

species of this character had their habitat in the district, and in its vicinity, the only tangible evidences which we yet possess that they ever existed, are the tracks and foot-prints which they left in the shales and sandstones of Connecticut and New Jersey.

In other cases, again, all that has so far been discovered of what, in their time, were manifestly important species, is a single tooth, or a single bone, or even only a small fragment of bone. That future research will disclose remains of these species, in larger quantities or in greater numbers, there is reason to believe, but however rich the finds may be, it will always be true that the fossils which have been preserved are but an insignificant portion of those which were actually formed, and that the remains of organisms which were fossilized were but an infinitesimal part of those which were completely destroyed before fossilization was possible.

Darwin's observations on sessile cirripeds corroborate in the most striking manner what has been stated in the preceding paragraphs, and show how a large group of animals, represented by an extraordinary number of individuals all over the world, in every latitude and "inhabiting various zones of depths from the upper tidal limit to fifty fathoms," may fail to leave even a trace of their existence during long geological periods. "Not long ago, paleontologists maintained that the whole class of birds came suddenly into existence during the Eocene Period; but now we know, on the authority of Prof. Owen, that a bird certainly lived during the Upper Greensand; and still more recently that strange bird, the

archæopteryx, with a long lizard-like tail bearing a pair of feathers on each joint, and with its wings furnished with two free claws, has been discovered in the Oölitic slates of Solenhofen. Hardly any recent discovery shows more forcibly than this how little we as yet know of the former inhabitants of the world."¹

Another important fact we should not lose sight of is, that as yet but a comparatively small portion of the earth has been explored by geologists. The formations of the earth in North America are fairly well known, but even in these portions of the world there is still much to be learned. As to South America, Asia, Africa, Australia, they are for the most part *terra incognita* to the paleontologist. Such being the case it were foolish in the extreme to dogmatize on the sequence of organic forms in past geologic time, or to attempt to base an argument against Evolution on the absence of certain transitional types and on the consequent imperfection of the record so far at our disposal.

It has been estimated that not so much as one per cent., of the countless species of animals which have flourished since the first dawn of life, has left the slightest trace of its past existence. Marine forms, as might be expected, are better represented than land forms. Indeed there are not wanting those who assert, that of terrestrial types not more than one species in a thousand is represented by known fossils.

¹"The Origin of Species," vol. II, pp. 79 and 80.

Extraordinary Intercalary Forms.

But in spite of the rarity of fossils in comparison with the almost infinite number of individuals represented; in spite of the paucity of fossil species as compared with the total number which must have existed since the advent of life; in spite of the limited area of the earth which has so far been explored by the paleontologist, there are, as indicated in the preceding chapter, many examples of intercalary forms of the most extraordinary character. And all the instances adduced, be it remembered, constitute so much positive evidence in behalf of the theory of organic Evolution. The absence of transitional varieties in certain formations is, at best, but negative evidence, and such evidence is of but little value, or rather it is of no value, in face of all the positive evidence which recent research has brought to light. Thanks to the discoveries of Gaudry, Marsh, Cope and others, the number of intermediate forms has, within the past few years, been wonderfully augmented, and there is every reason to believe that future exploration will, in like manner, contribute towards filling up many of the lacunæ which at present are pointed to as difficulties in the way of yielding rational assent to the current theory of transformism.

"Indeed, it may be asserted," Prof. Fiske truthfully observes, "as one of the most significant truths of paleontology, that extinct forms are almost always intercalary between forms now existing. Not only species, genera and families, but even orders of

contemporary animals, apparently quite distinct, are now and then fused together by the discovery of extinct intermediary forms. In Cuvier's time, horse, tapir, pig and rhinoceros were ranked as a distinct order from cow, sheep, deer, buffalo and camel. But so many transitional forms have been found in Tertiary strata, that pachyderms and ruminants are now united in a single order. By numerous connecting links the pig is now seen to be closely united with the camel and the antelope. Similar results relating to the proboscideans, the hyena family of carnivora, the apes, the horse and the rhinoceros, have been obtained from the exploration of a single locality near Mount Pentelicus in Greece. Among more than seventy species there discovered, the gradational arrangement of forms was so strongly marked, that the great paleontologist, M. Gaudry, became a convert to Mr. Darwin's theory in the course of the search."¹ Indeed, so much was M. Gaudry, who renews in our own day the triumphs of Cuvier in paleontology, impressed by the fossil remains of Greece and the transitional forms of other lands, that he did not hesitate thirty years ago to declare, that "the more we advance and fill up the gaps, the more we feel persuaded that the remaining voids exist more in our knowledge than in nature. A few blows of the pick-axe at the foot of the Pyrenees, of the Himalayas, of Mount Pentelicus; a few diggings in the sand-pits of Eppelsheim or in the Mauvaises Terres of Nebraska, have revealed to us the closest connecting links

¹ "Cosmic Philosophy," vol. II, pp. 40 and 41.

between forms which seemed before so widely separated. How much closer will these links be drawn when paleontology shall have escaped from its cradle."¹

Imperfection of the Geological Record.

What precedes supplies us with an answer regarding two great difficulties on which anti-evolutionists have always laid special stress. These difficulties, briefly stated, are the sudden apparition of whole groups of allied species in certain formations, even in the lowest fossiliferous strata, without any previous transitional forms leading up to such groups, and the occurrence in geological time of numerous animal forms of a much higher grade than an evolutionist should antecedently expect.

From what has already been said not only respecting the absence of countless species, but also of the denudation of immense areas which must at one time have been rich in important fossiliferous deposits, it is manifest that the objection is at best but a neutral one, and as such may be dismissed as in nowise seriously affecting the contention of evolutionists. Regarding the appearance in the earlier strata of animals which are zoologically of a higher grade than the principles of Evolution would lead one to look for, it may be said in reply that the objection urged proves, at most, that the imperfection of the geological record is even more extensive than it has usually been thought to be, and, likewise, that the advent of

¹ "Les Animaux Fossiles de Pikermi," p. 34.

life on the earth must date back much farther than is commonly thought. Not long since, it was the general opinion, that the first living organisms had their origin in the lower strata of the Silurian Age, but since then the Cambrian, the Huronian, and the Laurentian formations have been discovered, the united thickness of which, according to the eminent geologist, Sir W. Logan, "may possibly far surpass that of all the succeeding rocks from the base of the Palæozoic series to the present time," and may, therefore, carry us back to a period so remote, that the oldest Silurian fauna may in comparison be regarded as comparatively modern. So far as the information of paleontologists now extends, *Eozoön Canadense*, found even in the lowest deposits of the Laurentian, was the earliest form of life, but it is not impossible that in yet lower strata, beneath the ocean's floor perhaps, there are still more primitive types which as much antedate the time of *Eozoön Canadense*, as it antedates the advent of the last highest vertebrate.

Time, Change and Equilibrium.

But, it will be objected that the existence of such formations implies far more time than geologists can reasonably claim, far more than can be allowed by the almost certain conclusions of thermodynamics and astronomical physics. In reply it will suffice to observe, that much, very much, yet remains to be learned, concerning the time which has elapsed since the earth became a fit abode for the lower forms of life, and that until physicists, astronomers

and mathematicians can agree among themselves, as to the data on which they base their calculations, and until they can furnish more satisfactory results than they have hitherto offered, geologists will be quite within their right in regarding the objections urged as negative or indifferent.

In all discussions relating to the ascent of life and the paucity of transitional forms, we should not lose sight of the fact that ours is a period of tranquility, and that, therefore, in accordance with the principles of Evolution, there should now be fewer changes in the fauna and flora of the earth than during periods of change and widely-extended disturbance. But the earth has not always been so stable and tranquil. During the inconceivably long interval which has elapsed since the first beginnings of life on our globe, there have been countless periods of equilibrium alternating with changes which were more or less paroxysmal. The last of these critical epochs was during that long stretch of time, known as the Glacial Period, when ice and snow reigned supreme over a great portion of Europe and North America. And during these long geologic rhythms, these alternations of upheaval and subsidence, of denudation and sedimentation, during these periods of comparative tranquility and almost cataclysmal mutation, there were alternately periods which in the one case favored the permanence of species, and in the other were conducive to their rapid metamorphosis, and to the speedy production of intercalary forms which connected all the links of living organisms in one grand unbroken chain.

Paleontology Compared with Egyptology and Assyriology.

The work of the paleontologist resembles in great measure the work of those who, from fragmentary and unpromising materials, have revived for us the histories, so long buried in oblivion, of those great nations of the Orient which erstwhile flourished amid such splendor on the banks of the Nile, the Tigris and the Euphrates. In the beginning of the present century the history of Egypt was almost a sealed book, and as to Chaldea, Assyria and Babylonia, it could be affirmed, and with truth, scarcely yet a generation ago, that many of the most important features of their respective histories had little more for a basis than myth and conjecture. But thanks to the labors and discoveries of Champollion, Lassen, Burnouf, Rawlinson, Layard, George Smith, Mariette, Maspero, and their compeers, the mysterious hieroglyphics and curious cuneiform characters have been deciphered, and the treasures of knowledge so long concealed by them have been opened up to the world. In Egypt, temples and tombs have been searched for records bearing on the past. Pyramids and obelisks, sphinxes and cartouches, have been carefully scrutinized and compelled to give up their secrets to the persistent and determined votaries of history and science. And so, too, it has been in Mesopotamia and in the territory adjacent. From the Persian Gulf to the site of ancient Nineveh, from Tyre and Sidon to glorious Palmyra, the pick and the spade of the archæologist have been busy, especially during the past four decades, and the result has been that we now have more complete and

more accurate information respecting peoples who lived four and five thousand years ago, than we have in regard to the inhabitants of many of the most powerful nations of Europe during periods which carry us back but a few hundred years. Rolls of papyrus and mummy cases, tablets and cylinders, which were once but so many meaningless objects for the curious, have been converted into trustworthy records regarding an almost forgotten past. Seti and Rameses, Sennacherib and Assurbanipal live again, and in all their salient features they come before us with fully as much distinctness as do the historic and romantic figures of Charlemagne and Cœur de Lion.

Thus, likewise, is it in respect of paleontology. Thanks to the discoveries and labors of Cuvier, Smith, Sedgwick, Hugh Miller, Murchison, Hall, Barrande, Gaudry, Marsh, and a host of other successful students of nature, who have consecrated their lives to the work of collecting and coördinating the testimony of the rocks, we have now light where before all was darkness; we have knowledge where all was mystery. And though paleontology, like Egyptology and Assyriology, is still in its infancy, it has, nevertheless, already achieved marvels. From a few scattered fragments, the *disjecta membra* of organisms long since extinct, it has constructed for us a history which embraces periods of such duration, that in comparison with them the long dynasties of the Pharaohs sink into positive insignificance. It tells us the story of life from its humblest beginnings till the advent of man, the paragon of God's visible universe. It

shows us the grand unity of plan which has characterized the fauna and flora of the world, and exhibits to our view the direction Evolution must have taken in its progress from the simple to the complex, from the general to the special, from the primitive monad to the highest vertebrate. Like the records of the Egyptologist and the Assyriologist, those of the student of the past history of the earth have been imperfect and fragmentary in the extreme, but, notwithstanding this, and notwithstanding the enormous gaps which are everywhere discernible, the paleontologist has been able to give us an account which, considering the difficulties under which it has been written, all thoughtful minds must recognize as singularly complete and satisfactory, even in many of its details.

Darwin, in closing his interesting chapter on the imperfection of the geological record, makes a comparison which so beautifully illustrates the character of the materials from which the paleontologist must weave his story of the earth and its former inhabitants, that I reproduce it here in his own words: "For my part, following Lyell's metaphor, I look at the geological record as the history of the world, imperfectly kept and written in a changing dialect. Of this history we possess the last volume alone, relating only to two or three countries. Of this volume, only here and there a short chapter has been preserved; and of each page, only here and there a few lines. Each word of the slowly-changing language, more or less different in the successive chapters, may represent the forms of life, which are entombed in our

consecutive formations, and which falsely appear to have been abruptly introduced. On this view the difficulties above discussed are greatly diminished, or even disappear."¹

Sterility of Species when Crossed.

The third objection against Evolution, the last one we shall consider, is based on the sterility of species when crossed and on the infertility of hybrids. The argument as usually advanced appears well-founded, and is, it must be confessed, not without its difficulties.

According to anti-evolutionists species have been rendered barren by a special provision of nature, in order thereby to prevent confusion which would result from intercrossing. So convinced, indeed, was Frederick Cuvier, the brother of the illustrious paleontologist, of this view, that he did not hesitate to declare: "Without the employment of artificial means or without derogation to the laws of Providence, the existence of hybrids would never have been known." And Dufrenoy affirmed that "animals instinctively mate with individuals of their own species only, and avoid those of others, as they instinctively select food and eschew poison."

"In fact," writes De Quatrefages, who to the day of his death was opposed to the transmutation theory, "if in the organized world there exists anything which ought to strike the superficial observer, it is the order and constancy which we see there reigning during the past ages; it is the distinction which is maintained among those groups of beings

¹"The Origin of Species," vol. II, p. 88.

which Darwin and Lamarck, like ourselves, call species, even when in general form, function, instinct and habit, they resemble one another so closely that their discrimination is a matter of difficulty. Certainly the cause which maintains this order, this constancy over the entire surface of the globe, is of far greater importance than any mere particularity affecting individual life, or the simple local existence of a domestic race.

"Now, this cause is simple and unique. Suppress infecundity among different species; suppose that the unions among wild species were to become in every way fertile, and indefinitely so, as they are in our dove-cotes, cow-houses and dog-kennels among domestic races. And instantly what comes to pass? Barriers separating species and genera are taken away; crosses are effected in all directions; everywhere intermediate types make their appearance, and everywhere existing distinctions are gradually effaced. As for myself, I cannot see where the confusion would end. Entire orders and probably even classes would, after a few generations, present nothing but a group of bastard forms of doubtful characters, irregularly allied and intercrossed, among which disorder would go on increasing, thanks to the mixture rendered more and more complete, and thanks to atavism which would doubtless struggle for a long time with direct heredity. This is not an imaginary picture. Every reader, when asked what will be produced by promiscuous unions among the one-hundred-and-fifty races of pigeons recognized by Darwin, and the one-hundred-and-eighty races of

dogs shown at our expositions, will certainly give the same answer as I do.

"Infertility among species, therefore, has, in the organic world, a rôle which is almost analogous to gravitation in the sidereal world. It preserves the zoölogical or botanical distance among species, as attraction maintains the physical distances among the stars. Both have their perturbations, their unexplained phenomena. But, has anyone called in question the great fact which fixes in their respective places both satellites and suns? No. And can one, on this account, deny the fact which assures the separation of species the most closely allied, as well as of groups the most widely separated? By no means. In astronomy we should reject incontinently every hypothesis in opposition to the first. And, although the complication of phenomena is much greater in botany and zoölogy, serious study will always lead us to discard all doctrines that are at variance with the second."¹

Infertility among distinct species, as De Quatrefages here views the matter, is thus seen to be demanded by the fitness of things. It is required for the harmony of animated nature, and is rendered necessary by the hopeless confusion which would result if such infertility did not exist.

But the argument from infertility, as urged against evolutionists, has even greater force when regarded from another point of view—I mean from the standpoint of fact. Evolution, it is alleged, is disproved, not because it seems fit and necessary

¹"Darwin et ses Précurseurs Français," pp. 259 and 260.

that species should be reciprocally sterile, but because of the fact of infecundity; because, so it is said, not a single instance can be cited of continued fertility among the hybrid offspring of any two species, however closely related. Here is the core of the difficulty, "*le fait*," as the Marquis de Nadaillac phrases it, "*qui domine toute la question*."¹ Evolutionists, say their opponents, confound species with race, assert of one what is true only of the other, pile hypothesis upon hypothesis, and ultimately deny the reality of species, or see in this fundamental group only an artificial combination.

Morphological and Physiological Species.

As is evident, we are here again confronted with the old question of the reality and permanence of species. And, unfortunately, most of the reasoning one is asked to follow on the subject is carried on in a vicious circle, or is based on assumptions which are wholly unwarranted. What is species? This is a question which again comes to the fore. Morphologically, many of the domesticated pigeons, of which Darwin makes mention, notably the pouter, the tumbler, the fantail, and the carrier, are so unlike

¹For a masterly presentation of the Marquis de Nadaillac's objections against Evolution, see his "*Problème de la Vie*," and "*Le Progrès de l'Anthropologie*," in the *Compte Rendu* of the International Catholic Scientific Congress at Paris, in 1891. For a critical examination of his views, see a paper on "*Création et Évolution*," by Dr. Maisonneuve, in the same *Compte Rendu*, Section of Anthropology, as also a paper entitled, "*Pour la Théorie des Ancêtres Communs*," by the Abbé Guillemet, in the *Compte Rendu* of the same Congress, held at Brussels in 1894.

each other that they would be regarded as belonging not only to different species, but even to different genera, did we not know that they are all descended from the ordinary rock pigeon, *Columba livia*. For these birds, Huxley tells us, "not only differ most singularly in size, color, and habit, but in the form of the beak and the skull; in the number of tail feathers; the absolute and relative size of the feet; in the presence or absence of the uropygial gland; in the number of the vertebræ in the back; in short, in precisely those characters in which the genera and species of birds differ from one another." And so it is with the different races of dogs. Whether they are all originally descended from one or more species is yet a moot question, although there is reason to believe that most, if not all of them, are descended from the wolf and the jackal. But be this as it may, when we compare the divers races of the domestic dog, when we observe how they differ in the number of their teeth, toes and vertebræ, and note the divergencies in the form and disposition of other portions of the body, we see that they are so unlike that if found in a state of nature they would unhesitatingly be pronounced distinct species. Even Cuvier was forced to admit, that the differences in the forms of the skulls of certain canine races are so great, as to justify one in assigning them to distinct genera.

What has been said of pigeons and dogs may also, in great measure, be iterated in respect of sundry races of fowls, rabbits, sheep and horses. Morphologically their differences are so marked, that

they should be reckoned not only as distinct species, but also as distinct genera, but because they are fertile when crossed *inter se*, they must be regarded, anti-evolutionists insist, as all belonging to one and the same species. And for this reason, too, we are told that the species of any given organism is to be determined, not by its form, but by its filiation. According to this view, therefore, the determining characteristic of species is not something morphological, as Tournefort opined, but rather something, as Ray and Flourens taught, which is physiological.

But even physiological species is not the constant quantity it is represented to be by anti-transformists. Infertility of species and of their hybrid progeny does not constitute the positive line of demarcation, so often claimed by the advocates of the immutability of specific forms. On the contrary, as Darwin and others have shown, "neither sterility nor fertility affords any certain distinction between species and varieties." Long-continued experiments, of the most ingenious character, have demonstrated beyond question that sterility in animals is not to be regarded as an indelible characteristic, but as one capable of being removed by domestication. And, observations on numberless groups of plants and animals have disclosed the remarkable fact, that "the degree of fertility, both of first crosses and of hybrids, graduates from zero to perfect fertility."

From the foregoing, then, it is evinced that physiological species present as many and as grave difficulties as do morphological species. If it be true,