the full significance of the observations of Darwin, Wagner and their compeers. It is then found that the distribution of species in space is intimately connected with their succession in time; that the animals which occur in a determinate locality at present, closely resemble extinct animals which inhabited the same locality in ages long past, and hence the inference the naturalist draws, that existing types in a given area are genetically related to antecedent types of the same area. Thus, the marsupials which now inhabit Australia are allied to their fossil predecessors in the same part of the world. Similarly, the sloths, ant-eaters and armadillos now found in South America, are intimately related to numerous fossil forms which have been brought to light in this part of the Western continent.

Indeed, it is just such facts as these which impelled Darwin and others to conclude, that existing species must have originated by derivation from antecedent species, and that the divers species of any given area are but modified descendants of species long extinct.

"I was so much impressed with these facts," declares Darwin, "that I strongly insisted, in 1839 and 1845, on this 'law of succession of types,' on this wonderful relationship in the same continent, between the dead and the living! Prof. Owen subsequently extended the same generalization to the mammals of the Old World. We have the same law exhibited in his restoration of the extinct and gigantic birds of New Zealand. We see it also in the birds of the caves of Brazil. Mr. Woodward

has shown that the same law holds good with sea-shells, but from the wide distribution of most mollusca it is not well displayed by them. Other cases could be added, as the relation between the extinct and living brackish-water shells of the Aralo-Caspian sea."[1]

It is no explanation of the facts of geographical distribution to say that species are specially adapted to the habitats in which they are found; that South America, for instance, is especially fitted for edentates, and Australia for marsupials. "That it is not the suitability of organisms to the areas which they inhabit that has determined their creation upon these areas, is," says Romanes, "conclusively proved by the effects of the artificial transportation of species by man. For in such cases it frequently happens, that the imported species thrives quite as well in its new as in its old home, and indeed often supplants the native species. As the Maoris say: 'As the white man's rat has driven away the native rat, so the European fly has driven away our fly, so the clover kills our fern, and so will the Maori himself disappear before the white man.'"[2]

The Demonstrative Evidence of Evolution.

We come now to what Huxley designates specifically "the demonstrative evidence of Evolution," the evidence based on the lineal succession of several carefully-studied types, and above all, the

[1] "The Origin of Species," vol. II, p. 121.
[2] "Scientific Evidence of Organic Evolution," chap. IV.

evidence based on the ancestors of the horse discovered by Marsh and others. So strong, indeed, is this evidence considered, that it has been said that if the theory of Evolution had not existed before, "paleontology would have been compelled to invent it, so clearly are the traces of it to be seen in the study of Tertiary mammalia discovered since 1859."

According to Prof. Huxley, "the primary and direct evidence in favor of Evolution can be furnished only by paleontology." Again he avers that: "The only perfectly safe foundation for the doctrine of Evolution lies in the historical, or rather archæological evidence, which is furnished by fossil remains, that particular organisms have arisen by the gradual modification of their predecessors." He tells, too, that "On the evidence of paleontology, the Evolution of many existing forms of life from their predecessors is no longer a hypothesis, but a historical fact; it is only the nature of the physiological factor to which that Evolution is due which is still open to discussion."[1]

But what about the pedigree of the horse? What about those ancestral equine forms about which so much has been said and written?

The ancestors of the horse, as revealed by the discoveries of Marsh and others, are "*Protohippus* or *hipparion*, which is found in the Pliocene; *miohippus* and *mesohippus*, found in the Miocene; *orohippus* in the Eocene; and *eohippus*, at the base of the Eocene. In the *protohippus* each foot has three well-formed digits; *miohippus*, in addition to this, has a

[1] "Encyclopædia Britannica," vol. VIII, p. 751.

rudimentary metacarpal bone of a fourth digit in the fore-foot; in *mesohippus* this rudimentary metacarpal bone is more fully developed; in *orohippus* there are four well-developed digits in the fore-foot, three in the hind-foot; while in *eohippus* five digits are present. Thus, this series of fossil forms furnishes a complete gradation, from the older Tertiary forms with four toes, up to the horse with one toe. These forms differ not only as regards the number of toes, but also in other respects, chiefly in the gradual diminution and loss of independence of the ulna and fibula, and in the gradual elongation of the teeth and increasing complexity of the grinding surfaces."[1]

Another interesting example frequently cited, of transitionary forms, is the fossil, *planorbis*, found in the bed of an old lake near the small village of Steinheim, in Wurtemberg. In the successive strata of this lake bottom occur an immense number of shells of divers forms, and all from a few varieties of one and the same species. In passing from the lowest to the highest layers a great modification of forms is observed, so much so, indeed, that were it not for the countless intermediate forms one should unhesitatingly say that the extreme forms belong, not only to different species, but even to different genera. As it is, however, the gradations are so insensible that the conclusion is almost irresistible

[1] "Lectures on the Darwinian Theory," by Dr. A. M. Marshall, p. 67. For an interesting discussion with diagrams, of this remarkable series of ancestral equine forms, see the third of Huxley's "Lectures on Evolution," entitled The Demonstrative Evidence of Evolution.

that the various species observed are, at least in this case, originated by derivation with modifications.[1]

The case just adduced is frequently appealed to by evolutionists, not only because it has been exhaustively studied, but also because it tells so strongly in favor of the theory of derivation.

An equally striking instance, perhaps, is found in the case of another group of mollusca belonging to the *paludina*. At first, the six or eight known gradational forms of this mollusc were reckoned as entirely distinct species. Subsequently, however, numerous connecting forms were discovered, so that now over two hundred varieties are counted. But so gradual are the transitions of one form into another, that shells which otherwise would be considered as belonging to different genera are, by reason of the known connecting links, regarded as constituting but one and the same species.[2]

Similar gradations have been shown by Cope to exist among certain extinct mammalian forms, notably among the species of the generalized family, *oreontitæ*, but it is unnecessary to give further illustrations of this character, as those just instanced are quite sufficient to exhibit the nature and force of the argument which is based on the existence of such gradational forms.

---

[1] Cf. A. Hyatt's "Anniversary Memoir of the Boston Society of Natural History, 1880, on Genesis of Tertiary Species of Planorbis at Steinheim."

[2] Cf. Romanes' "Darwin after Darwin," vol. I, p. 19.

Generalized Types.

Confirmatory of the argument founded on the remarkable series of transitional forms we have just been considering, are those curious extinct animals called by Huxley generalized, and by Dana, comprehensive types; types which by Agassiz were variously designated as combining, connecting, synthetic and prophetic types, and which embrace those strange creatures that embodied the characters of two or more groups at present widely separated from each other. Among these were certain early vertebrates which possessed both fish-like and reptilian characters. At a later geologic epoch there existed other animals, which possessed the characters of reptiles and birds in such a curious combination, that we are yet unable to decide whether they should be called reptilian birds or bird-like reptiles. Among these generalized types there were, in the words of Grant Allen: "Lizards that were almost crows, marsupials that were almost ostriches, insectivores that were almost bats, rodents that were almost monkeys." "Just on the stroke, when they were most needed," declares the same writer, "connecting links turned up in abundance between fish and amphibians, amphibians and reptiles, reptiles and birds, birds and mammals, and all of these together in a perfect network of curious cross-relationships."

Among these generalized forms may be mentioned the *archæopteryx*, the *pterodactyl* and the *compsognathus*. "In the *archæopteryx*," says Huxley, "we have an animal which, to a certain extent, occupies a midway place between a bird and a

reptile." The *pterodactyl* was a reptile which was avi-form and capable of flying. The *compsognathus*, like the *archæopteryx*, was intermediate in form between a reptile and a bird, but was probably rather an avian reptile than a reptilian bird.

Again we have such fossil vertebrates as Cuvier's *anoplotherium*, which was intermediate in character between pigs and ruminants; the *palæotherium* which connected together such dissimilar animals as the horse, the tapir, and the rhinoceros. More remarkable still are the generalized types known as the *condylarthra*, the primitive form of which Cope considers the common ancestor of all true mammalia.[1]

And so we might mention other synthetic types brought to light by Gaudry, Rütimeyer, and other paleontologists. It was, indeed, M. Gaudry's researches in Attica, where he discovered an extraordinary number of gradational forms among the higher vertebrates, which convinced him that Evolution is the only theory that is competent to explain the existence of those remarkable connecting types which are every day, thanks to the investigations now conducted throughout the world, becoming more numerous and marvelous. "A few strokes of the pick-axe at the foot of Mount Pentelicus," says the eminent French savant, "have revealed to us the closest connecting links between forms which before seemed very widely separated."

How much closer and more remarkable these links will become with the progress of research, when

[1] Cf. "Origin of the Fittest," pp. 343, et seq.

the as yet vast and unexplored regions of the earth shall have yielded up a portion of their fossil treasures, can easily be divined. Already the generalized fossil types which have been discovered, have completely revolutionized all systems of classification which were based on existing specialized forms. For, by tracing the widely separated groups of the present back to past geologic time, we find that the specialized types of our day gradually converge towards, and merge into, the generalized types long since extinct. Species the most diverse gradually approach each other, and eventually unite to form common branches, and these again coalesce in a common trunk.[1]

And this is just what the theory of Evolution demands. For, "If the theory of Evolution be true," says Huxley, "it follows that however diverse the different groups of plants and of animals may be, they must all, at one time or other, have been connected by gradational forms; so that, from the highest animals, whatever they may be, down to the lowest speck of protoplasmic matter in which life may be manifested, a series of gradations, leading from one end of the series to the other, either exists or has existed."[2]

[1] "Hence," declares Huxley, in his article on Classification in the Encyclopædia Britannica, "it follows that a perfect and final zoölogical classification cannot be made until we know all that is important concerning: 1, the adult structure; 2, the personal development; 3, the ancestral development of animals. It is hardly necessary to observe that our present knowledge, as regards even the first and second heads, is very imperfect; while as respects the third it is utterly fragmentary."

[2] "Lectures on Evolution," Lecture II.

Probability of Evolution.

Such, then, in brief, is the argument in favor of Evolution from classification, morphology, embryology, geographical distribution and geological succession. The argument, as based on any one of these four classes of facts, is strong, and to many, if not most contemporary naturalists, conclusive. But when we consider the joint effect of the argument built on the four classes of facts, and note in detail the perfect harmony, the argument becomes still stronger and, to all appearances, irrefragable. The evidence furnished by one class of facts corroborates and explains those offered by the others, and thus the cumulative force of the testimony, given by all the four classes, renders the theory, to say the least, in the highest degree probable. We may not be prepared to admit that the theory has the force of a demonstration. If it had, organic Evolution would cease to be any longer a matter of scientific inquiry and would at once become a matter of scientific fact.

But although Evolution is but a theory, and not a demonstration, a probability and not a certainty, it nevertheless possesses for the working naturalist a value that can be fully appreciated only by those who have labored in the museum and in the laboratory. "Probability," Bishop Butler tells us, "is the guide of life." It is no less truly the guide of science, and a highly probable theory often contributes as effectually towards the advancement of science and the acquisition of truth as would a demonstrated fact.

From what precedes it is evinced, that Evolution as a theory, to claim no more for it, is in the highest degree probable. It is, in fact, the sole natural explanation of the facts discussed; the sole theory that is in accordance with what Sir William Hamilton calls the law of parsimony; a law which was fully recognized by Fathers and Scholastics when they taught that we should not invoke the action of supernatural causes, when natural agencies are adequate to account for the facts and phenomena observed.

Special Creation and Evolution.

Special creation, as an explanation of the multitudinous forms of life with which the earth teems, and has teemed during long æons past, is but an assumption, and an assumption, too, that has no warrant outside of the individual opinions of certain commentators of Scripture; opinions which, by the very nature of the case, can carry with them no greater weight than would attach to the views of their authors on any other question of natural science. As to Scripture itself, and the teaching of the Fathers and Doctors of the Church, we shall see in the sequel that their testimony is as strongly in favor of derivative creation, Evolution under the Providential guidance of natural causes, as it possibly can be in favor of the old and now almost universally discarded theory of special creations.[1]

[1] "En paléontologie," declared the Abbé Guillemet before the International Catholic Scientific Congress at Brussels last year, "les inductions évolutionistes expliquent sans peine par la descendance d'ancêtres communs ces *enchaînements* si bien mis

As a theory, Evolution certainly reposes on as firm a foundation as do the atomic theory of matter and undulatory theory of light, or as does Newton's theory of universal gravitation. And as these theories have been of priceless service to the chemist, the physicist and the astronomer, in the study of their respective sciences, so also has Evolution been of untold value to the naturalist, in enabling him to coördinate a vast body of facts, that else were naught but a stupendous chaotic mass. It has proved to him to be an "open sesame" to many of nature's secrets, and like the clue of Ariadne, it has enabled him to find his way out of the bewildering labyrinth in which every true student of nature must pass at least a portion of his existence.

It is said that "a striking corroboration of a scientific theory is furnished when it enables us correctly to *predict* discoveries." Judged by this standard Evolution can compare favorably with the best accredited theories of modern science. It will suffice to refer to but two cases in point, although it were easy to adduce numerous others.

---

en evidence par des savants spiritualistes et chrétiens, tels que D'Omalius d'Halloy et Albert Gaudry, et dont M. de Nadaillac nous a concédé la réalité. Le fixisme, au contraire, en est réduit à invoquer une filiation intellectuelle dans la pensée du Créateur, une sorte d'évolutionisme idéal. On comprend cela pour un architecte humain, qui ne peut pas tirer une cathédrale d'une cathédrale sinon par imitation. Mais celui dont 'les dons sont sans répentance' detruira-t-il sans cesse ce qu'il a créé pour recréer à nouveau ? Ne préférera-t-il pas conserver à ses créatures une vie renouvelée et rajeunie dans une descendance qu'il perfectionnera de génération en génération, récompensant par l'ascension de fils la fidélité des progéniteurs à leur lois naturelles." "Compte Rendu," Section d'Anthropologie, p. 27.

In the first edition of his "Origin of Species" Darwin wrote: "We may thus account even for the distinctness of whole classes from each other—for instance, of birds from all other vertebrated animals, by the belief that many animal forms of life have been utterly lost, through which the early progenitors of birds were formerly connected with the early progenitors of other vertebrate classes."

At the time this prophecy was made there was no positive evidence of the existence of such intercalated forms as Darwin required. Three years later the *archæopteryx* was discovered, meeting completely all the requirements of theory. Subsequent discoveries, notably by Marsh, disclosed other transitional forms which "bridge over the gap between reptiles and birds, in this sense, that they enable us to picture to ourselves forms from which both birds and reptiles as we know them could have sprung."

In his lecture on the Evolution of the horse, in 1876, Prof. Huxley spoke as follows: "Thus, thanks to these important researches [those of Marsh and other paleontologists], it has become evident that so far as our present knowledge extends, the history of the horse type is exactly and precisely that which could have been predicted from a knowledge of the principles of Evolution. And the knowledge we now possess justifies us completely in the anticipation that, when the still lower Eocene deposits, and those which belong to the Cretaceous epoch, have yielded up their remains of ancestral equine animals, we shall find first, a form with four complete toes,

and a rudiment of the innermost or first digit in front, with probably a rudiment of the fifth digit in the hind foot; while in still older forms the series of the digits will be more and more complete, until we come to the five-toed animals, in which, if the doctrine of Evolution is well founded, the whole series must have taken its origin."

Only a few months after this declaration, Prof. Marsh unearthed in the Eocene deposits of the West an equine animal, *eohippus*, having four complete toes and a rudimentary one in the front foot, thus making good the first part of the prophecy. As to the remaining part, it is, for men of science, only a question of time until it, too, sees its fulfillment.

But the theory of Evolution enables not only paleontologists, but also morphologists and embryologists, to predict the unseen and unknown. And this, to say no more, is certainly a strong substantiation of its truth. For we can ask no more of a theory than that it accord with the facts it is designed to explain. And the more perfectly the theory harmonizes with the facts observed, the more nearly is it demonstrated, so far as any purely inductive conclusion can be demonstrated.

The theory of organic Evolution may not, as yet, be susceptible of an experimental demonstration—although there are not wanting those who think such a demonstration is forthcoming, if, indeed, it has not already been furnished—but it unquestionably occupies a high rank among the best accredited theories of contemporary science. It seems, even now, to repose on as firm a basis as did the Copernican theory

in the days of Galileo and Tycho Brahe. For Evolution, like the heliocentric theory, is in perfect harmony with all the manifold facts which it is designed to integrate and interpret. How long will it be before it passes from a theory to a demonstration? Or, will it ever be demonstrated in such wise as to command the assent of all who are capable of weighing evidence, and discriminating between a scientific fallacy and a legitimate scientific induction? These are questions which only the future can answer. Judging, however, by the progress which has been made during the past half century towards the solution of many of the problems which have been discussed in this chapter, it does not seem unreasonable to express the belief that it is only a question of time, and probably not a very long time, until the theory of organic Evolution shall be as firmly established as is now the Copernican one of the solar system.