Meckel called attention to a Latin treatise, "Theoria Generationis," published in 1759 by Caspar Frederick Wolff, as the dissertation for his doctor's degree. In this paper Wolff had traced the development of both the chick and certain flowering plants back to very simple beginnings, and he showed that the development is really an epigenesis and not an evolution. This view has been fully confirmed by the vast amount of research in embryology that has been carried out during the latter half of the nineteenth century.

The almost mediæval theory of evolution of Bonnet and his friends seems so absurd to-day that it would hardly be worth mentioning if it were not for the fact that the theory has been revived recently in a more subtle form.

To be sure the individual development of organisms, so far as we can see with the eye or with the most powerful microscopes, is clearly a process of epigenesis. But, after all, there is much that still remains invisible, and the utmost limits of our vision include only superficial manifestations of forces working within the protoplasm. May it not, then, be true that the embryo is really preformed in invisible particles within the germ-plasm? May not differentiation be in essence merely the visualization of pre-existing invisible potentialities? If we answer these questions in the affirmative, our explanation of ontogeny is as much evolution as was Bonnet's. There has been much discussion of this subject within the past ten years, but it is so intimately connected with the theories of heredity that it will be more conveniently reviewed in connection with that subject (see *Heredity*).

ORGANIC EVOLUTION.—Usually when one speaks of evolution one means what has been called *organic evolution*, the origin of diversity in the organic world by means of natural processes.

The opposing theory is that of *special creation*. According to this latter view, each species was established in the beginning by a miraculous act of creation. Each species is, then, a distinct and concrete phenomenon of nature. There is but one true classification which is to be discovered, not invented, by naturalists.

From the point of view of evolution, on the other hand, the great fact of nature is the diversity of organic forms, and no sharp line can be drawn between varieties, species, genera, and families. A classification is merely a convenient invention of the human mind to summarize the present state of knowledge in regard to the structure of organisms, and must change from time to time as such knowledge increases. The idea of miraculous intervention is rejected, and the effort is to discover in the organic world the same orderly working of the laws of nature that has been found to obtain in the inorganic world.

In regard to evolution, it must be borne in mind that two questions are involved: First, does the theory of evolution, as a whole, furnish a better summary of our knowledge of organisms than the theory of special creation? In other words, is evolution to be regarded as an historical fact? Second, what are the factors into which the theory of evolution may be resolved, or, how may the fact of evolution be explained as a process?

While there is much difference of opinion among naturalists in regard to the second question, the first is to-day answered by almost every man of science in the affirmative. On the other hand, there are many persons who have not paid especial attention to natural history and who still hold to the doctrine of special creation. Therefore, it may be well to give a brief summary of the evidence on which men of science base their belief in evolution as a fact.

The Evidence of Evolution.—1. In the first place, we have the *analogy of the other sciences*. For the ancients the sun, the moon, and the planets were controlled in their movements by attendant spirits. Until well into the nineteenth century the structure of the earth was explained as the result of a series of catastrophes accompanied by changes in the order of nature. But Newton showed that the movements of the planets could be described by the same formula that describes the falling of a stone, and the result of the labors of Hutton, Lyell, and their successors, has been to show that the structure of the earth may be explained as the gradual effect of forces now to be observed at work upon the earth's surface. In a similar way, in physics and chemistry the supernatural has been replaced by the natural, until the doctrine of special creation, if accepted, would remain the only exception to the general rule that all phenomena of nature are to be explained by natural laws.

When we say "explained" it must be borne in mind that, in reality, science explains nothing. What science really does is to describe phenomena by means of brief formulæ that summarize the greatest possible amount of knowledge. A "natural law" is not an object of nature, it can do nothing. It is merely a human invention to summarize man's experience of the past and his belief as to the future. When we say that a stone falls with the velocity, $v = gt$, we mean that, whenever the experiment has been tried under proper conditions, this formula has been found to describe truly the result, and we have no reason to believe that it will not always be found to be true in the future. And this is all we mean when we say that the stone falls because of the law of gravitation. In ordinary language we are said to have explained the fall of the stone, but, in fact, we do not know what gravitation is, and we know no more *why* the stone falls than we did before. The common error of deifying natural law may be avoided if we remember that a natural law is a description of a sequence of events that may be expected to occur always in the same order under the same conditions, and an event is explained, or "made plain," when referred to its proper place in this sequence.

Now the question before the naturalist is, Shall the factor of special creation be included in the formula descriptive of the diversity of form in the organic world? We have seen that in all the other sciences the supernatural factors have been rejected as superfluous, therefore from analogy it is *a priori* probable this factor should be rejected also in biological theory, including the theory of the origin of species.

2. Turning now to the results of observation, it is evident that from the doctrine of special creation it would be impossible to predict anything in regard to the *classification* of animals and plants, except that it might be supposed that species would be fairly distinct. From the theory of evolution, on the contrary, it might be expected that it would be difficult in many cases to distinguish between varieties and species on the one hand, and between species and genera on the other. Moreover, it would be expected that, to show their true affinities, in the classification the species would have to be arranged like the buds on a tree, in which the buds are the species, while the twigs, the branches, and the stem would represent their hypothetical lines of descent. These two predictions are fully verified in practice, and the theory is to that extent confirmed.

3. The classification of species leads directly to the study of their *geographical distribution*. The theory of evolution assumes that each species began with relatively few individuals in a restricted locality, from which it spread as the number of individuals increased until it reached its maximum extension. Thus far the theory of special creation might agree. But it would deny the further assumption, that each genus was at first a single species which, as it gradually extended its area of distribution, became exposed to different conditions in different parts of this area, and that, as a result of the operation of natural laws, the individuals in these different sections became changed in the course of generations so as to constitute distinct varieties and later species.

As a corollary to this theorem of evolution, we should expect that the more inclusive a group, the wider would be its range. The length of time required for the evolution of an order would probably be greater than for that of a genus, hence there would be more time for migration and, consequently, a wider range.

Another corrollary is that there should be a close relation between the affinities of the organisms in any area and the physical barriers separating it from other areas.

The study of geographical distribution confirms these

predictions. It is found that, while some species have a cosmopolitan range, most species have more restricted ranges than the genera to which they belong, and the genera in turn have smaller ranges than their families and orders.

The affinities of species in any region are found, in fact, to depend more upon the position of barriers than upon the climate or other conditions. This is shown by a comparison of the productions of the Northern hemisphere with those of the more isolated areas of the Southern hemisphere. Oceanic islands, as compared to continental islands, furnish also important evidence on this point.

It must not be forgotten, however, that the facts of geographical distribution present some difficulties for the theory of evolution. But, while some of these still remain to be solved, most of them have been cleared up by a study of the past history of the earth and the geological sequence and distribution of organisms.

4. It might be expected that a study of *palæontology* would furnish the very best evidence of evolution, if it were not for the fact that the preservation of organisms as fossils depends on so many factors of chance that the odds against the preservation of any individual, or even any species, are very high, and the odds against its being both preserved and discovered by palæontologists are still higher. Nevertheless, palæontology has furnished much evidence, and, so far as it goes, it all supports the theory.

In the first place, the evidence from palæontology supplements that from the present geographical distribution by showing the geographical distribution in previous geological periods, and thus making it possible to trace the migrations of forms and to explain their present distribution. In some areas there is a marked similarity between species now living on the surface and the fossils found in the underlying deposits. In cases in which the present distribution is discontinuous to a marked degree, as in the marsupials, tapirs, and camels, it has been found that during earlier periods they occupied intermediate areas.

Direct evidence is furnished by the study of the succession of forms in geological time. In general it may be said that, the farther back we go in time, the less differentiated the forms appear. And in a few series, such as the camels and the horses, it has been possible to trace very completely the line of descent from a very generalized type to the highly differentiated forms now living. The study of such a series leaves one with very little doubt as to the fact of evolution.

5. But the fossils are not the only source of information in regard to the past history of species. Each individual may give in the course of its development an abbreviated and simplified picture of the history of its race. At least, such is the inference drawn from a large body of fact furnished by the study of *embryology*. It has been found, as a general rule, that the earlier stages in the development of any form correspond to the more generalized, lower, types of the same group. And in some cases, for example, the fishes, it has been shown that the succession of these stages of gradually increasing differentiation correspond with the succession of forms in geological time. This is exactly what would be expected on the theory of evolution. On the theory of special creation one would expect the development of the individual to take place in as direct a manner as possible, unless there is some physical necessity for the indirect methods which give the appearance of recapitulation of ancestral history. That there is no such necessity is shown by the absence of these ancestral stages in the development of many species, while they are present in related forms, and by the fact that two individuals may reach a practically identical adult structure by entirely different modes of development, as, for example, individuals developed from buds and from eggs of the same species (see article *Budding*).

6. Further evidence of the past history of a species is furnished by the presence of *vestigial organs*, organs that are arrested in development and are apparently of no use to the species in which they occur, but which are homologous with fully developed functional organs in other, usually lower, species of the same or related groups. The human body contains a great number of such vestiges. They are perfectly unintelligible on the theory of special creation, and perfectly in harmony with the theory of evolution.

7. The study of comparative anatomy affords also another line of evidence concerning evolution. This is found in the distribution of *homologous organs*. If each species has been created separately there is no reason why organs constructed on the same fundamental plan, that is homologous organs, should not be found in any number of species. But if, on the contrary, the numerous species in any great group have arisen by the diversification of a relatively simple undifferentiated type, then we would expect the species in one group to show their common origin in similarity of plan of structure, and we would expect them to differ in plan of structure from species of another group having a different origin, although their organs might be called upon to perform similar functions.

Now this is just what we do find to be the case. An internal digestive tract is a fundamental characteristic of all animals above the Protozoa, and we can regard it as probably more or less homologous in all species. But when we come to less fundamental structures, such as legs, wings, and eyes, it is found that the homologies between species are confined to their own great groups. For example, although the wing of an insect and the wing of a bird have exactly analogous functions, they are not in any degree homologous. On the other hand, the wing of a bird and the wing of a bat, while differing in detail, have the same architectural plan, which is also the same as that of the arm of man and the foreleg of a horse. Thus the fore-limb throughout the vertebrate series is homologous, although differing greatly in function. This is but one of a great many similar facts, all of which go to show that the vertebrates are derived from a common ancestral type. In the same way the eyes are homologous in all vertebrates, and are not homologous with those of any other group. Mivart thought he had found an homology in the eye of the squid. In its optical principles and general form this eye resembles that of a vertebrate very closely. But a careful examination of its mode of development and minute structure shows that it is formed upon an entirely different plan.

Looking back over these seven lines of evidence, we find that, while they present some difficulties, these are all capable of explanation from the point of view of evolution; and these lines of evidence support and supplement one another so completely that the man of science appears to be justified in accepting evolution as a fact, provided he can construct a valid theory to explain or describe the method of evolution.

History of the Theories of Evolution.—The idea of evolution appears in the speculations of the "nature philosophers" of the last decade of the eighteenth century and the first decade of the nineteenth. According to Osborn, this is largely due to the influence of the Greek philosophers. At any rate, the idea seems to have been in the air at this time, for several of these men suggested more or less independently of one another that species are not fixed things, but are subject to change, and that their present form is the result of such change. In each case, however, it was more the groping after a theory than the formation of one, and what was of scientific value was often hidden by the fanciful and absurd. The question was chiefly as to evolution as a fact, and little attempt was made to answer the question as to method, as to how evolution could be brought about.

The first consistent attempt to answer this question of method was made by Lamarck in the year 1809 in his "Philosophie Zoologique." According to Lamarck, "the systematic divisions of classes, orders, families, genera, and species, as well as their designations, are the arbitrary and artificial productions of man. The kinds or species of organisms are of unequal age, developed one after the other, and show only a relative and temporary persistence; species arise out of varieties. The difference in the conditions of life have a modifying influence on the organization, the general form, and the parts of animals, and so have the use and disuse of organs. In the first beginning only the very simplest and lowest animals and plants come into existence; those of a more complex organization only at a later period. The course of the earth's development and that of its organic inhabitants was continuous, not interrupted by violent revolutions." He not only asserted as others had done that species have developed, but he gave an answer to the question, How? It is a well-known fact that muscles and other parts that are much used grow stronger, become harder, or are modified in some way that is usually of advantage, while parts that are not used tend to dwindle. Lamarck believed that species are subject to a continued transformation by the inheritance of the results of use and disuse. As the use and disuse of organs is determined by the habits of the individual, Lamarck regarded habit as the chief cause of evolution. An animal's wish to do a certain sort of thing and his constant striving to do it resulted in a change of structure in his descendants that would render them better able to do this thing. On the face of it, it seems reasonable enough to suppose that the well-known effects of use and disuse are inherited, and that varieties and finally whole species have arisen or have suffered change in that manner. But, when Lamarck attempted to carry out this theory in detail, he ran into manifest absurdities, as, for instance, when he attributes the long neck of the giraffe to its habit of striving to reach the leaves of trees. It was perhaps as much on account of the number of such absurdities, as on account of the advance beyond its age, that this work of Lamarck's remained for a long time in obscurity, and was not even mentioned by such men as Goethe and Cuvier, although Lamarck held a high rank by reason of his other works, especially his "Histoire Naturelle des Animaux sans Vertèbres," published in 1815–22.

Another Frenchman, Etienne Geoffroy St. Hilaire, arrived at a similar theory of evolution at about the same time that Lamarck did, but he did not publish until 1828 and 1830. His theory was the same as Lamarck's, except that he laid less stress on habit and the inherited effects of use and disuse and more on changes in external conditions. His most important contribution is the idea of permanence of sports giving rise to new varieties and species. He attacked Cuvier's theory that the animal kingdom presents four great independent types of structure—radiate, articulate, molluscan, and vertebrate—and attempted to prove that the whole animal kingdom is formed upon a single structural plan. This gave rise to a dispute which culminated in the famous debates of February 22d and July 19th, 1830, in which Cuvier, with his superior knowledge of comparative anatomy, came off the victor.

From this time on for nearly thirty years the believers in special creation and the permanence of species rested assured of their position, relying on the wide knowledge and high authority of Cuvier. They little dreamed of the volcano beneath their feet. For the echoes of the famous debate of 1830 had hardly died away when Charles Darwin started on a voyage that was to have for its chief result the greatest revolution in thought of modern times.

When Darwin started on his voyage in the *Beagle* in 1831, he took with him a copy of Lyell's "Principles of Geology," and he was thus predisposed to regard the phenomena of nature as occurring in an orderly and uninterrupted sequence; moreover, there was in this book a discussion of Lamarck's theory, so that this must also have been fresh in his mind. From his autobiography (p. 82) we learn that he had been "deeply impressed by discovering in the Pampean formation great fossil animals covered with armor like that on existing armadillos; secondly, by the manner in which closely allied animals replace one another in proceeding southward on the continent; and thirdly, by the South American character of most of the productions of the Galapagos Archipelago, and more especially by the manner in which they differ slightly on each island of the group; none of the islands appearing to be very ancient in a geological sense." It seemed to him that such facts, as well as many others could be explained only by the supposition that species gradually become modified. But it seemed to him equally evident that neither the action of the surrounding condition, as Geoffroy St. Hilaire thought, nor the will of the organisms, as Lamarck supposed, could account for the innumerable cases in which organisms of every kind are beautifully adapted to their habits of life. In 1837 Darwin began to collect evidence, in the hope of obtaining some light on the subject. So far he had gone no farther than his predecessors. He had found much evidence for a theory of descent, but the question, How? still remained unanswered. In collecting facts he paid special attention to the modifications of domestic species, and soon came to the conclusion that in these cases "selection was the keystone of man's success in making useful races of animals and plants. But how selection could be applied to organisms living in a state of nature remained for some time a mystery."

In October, 1838, Darwin happened to read for amusement Thomas Robert Malthus's "Essay on the Principle of Population" (1803), and then the solution of the problem flashed upon him. Malthus quotes from Benjamin Franklin's "Observations Concerning the Increase of Mankind" (1751) the remark that "there is no bound to the prolific nature of plants or animals but what is made by their crowding and interfering with each other's means of subsistence." He applies this, as Franklin did, to mankind, and he shows, moreover, that man tends to increase in a geometrical progression, and that if it were not for checks on population, the number of human beings on the earth would be doubled at least once in every twenty-five years. And, further, while population tends to increase in geometrical ratio the food supply, according to Malthus, can be increased only at most in an arithmetical ratio. As population tends to increase faster than the food supply, the lack of food soon becomes the principal check to further increase. Darwin, from his long-continued observation of the habits of animals and plants, was well prepared to appreciate the struggle for existence which goes on everywhere as the result of this law of increase, and it struck him at once "that under these circumstances favorable variations would tend to be preserved and unfavorable ones to be destroyed. The result of this would be the formation of new species." Darwin called this the process of *natural selection*. With characteristic caution, he did not even permit himself to write out his theory for a long time, but continued searching for evidence for and against it.

In the mean time, Alfred Russell Wallace made a journey to the Malay Archipelago. Like Darwin, he was much impressed by the evidences that he found for the evolution of species. While in Borneo in February, 1855, he wrote a paper on this subject that was published in the *Annals and Magazine of Natural History* in the following September. In this paper he stated the law that, "Every species has come into existence coincident, both in space and time, with a pre-existing, closely allied species." This is the next thing to saying that every species has been evolved from a pre-existing, closely allied species. Wallace evidently hesitated to state the law in this form because he had no theory to offer as to the manner in which evolution is brought about. He brought forward the evidence from classification, from geographical distribution, palæontology, and vestigial organs; and the law that has been quoted was the final result of this paper. The question, "How?" still haunted him, however. Three years later, Mr. Wallace was at Ternate in the Moluccas and, while confined to his bed by fever, he was meditating on this problem. The "positive checks" occurred to him—war, disease, famine, and the like—described by Malthus in his "Essay on Population." He

saw that these must apply to the animals as well as to man, and he thought of the much more rapid multiplication of animals, and then there suddenly flashed upon him the idea of the survival of the fittest, "that the individuals removed by these checks must be on the whole inferior to those that survive." Three days later a paper embodying this theory was written and on its way to England, addressed, strange to say, to Mr. Darwin, who had been working on this same theory for years. The immediate result was that Darwin was reluctantly persuaded to publish an abstract of his work, together with Wallace's paper, and the two appeared in the *Journal of the Proceedings of the Linnean Society* for 1858 ("Zool.," vol. iii., 1858, p. 45). In 1859 the "Origin of Species" was given to the world and gave the impetus to that great revolution in thought to which we have already referred.

We certainly cannot honor too highly the pure love of truth and devotion to science, uncontaminated by ambition for fame, which we see in these two men, and we are especially called upon to admire the loyal and ungrudging way in which Wallace attributes all the honor of the great discovery to Darwin. It is of interest to us Americans to note that the man who furnished the necessary cue to both Darwin and Wallace, Thomas Robert Malthus, received it in turn from our fellow-countryman, Benjamin Franklin.

We are indebted to Darwin for the first presentation of a theory of evolution that carried with it conviction to the scientific mind. Because it did carry conviction it was attacked with great vigor on all sides, scientific and unscientific alike. The younger generation of to-day can hardly appreciate the bitterness of the struggle between the advocates of tradition and those of the new idea.

As men of science gradually became convinced of the fact of evolution, there arose a calmer discussion as to the method. Some have held that natural selection is the sole factor; others, that it is the prime factor, but that it is supplemented by other factors; then there are the "neo-Lamarckians," who hold that, while natural selection is a factor, it is one of minor importance compared to the inheritance of acquired modifications. We will turn now to a very brief consideration of each of these factors.

Factors of Organic Evolution, Variation.—Variation may be defined as deviation from the type of the species, race, or family, or from whatever may be taken as the standard. Without variation there could be no change of type, and variation must, therefore, be at the basis of every theory of evolution.

So long as species were regarded as fixed, immutable objects of nature variations were generally disregarded. Thus, when Darwin began to collect data on the subject he found few recorded observations. While he succeeded in finding much evidence of variability in domestic races, he supposed variations of wild races to be relatively infrequent and slight in amount. Wallace was the first to point out that wild species are frequently highly variable. During the past decade a great deal of attention has been paid to variation, and a considerable amount of literature has accumulated on the subject.

It has been found that all characteristics of organisms are subject to variation. Some variations are *congenital*, that is, apparently independent of the environment; while others are *acquired modifications* due to a reaction of the organism to a definite factor in the environment.

Variations may be *abnormal*, that is, wide and infrequent departures from the type, such as the horticulturists call *sports;* or they may be *normal*, occurring in varying degrees in a majority of the individuals of the species, as, for example, variations of stature in man.

The first quantitative measurements of variation were made by J. A. Allen in 1871. Galton a little later introduced the statistical treatment of variations, and Pearson has shown how they may be subjected to accurate mathematical analysis. The subject will be treated here only so far as may be necessary for the understanding of natural selection. (For more extended treatment, see article *Variation.*)

Most persons regard "chance" as something entirely apart from law—something which cannot be predicted. But the mathematicians have shown long ago that chance is subject to strict mathematical laws. Single events cannot be predicted, it is true, but the general result can be predicted with certainty. For example, Weldon has published the results of four series of experiments in throwing dice. In each series there were 4,096 throws of 12 dice, and at each throw the number of dice having more than three points on the upper side were counted and recorded. The frequency with which 1, 2, 3, etc., dice showed more than three points was tabulated—and the results, when plotted, were found to follow very closely the theoretical curve of chance, which is described by an exact mathematical formula. Now it is found in a large number of cases that the variations in the characters of organisms which can be determined accurately—by counting, as the number of ray flowers in the daisy; or by measurement, as the length of a man's head—when tabulated and plotted occur with the frequencies predicted by the law of chance. So we may say that normal variations occur, as a rule, by chance.

This is best illustrated by an example. In the course of investigations carried on under the direction of the writer, measurements were made of the width of the angle at the apex of the shell in ninety-seven specimens of *Purpura lapillus*, a marine snail common on the New England coast. The results were tabulated as follows:

	Classes.				
Width of angle in degrees ..	60–65	65–70	70–75	75–80	80–85
Frequency	3	21	45	24	4

These results may be represented graphically by the five rectangles in Fig. 1945, where the limits of the class

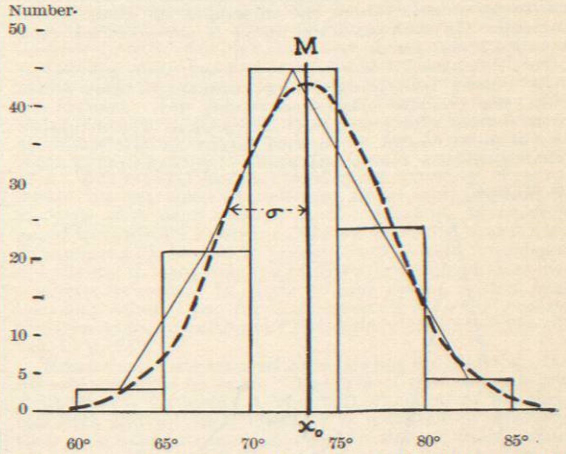

FIG. 1945.—Graphic Representation of a Series of Variations. Variation in the width of the angle at the apex of the shell in *Purpura lapillus*.

are represented by the width of the rectangle, and the height represents the number of individuals included, or its frequency. It will be noticed that the middle rectangle is the highest and, therefore, represents the most frequent class. This has been called the *mode*, or model class, and may be taken as representing the *type* of apical angle for the species. It will be noticed also that the classes having the least frequency are those farthest removed from the mode. By some easy mathematics one may readily obtain the general average, or arithmetical *mean*, of all the measurements, which in this case is