Davidson's exhaustive researches on the brachiopods of the English formations, lead him to the same conclusions as those arrived at by Barrande after his prolonged studies of the trilobites and cephalopods of Bohemia, viz., that there is not the slightest trace of any tendency towards development on the part of the species examined.

Similar testimony is given by Mr. Williamson regarding fossil plants. After forty years of patient study of the vegetable remains of different geological ages, he does not hesitate to affirm that the ferns whose imprints are of such frequent occurrence in certain strata of the Carboniferous Age, have retained their essential characteristics until the present time. For, if we compare those which now abound in our forests with those which gave beauty to the landscape in Paleozoic time, we find that they have neither advanced nor retrograded.

It were easy to add to the list of persistent types of animals and plants, of those, namely, which endured unchanged during long geologic periods. I might speak of the terebratulæ and globigerinæ which take us back to the Cretaceous Period; of certain types of scorpions which flourished during the Carboniferous Age and which are scarcely distinguishable from modern scorpions; of the lingulæ and lingulellæ which, appearing in the lower Silurian rocks, have persisted practically unchanged through all the grand climacterics of the world.[1]

[1] For able and dignified discussions of the questions here considered, see "Paléontologie et Darwinisme," by the eminent Belgian geologist, Charles de la Vallée Poussin, in the "Revue de Questions Scientifiques" for January, 1877, and "Le Transformisme et la Discussion Libre," in the same review for January and April, 1889, by De. Kirwan, who writes under the pseudonym of Jean d' Estienne.

In the preceding pages I have presented fully, and somewhat in detail, one of the stock arguments of anti-evolutionists against the transmutation of species. I have allowed the ablest and most noted opponents of the Evolution theory to present their objection in their own words, and have endeavored to select what have always been considered the most telling arguments against transpeciation. What, now, is the answer to the objection, or is any answer possible? What explanation can be given of facts which seem so utterly irreconcilable with the cardinal principles of Evolution, and so antagonistic to the fundamental tenets of the leading exponents of transformism.

Misapprehension of the Nature of Evolution and Answer to Objections.

The objection, as presented, rests on a total misapprehension of the nature of Evolution. It assumes that when an animal or a vegetable form once comes into existence, it must necessarily and continuously undergo progressive modifications. It assumes, too, that such modifications as may occur, must take place at the same rate in one form of life as in another. Both these postulates are equally unwarranted, for they are both totally at variance with Evolution as understood by its founders and approved spokesmen.

An answer, however, to the objection, was indicated nearly a century ago by Cuvier's great con-

temporary, Lamarck. Replying to the argument based on the unchanged condition of the fauna and flora of Egypt, he observed that "the animals and plants referred to had not experienced any modification in their specific characters, because the climate, soil and other conditions of life had not varied in the interval. But if," he continued, "the physical geography, temperature and other natural conditions of Egypt, had altered as much as we know they have done in many countries in the course of geological periods, the same animals and plants would have deviated from their pristine types so widely as to rank as new and distinct species."[1]

This answer of Lamarck's is, with some modifications, the answer which is now given by men of science to the objection under consideration. Whenever the environment remains unchanged, where the conditions of life are always identical, the fauna and flora of a given area may persist without any specific mutations for an indefinite period of time. Regarding Egypt it is notorious, that its climate and soil are to-day precisely what they were during the reign of the first of the Pharaohs, and precisely what they were when the bull Apis was led in solemn procession to the temples of Memphis and Heliopolis. As to other examples of animals and plants which have resisted specific change, not only during thousands, but also millions of years, the same answer may be given. The environment may have been modified more or less, but not sufficiently to effect

[1] "Philosophie Zoölogique," pp. 70, et seq.

transmutation of the species named. For it must be borne in mind, that all species are not equally susceptible of change in consequence of mutations of climate and physical geography. Some are more stable and more cosmopolitan than others, and hence are capable of accommodating themselves within certain limits to quite considerable changes in surrounding conditions, without exhibiting the slightest indications of specific transmutations.

Then, too, we have "elastic types," those types, namely, which as M. Gaudry tells us, have the power of undergoing greater or less modifications and of returning sooner or later to their original condition. The rhynconella is a case in point. When the ocean bed is in anywise modified, rhynconella exhibits a corresponding change; when the ocean returns to its original state, rhynconella reverts to its pristine condition. Thus, in virtue of its elasticity, of its facility of accommodating itself to changes of environment, this marvelous brachiopod has been able to pass unscathed through mutations and catastrophes innumerable.

Again, it may be observed, that the changes of environment are not always so great as they are sometimes imagined to be. Thus, the conditions of life in a given area of the ocean may remain practically unchanged for long geological periods. The temperature and depth of the water might easily remain constant for untold æons, and, in such an event, there is no reason why the ocean fauna should not endure without variation for an indefinite time.

Even in the case of the vegetable organisms which Mr. Carruthers puts in evidence, there is reason to believe that the variations in climate to which they have been subject, have been far less than is usually thought. We can say of these what Darwin asserts of certain Arctic forms, that "they will not have been exposed to any great diversity of temperature and, as they all migrated in a body together, their mutual relations will not have been much disturbed." [1] Where, however, Arctic species have been left stranded on Alpine areas by the retreat of glaciation, and where the species thus isolated have been subsequently exposed to differences of climate, and to the influences of foreign plants and insects, we would expect to discover evidences of transmutation, to find the stranded species to differ, not only from their parent Arctic forms, but to differ also from those of the same origin occurring on neighboring mountain ranges. And this is what Darwin tells us is the fact, "for if," he says, "we compare the present Alpine plants and animals of the several great European mountain ranges, one with another, though many of the species remain identically the same, some exist as varieties, some as doubtful forms or sub-species, and some as distinct, yet closely allied species, representing each other on the several ranges." [2]

In the instance just quoted, as in countless others that might be adduced, we have an illustration of a phenomenon with which all naturalists are

[1] "The Origin of Species," vol. II, p. 154.

[2] Op. cit. vol. II, p. 155.

familiar, to-wit, that some types, both of animals and plants, are more plastic than others. Those which are the most plastic most readily undergo specific transformation, whilst, on the contrary, those which are rigid experience little or no change, even when exposed to very considerable mutations of environment.

Existence and Cause of Variations.

Of the existence of variations, numerous and important, there can then be no reasonable doubt. This fact, long known, is daily corroborated by evidence which cannot be gainsaid. But the existence of variations must not be confounded with the cause which originates them, for this, as yet, is shrouded in mystery. Huxley admits this without hesitation and refers to it as follows: "The cause of the production of variations is a matter not at all properly understood at present. Whether variation depends upon some intricate machinery, if I may use the phrase, of the living organism itself, or whether it arises through the influence of conditions upon that form, is not certain, and the question for the present may be left open. But the important point is that, granting the existence of the tendency to the production of variations, then, whether the variations which are produced shall survive and supplant the parent, or whether the parent form shall survive and supplant the variations, is a matter which depends entirely on those conditions which give rise to the struggle for existence. If the surrounding conditions are such that the parent form is more

competent to deal with them, and flourish in them, than the derived forms, then in the struggle for existence the parent form will maintain itself and the derived forms will be exterminated. But if, on the contrary, the conditions are such as to be more favorable to a derived than to a parent form, the parent form will be extirpated and the derived form will take its place. In the first place there will be no progression, no change of structure, through any imaginable series of ages; and in the second place there will be modification and change of form." [1]

Paucity of Transitional Forms.

The second objection, like the preceding, is an obvious one, and at first sight equally plausible. It is based on the paucity of transitional forms, or "missing links," in the various sedimentary strata of the earth's crust. At first blush the objection seems to be fatal to the theory of Evolution, as it certainly would be fatal, if well founded, to the theory of natural selection, which supposes that species have advanced from lower to higher forms by infinitesimal increments. So much importance, indeed, does Darwin attach to this objection, that he devotes a whole chapter in his "Origin of Species" to its solution. And although he frankly admits that the geological record, so far as at present known, still opposes insuperable difficulties to his theory of natural selection, it does not follow, as we shall see farther on, that such difficulties can validly be urged

[1] "Science and Hebrew Tradition," pp. 83 and 84.

against the general theory of organic Evolution, as distinguished from Evolution through natural selection.

In the first place it is to be observed, that transitional forms are the first to become extinct in the struggle for existence; for it is well known that competition is more marked and devastating among intermediate or intercalated forms, than among forms which are more widely divergent. Thus, in philology it is remarked, that among a large number of dialects, certain closely allied ones die out, whilst others, more widely differentiated, become the dominant forms of speech. The means perish, while the extremes wax strong and end by attaining supremacy. Hence, of the countless dialects which in Italy, France and Spain had their origin in the Latin tongue, but three have attained to the dignity of a dominant language, and of being the vehicle of a national literature. These three are what are now known as the Italian, French and Spanish languages, the competing dialects having been worsted in the struggle for existence, and condemned to an earlier or later extinction.

A process quite analogous to this goes on among the divers forms of animated nature, the means showing themselves the weaker, and the extremes exhibiting themselves the stronger in the contest for supremacy. Commenting on this fact, Darwin writes as follows: "As the species of the same genus usually have, though by no means invariably, much similarity in habits and constitution, and always in structure, the struggle will generally be more severe

between them, if they come into competition with each other, than between the species of distinct genera. We see this in the recent extension over the United States, of one species of swallow, having caused the decrease of another species. The recent increase of the missel-thrush in parts of Scotland has caused the decrease of the song-thrush. How frequently we hear of one species of rat taking the place of another species under the most different climates! In Russia, the small, Asiatic cockroach has everywhere driven before it its great congener. In Australia, the imported hive-bee is rapidly exterminating the small, stingless, native bee. One species of charlock has been known to supplant another species; and so in other cases. We can dimly see why competition should be most severe between allied forms which fill nearly the same place in the economy of nature; but probably in no one case could we precisely say why one species had been victorious over another in the great battle of life."[1]

Variations and the Formation of Fossiliferous Deposits.

Then again, it must be observed that it is not probable that variation has been going on at a uniform rate during the long course of the life-history of the earth. On the contrary, it is more likely that long periods of stability have alternated with brief periods of disturbance of greater or less extent. During the former periods specific forms would experience comparatively little change, whereas, during the latter, variations would rapidly accumulate and be strongly

[1] "The Origin of Species," vol. I, pp. 93 and 94.

accentuated. Such being the case, the number of gradational forms will be far less numerous than the forms contained in the species which persist with little or no modifications during long cycles of time.

Furthermore, it is now generally admitted that the strata which are richest in fossils were usually, if not always, deposited during eras which were least favorable for the development of transitional forms, that is, during eras when variation and extinction were least rapid. On the theory that natural selection has been the dominant factor in Evolution; on the theory, namely, that progress has resulted solely, or at least chiefly, in consequence of the accumulation of infinitesimal increments, a condition of things must have existed during the formation of fossiliferous strata, which it is certain could have obtained only at extremely rare intervals. For, as Darwin points out: "In order to get a perfect gradation between two forms in the upper and lower parts of the same formation, the deposit must have gone on continuously accumulating during a long period sufficient for the slow process of modification; hence the deposit must be a very thick one, and the species undergoing change must have lived in the same districts throughout the whole time. But we have seen that a thick formation, fossiliferous throughout its entire thickness, can accumulate only during a period of subsidence; and to keep the depth approximately the same, which is necessary that the same marine species may live on the same space, the supply of sediment must nearly counterbalance the amount of subsidence. But this same movement of

subsidence will tend to submerge the area whence the sediment is derived, and thus diminish the supply whilst the downward movement continues. In fact, this nearly exact balancing between the supply of sediment and the amount of subsidence is probably a rare contingency; for, it has been observed by more than one paleontologist, that very thick deposits are generally barren of organic remains, except near their upper or lower limits."[1]

The foregoing are but a few of the reasons that might be assigned for the paucity of intermediate forms which characterizes the earth's fossil-bearing strata. When we come to reflect on the matter, however, the wonder is not that there is such a small number of gradational forms, but rather that there are any fossils at all. For everything has tended to render their formation impossible; and in the comparatively few instances in which circumstances have been favorable to the fossilization of animal or vegetable forms, a variety of circumstances has intervened to compass their destruction. Such being the case, therefore, we should be surprised, not at the existence of such extensive tracts that are utterly devoid of any traces of organic life, but rather at the fact that there are so many formations in different parts of the world which contain such a wealth of fossil remains.

For let us consider for a moment under what adverse conditions the slight vestiges of the fauna and flora of the ancient world have been preserved; what are a few of the agents of destruction, how

[1] Op. cit., vol. II, pp. 68 and 69.

continuous their action, and how inevitable their effect. We shall then learn that evolutionists have reason for insisting so strongly on the imperfection of the geological record, and for appealing to the results of future research and discovery for a confirmation of certain facts of their theory, and for an explanation of certain difficulties which, as matters now stand, are admittedly insoluble.

As to the formation of fossils, it is, as is well known, only the hard portions of organisms which are ever fossilized. But even these, as well as the softer parts, soon suffer disintegration unless in some way screened from sub-ærial agencies competent to decompose them, and unless they are protected from the solvent action of salt water, or fresh water holding carbonic acid in solution.

Again, as Darwin remarks, "we probably take a quite erroneous view, when we assume that the sediment is being deposited over nearly the whole bed of the sea at a rate sufficiently thick to embed and preserve fossil remains. Throughout an enormously large proportion of the ocean, the bright blue tint of the water bespeaks its purity. The many cases on record of a formation conformably covered, after an immense interval of time, by another and later formation, without the underlying bed having suffered in the interval any wear and tear, seem explicable only on the view of the bottom of the sea not rarely lying for ages in an unaltered condition."[1] "In regard to the mammiferous remains," the same authority continues, "a glance at

[1] Op. cit., vol. II, p. 58.

the historical table published in Lyell's 'Manual' will bring home the truth, how accidental and rare is their preservation, far better than pages of detail. Nor is their rarity surprising when we consider how large a proportion of the bones of Tertiary mammals have been discovered either in caves or in lacustrine deposits; and that not a cave or true lacustrine bed is known belonging to the age of our secondary or Palæozoic formations."[1]

But if the formation of fossils be rare and something wholly exceptional, when we consider the myriad organisms which are never fossilized; if shells and bones are always disintegrated unless adequately protected from the countless unfavorable and destructive agencies to which they are exposed, their preservation, after having been formed, is something which, when the facts of the case are known, must appear even more remarkable.

Romanes on Difficulties Attending Preservation of Fossils.

Mr. George Romanes, Darwin's favorite and most ardent disciple, has so accurately and picturesquely described the divers agencies which contribute to the annihilation of fossil forms, that I need make no apology for quoting him at length.

"But of even more importance," he writes, "than this difficulty of making fossils in the first instance, is the difficulty of preserving them when they are made. The vast majority of fossils have been formed under water, and a large proportional number of these, whether the animals were marine, terrestrial, or inhabitants of fresh water, have been formed in sedimentary deposits either of sand, gravel or other porous material. Now, where such deposits have been afterwards raised into the air for any considerable time, and this has been more or less the case with all deposits which are available for exploration, their fossiliferous contents will have been, as a general rule, dissolved by the percolation of rain-water charged with carbonic acid. Similarly, sea-water has recently been found to be a surprisingly strong solvent of calcareous material; hence, Saturn-like, the ocean destroys its own progeny as far as shells and bones of all kinds are concerned, and this to an extent of which we have probably no adequate conception.

"Of still greater destructive influence, however, than these solvent agencies in earth and sea, are the erosive agencies of both. Anyone who watches the pounding of the waves upon the shore; who then observes the effect of it upon the rocks broken into shingle, and on the shingle reduced to sand; who, looking behind him at the cliffs, sees there evidence of the advance of this all-pulverizing power—an advance so gradual that no yard of it is accomplished until within that yard the 'white teeth' have eaten well into the 'bowels of the earth;' who then reflects that this process is going on simultaneously over hundreds of thousands of miles of coast-lines throughout the world; and who finally extends his mental vision from space to time, by trying dimly to imagine what this ever-roaring monster must have consumed during the hundreds of millions of years

[1] Ibid, pp. 59 and 60.

that slowly rising and slowly sinking continents have exposed their whole areas to her jaws; whoever thus observes and thus reflects must be a dull man, if he does not begin to feel that in the presence of such a destroyer as this we have no reason to wonder at a frequent silence in the testimony of the rocks.

"But although the erosive agency of the sea is thus so inconceivably great, it is positively small as compared with erosive agencies on land. The constant action of rain, wind and running water, in wearing down the surfaces of all lands into 'the dust of continents to be;' the disintegrating effects on all but the hardest rocks of winter frosts alternating with summer heats; the grinding power of ice in periods of glaciation, and last, but not least, the wholesale melting up of sedimentary formations whenever these have sunk any considerable distance beneath the earth's surface — all these agencies taken together constitute so prodigious a sum of energies, combined through immeasurable ages in their common work of destruction, that when we try to realize what it must amount to, we can scarcely fail to wonder, not that the geological record is highly imperfect, but that so much of the record has survived as we find to have been the case. And, if we add to these erosive and solvent agencies on land the erosive and solvent agencies of the sea, we almost begin to wonder that anything deserving the name of geological record is in existence at all."[1]

[1] "Darwin and After Darwin," vol. I, pp. 423–425. For an exhaustive discussion of the disintegrating and destructive effects of aqueous, glacial and igneous agencies, the reader may consult with profit the pages of Lyell's admirable "Principles of Geology."

That the effects of denudation are not exaggerated in the preceding quotation, is manifest from a number of facts to which Darwin has directed attention, and of which he was the first to realize the true import in their bearings on Evolution. In Europe, but especially in North and in South America, there are immense areas, embracing many thousands of square miles, in which the surface rocks are entirely granitic or metamorphic. This implies that denudation has here taken place on a tremendous scale. And the utter absence of fossils in such rocks shows conclusively how completely the work of destruction was accomplished, so completely, indeed, that of the animal and vegetable remains which must have originally existed in these portions of the earth not a vestige now remains. In view of such facts Darwin considers it "quite probable, that in some parts of the world whole formations have been completely denuded, with not a wreck left behind."

Small Percentage of Fossil Forms.

But this is not all. We have positive evidence that during certain periods many species existed in countless numbers, although, so far, not a fragment of bone has been found within the area in which they once flourished. The strange, bird-like forms that once inhabited the Connecticut valley are instances in point. Although more than a score of