EVOLUTION AND PERMANENCE OF TYPE.

In connection with modern views of science we hear so much of evolution and evolutionists that it is worth our while to ask if there is any such process as evolution in nature. Unquestionably, yes. But all that is actually known of this process we owe to the great embryologists of our century, Döllinger and his pupils K. E. von Baer, Pander, and others, — the men in short who have founded the science of Embryology. It is true there are younger men who have done since, and are doing now, noble work in this field of research; but the glory must, after all, be given to those who opened the way in which more recent students are pressing forward.

The pioneers in the science of Embryology, by a series of investigations which will challenge admiration as long as patience and accuracy of research are valued, have proved that all living beings produce eggs, and that these eggs contain a yolk-substance out of which new beings, identical with their parents, are evolved by a succession of gradual changes. These successive stages of growth constitute evolution, as understood by embryologists, and within these limits all naturalists who know anything of Zoölogy may be said to be evolutionists. The law of evolution, however, so far as its working is understood, is a law controlling development and keeping types within appointed cycles of growth, which revolve forever upon themselves, returning at appointed intervals to the same starting-point and repeating through a succession of phases the same course. These cycles have never been known to oscillate or to pass into each other; indeed, the only structural differences known between individuals of the same stock are monstrosities or peculiarities pertaining to sex, and the latter are as abiding and permanent as type itself. Taken together the relations of sex constitute one of the most obscure and wonderful features of the whole organic world, all the more impressive for its universality.

Under the recent and novel application of the terms "evolution" and "evolutionist," we are in danger of forgetting the only process of the kind in the growth of animals which has actually been demonstrated, as well as the men to whom we owe that demonstration. Indeed, the science of Zoölogy, including everything pertaining to the past and present life and history of animals, has furnished, since the beginning of the nineteenth century, an amount of startling and exciting information in which men have lost sight of the old landmarks. In the present ferment of theories respecting the relations of animals to one another, their origin, growth, and diversity, those broader principles of our science — upon which the whole animal kingdom has been divided into a few grand comprehensive types, each one a structural unit in itself — are completely overlooked.

It is not very long since, with the exception of Insects, all the lower animals were grouped together in one division as Worms, on account of their simple structure. A century ago this classification, established by Linnæus, was still unquestioned. Cuvier was the first to introduce a classification based not merely upon a more or less complicated organization but upon ideas or plans of structure. He recognized four of these plans in the whole animal kingdom, neither more nor less. However, when this principle was first announced, the incompleteness of our knowledge made it impossible to apply it correctly in every case, and Cuvier himself placed certain animals of obscure or intricate structure under the wrong head. Nevertheless the law was sanctioned, and gave at once a new aim and impulse to investigation. This idea of structural plans, as the foundation of a natural classification, dates only from the year 1812, and was first presented by Cu-

vier in the Annals of the Museum in Paris.

About the same time another great investigator, Karl Ernst von Baer, then a young naturalist, Döllinger's favorite and most original pupil, was studying in Germany the growth of the chicken in the egg. In a different branch of research, though bearing equally on the structural relations of organized beings, he, without knowing of Cuvier's investigations, arrived at a like conclusion, namely, that there are four different modes of growth among animals. This result has only been confirmed by later investigators. Every living creature is formed in an egg and grows up according to a pattern and a mode of development common to its type, and of these embryonic norms there are but four. Here, then, was a double confirmation of the distinct circumscription of types, as based upon structure, announced almost simultaneously by two independent investigators, ignorant of each other's work, and arriving at the same result by different methods. The one, building up from the first dawn of life in the embryonic germs of various animals, worked out the four great types of organic life from the beginning; while his co-worker reached the same end through a study of their perfected structure in adult forms. Starting from diametrically opposite points, they met at last on the higher ground to which they were both led by their respective studies.

For a quarter of a century following, the aim of all naturalists was to determine the relations of these groups to one another with greater precision, and to trace the affinities between the minor divisions of the whole animal kingdom. It was natural to suppose that all living beings were in some way or other connected; and, indeed, the discoveries in Geology, with its buried remains of extinct life, following fast upon those of Cuvier in structure and of Von Baer in Embryology, seemed to reveal, however dimly and in broken outlines, a consistent history carried on coherently through all times and extending gradually over the whole surface of the earth, until it culminated in the animal kingdom as it at present exists, with man at its head.

The next step, though a natural result of the flood of facts poured in upon us under the new stimulus to research, led men away from the simple and, as I believe, sound principles of classification established by the two great masters of zoölogical science. The announcement of four typical divisions in the animal kingdom stirred investigators to a closer comparison of their structure. The science of Comparative Anatomy made rapid strides; and since the ability of combining facts is a much rarer gift than that of discerning them, many students lost sight of the unity of structural design in the multiplicity of structural detail. The natural result of this was a breaking up of the four great groups of Radiates, Mollusks, Articulates and Vertebrates into a larger number of primary divisions. Classifications were multiplied with astonishing rapidity, and each writer had his own system of nomenclature, until our science was perplexingly burdened with synonymes. I may mention, as a sample, one or two of the more prominent changes introduced at this time into the general classification of animals.

The Radiates had been divided by Cuvier into three classes, to which, on imperfect data, he erroneously added the Intestinal Worms and the Infusoria. These classes, as they now stand according to his classification, with some recent improvements, are Polyps (corals, sea-anemones, and the like), Acalephs (jelly-fishes), and Echinoderms (star-fishes, sea-urchins, and holothurians, better known, perhaps, as Beche-de-mer). Of these three classes the two first, Polyps and Acalephs, were set apart by Leuckart and other naturalists as "Cœlenterata," while the Echinoderms by themselves were elevated into a primary division. There is, however, no valid ground for this. The plan of structure is the same in all three classes, the only difference being that various organs which in the Polyps and Acalephs are, as it were, simply hollowed out of the substance of the body, have in the Echinoderms walls of their own. This is a special complication of structural execution, but makes no difference in the structural plan. The organs and the whole

structural combination are the same in the two divisions. In the same way Cephalopods, squids and cuttlefishes, which form the highest class among Mollusks, were separated from the Gasteropods and Acephala, and set apart as a distinct type, because their eggs undergo only a surface segmentation instead of being segmented through and through, as is the case with the members of the two other classes. But this surface segmentation leads ultimately to a structure which has the same essential features as that of the other Mollusks. Indeed, we find also in other branches of the animal kingdom, the Vertebrates for instance, partial or total segmentation, in different classes; but it does not lead to any typical differences there, any more than among Mollusks. Another instance is that of the Bryozoa and Tunicata, which were separated from the Mollusks on account of the greater simplicity of their structure and associated with those simpler Worms in which articulated limbs are wanting. In short, the numerous types admitted nowadays by most zoölogists are founded only upon structural complication, without special regard to the plan of their structure; and the comprehensive principle of structural conception or plan, as determining the primary types, so impressive when first announced, has gradually lost its hold upon naturalists through their very familiarity with special complications of structure. But since we are still in doubt as to the true nature of many organisms, such as the sponges and the Protozoa so-called, it is too early to affirm positively that all the primary divisions of the animal kingdom are included in Cuvier's four types. Yet it is safe to say that no primary division will stand which does not bear the test he applied to the four great groups, Radiates, Mollusks, Articulates, and Vertebrates, namely, that of a distinct plan of structure for each.

The time has, perhaps, not come for an impartial appreciation of the views of Darwin, and the task is the more difficult because it involves an equally impartial review of the modifications his theory has undergone at the hands of his followers. The aim of his first work on The Origin of Species was to show that neither vegetable nor animal forms are so distinct from one another or so independent in their origin and structural relations as most naturalists believed. This idea was not new. Under different aspects it had been urged repeatedly for more than a century by DeMaillet, by Lamarck, by E. Geoffroy St. Hilaire and others; nor was it wholly original even with them, for the study of the relations of animals and plants has at all times been one of the principal aims of all the more advanced students of Natural History; they have differed only in their methods and appreciations. But Darwin has placed the subject on a different basis from that of all his predecessors, and has brought to the discussion a vast amount of well-arranged information, a convincing cogency of argument, and a captivating charm of presentation. His doctrine appealed the more powerfully to the scientific world because he maintained it at first not upon metaphysical ground but upon observation. Indeed it might be said that he treated his subject according to the best scientific methods, had he not frequently overstepped the boundaries of actual knowledge and allowed his imagination to supply the links which science does not furnish.

The excitement produced by the publication of The Origin of Species may be fairly compared to that which followed the appearance of Oken's Natur-Philosophie, over fifty years ago, in which it was claimed that the key had been found to the whole system of organic life. According to Oken, the animal kingdom, in all its diversity, is but the presentation in detail of the organization of man. The Infusoria are the primordial material of life scattered broadcast everywhere, and man himself but a complex of such Infusoria. The Vertebrates represent what Oken calls flesh, that is, bones, muscles, nerves, and the senses, in various combinations; the Fishes are Bone-animals (Knochen-Thiere); the Reptiles, Muscle-animals (Muskel-Thiere); the Birds, Nerve-animals (Nerven-Thiere); the Mammals — with man, combining in his higher structure the whole scheme of organic life, at their head — are Sense-ani-

mals (Sinnen-Thiere). The parallelism was drawn with admirable skill and carried into the secondary divisions, down to the families and even the genera. The Articulates were likened to the systems of respiration and circulation; the Mollusks to those of reproduction; the Radiates to those of digestion. The comprehensiveness and grandeur of these views, in which the scattered elements of organic life, serving distinct purposes in the lower animals, are gathered into one structural combination in the highest living being appealed powerfully to the imagination. In Germany they were welcomed with an enthusiasm such as is shown there for Darwinism. England was lukewarm, and France turned a cold shoulder, as she at present does to the theory of the great English naturalist. The influence of Cuvier and the Jussieux was deeply felt in Western Europe, and perhaps saved French naturalists from falling into a fanciful but attractive doctrine, numbered now among the exploded theories of the past.

Darwin's first work, though it did not immediately meet with the universal acceptance since accorded to it, excited, nevertheless, intense and general interest. The circumstance that almost identical views were simultaneously expressed by Wallace, and that several prominent investigators hailed them as the solution of the great problem, gave them double strength; for it seemed improbable that so many able students of nature should agree in their interpretation of facts, unless that interpretation were the true one. The Origin of Species was followed by a second work, The Variation of Animals and Plants under Domestication, to which a third soon succeeded, The Descent of Man. The last phase of the doctrine is its identification with metaphysics in Darwin's latest work on The Expression of the Emotions in Man and Animals. I can only rejoice that the discussion has taken this turn, much as I dissent from the treatment of the subject. It cannot be too soon understood that science is one, and that whether we investigate language, philosophy, theology, history, or physics, we are dealing with the same problem, culminating in the knowledge of ourselves. Speech is known only in connection with the organs of man, thought in connection with his brain, religion as the expression of his aspirations, history as the record of his deeds, and physical sciences as the laws under which he lives. Philosophers and theologians have yet to learn that a physical fact is as sacred as a moral principle. Our own nature demands from us this double allegiance.

It is hardly necessary to give here an analysis of the theory contained in these works of Darwin. Its watchwords, "natural selection," "struggle for existence," "survival of the fittest," are equally familiar to those who do and to those who do not understand them; as well known, indeed, to the amateur in science as to the professional naturalist. It is supported by a startling array of facts respecting the changes animals undergo under domestication, respecting the formation of breeds and varieties, respecting metamorphoses, respecting the dangers to life among all animals and the way in which nature meets them, respecting the influence of climate and external conditions upon superficial structural features, and respecting natural preferences and proclivities between animals as influencing the final results of interbreeding. In the Variation of Animals and Plants under Domestication all that experiments in breeding or fancy horticulture could teach, whether as recorded in the literature and traditions of the subject or gathered from the practical farmers, stock-breeders, and gardeners, was brought together and presented with equal erudition and clearness. No fact was omitted showing the pliability of plants and animals under the fostering care of man. The final conclusion of the author is summed up in his theory of Pangenesis. And yet this book does but prove more conclusively what was already known, namely, that all domesticated animals and cultivated plants are traceable to distinct species, and that the domesticated pigeons which furnish so large a portion of the illustration are, notwithstanding their great diversity under special treatment, no exception to this rule. The truth is, our domesticated animals, with

all their breeds and varieties, have never been traced back to anything but their own species, nor have artificial varieties, so far as we know, failed to revert to the wild stock when left to themselves. Darwin's works and those of his followers have added nothing new to our previous knowledge concerning the origin of man and his associates in domestic life, the horse, the cow, the sheep, the dog, or, indeed, of any animal. The facts upon which Darwin, Wallace, Hæckel, and others base their views are in the possession of every well-educated naturalist. It is only a question of interpretation, not of discovery or of new and unlooked-for information.

Darwin's third book, The Descent of Man, treats a more difficult part of the subject. In this book the question of genealogy is the prominent topic. It had been treated already, it is true, in The Origin of Species, but with no special allusion to mankind. The structure was as yet a torso, a trunk without a head. In these two volumes the whole ground of heredity, of qualities transmitted to the new individual by his progenitors, and that of resemblance — whether physical, intellectual, or moral, between mankind and the higher mammalia, and especially between ourselves and our nearest relations, the anthropoid monkeys, — are brought out with the fulness of material and the skill of treatment so characteristic of the author. But here again the reader seeks in vain for any evidence of a transition between man and his fellow-creatures. Indeed, both with Darwin and his followers, a great part of the argument is purely negative. It rests partly upon the assumption that, in the succession of ages, just those transition types have dropped out from the geological record which would have proved the Darwinian conclusions had these types been preserved, and that in the living animal the process of transition is too subtle for detection. Darwin and his followers thus throw off the responsibility of proof with respect both to embryonic growth and geological succession.

Within the last three or four years, however, it has seemed as if new light were about to be thrown at least upon one of these problems. Two prominent naturalists announced that they had found indications of a direct structural connection between primary types: in the one case between Mollusks and Vertebrates, in the other between Radiates and Articulates. The first of these views was published by a Russian investigator of great skill and eminence, Kowalevsky. He stated that the Ascidians (the so-called soft-shelled clams) showed, in the course of their growth, a string of cells corresponding to the dorsal cord in Vertebrates. For the uninitiated I must explain that, at one stage of its development, in the upper layer of cells of which the Vertebrate germ consists, there arise two folds which, curving upward and inward, form first a longitudinal furrow and finally a cavity for the nervous centres, the brain and spinal cord, while the lower layer of these cells folds downward to enclose the organs of digestion, circulation, and reproduction. Between these two folds, but on the dorsal side, that is, along the back, under the spinal marrow, arises a solid string of more condensed substance, which develops into the dorsal cord, the basis of the backbone. Kowalevsky describes, in the Ascidians, a formation of longitudinally arranged cells as representing an incipient backbone, running from the middle of the body into the tail, along a furrow of the germ of these animals in which the main nervous swelling is situated. This was hailed as a great discovery by the friends of the transmutation theory. At last the transition point was found between the lower and higher animals, and man himself was traced back to the Ascidians. One could hardly open a scientific journal or any popular essay on Natural History, without meeting some allusion to the Ascidians as our ancestors. Not only was it seized upon by the many amateur contributors to the literature of this subject, but Darwin himself, and his ardent followers, welcomed this first direct evidence of structural affinity between the Vertebrates and the lower animals.

The existence of these cells, though never thought of in this light before, was not unknown to naturalists. I have my-

self seen and examined them, and had intended to say something in this article of their nature and position; but while I was preparing it for the press the subject was taken from me and treated by the hand of a master whom all naturalists venerate. I have received very recently from the aged Nestor of the science of Embryology, K. E. von Baer, to whose early investigations I have already alluded, a pamphlet upon the development of the Ascidians as compared to that of the Vertebrates. There is something touching in the conditions under which he enters the lists with the younger men who have set aside the great laws of typical structure, to the interpretation of which his whole life has been given. He is now very feeble and nearly blind; but the keen, far-reaching, internal sight is undimmed by age. With the precision and ease which only a complete familiarity with all the facts can give, he shows that the actual development of the Ascidians has no true homology with that of the Vertebrates; that the string of cells in the former — compared to the dorsal cord of the latter — does not run along the back at all, but is placed on the ventral side of the body. To say that the first Vertebrates or their progenitors carried their backbones in this fashion is about as reasonable as to say that they walked on their heads. It is reversing their whole structure, and putting their vertebral column where the abdominal cavity should be. Von Baer closes his paper in these words: "It will readily be granted that I have written for zoölogists and anatomists; but I may perhaps be blamed for being frequently very circumstantial where a brief allusion would have been sufficient. In so doing, I had the many dilletanti in view, who believe in complete transmutations, and who might be disposed to consider it mere conceit not to recognize the Ascidians as the ancestors of Man. I beg to apologize for some repetitions arising from this consideration for the dilletanti."

The other so-called discovery is that of Hæckel, that star-fishes are compound animals, made up, as it were, of worm-like beings united like rays in one organism. A similar opinion had already been entertained by Duvernoy, and in a measure also by Oken, who described the Echinoderms as Radiate-worms. This doctrine, if true, would at once establish a transition from Radiates to Articulates. There is, in the first place, not the slightest foundation for this assumption in the structure of the star-fish. The arms of these animals are made up of the same parts as the vertical zones of a sea-urchin and of all the Radiates, and have no resemblance whatever to the structure of the Worms. Each ambulacral zone of a star-fish or a sea-urchin is strictly homological to a structural segment of an Acaleph or to a radiating chamber of a Polyp. Moreover, the homology between a sea-urchin and a star-fish is complete; if one is an organic unit the other must be so also, and no one ever suggested that the sea-urchin was anything but a single organism. In comparing the Radiates with other animals, it is essential to place them in the same attitude, so that we compare like with like; otherwise, we make the mistake of the Russian naturalist, and compare the front side of one animal with the dorsal side of another, or the upper side of one with the lower side of another; thus taking mere superficial resemblance between totally distinct parts for true homologies. In all Mollusks, Articulates, and Vertebrates the parts are arranged along a longitudinal axis; in Radiates alone they are disposed around a vertical axis, like spherical wedges, comparable in some instances to the segments of an orange. This organic formula, for so we may call it, is differently expressed and more or less distinct in different Radiates. It may be built up in a sphere, as in the sea-urchins, or opened out into a star, like the five-finger; it may be in the form of a sac divided internally, as in the sea-anemones, or in that of a disk, channelled or furrowed so as to divide it into equal segments, like the jelly-fish; but upon comparison the same structural elements are found in all. These structural elements bear an identical relation to the vertical axis of the animals. To compare any Radiate with any Articulate is therefore to compare the vertical axis of one animal with the horizontal axis of the other. The parallelism will not bear

examination any more than that between the Mollusks and Vertebrates. Even in those holothurians and sea-urchins in which one side of the body is flattened, the structure exhibits the same plan and the parts are arranged in the same way as in all other Radiates, whatever be their natural attitude in the element in which they live; whether they stand upright with the mouth turned upward, or hang down in the reverse position, or crawl about horizontally. In like manner the vertical position of man in no way invalidates the homology of his organization with that of the fishes, reptiles, birds, and mammalia. These two cases are thus far the only instances which have been brought forward to prove actual structural affinity between distinct primary divisions of the animal kingdom.

It is not my intention to take up categorically all the different points on which the modern theory of transmutation is based. Metamorphosis plays a large part in it, and is treated as an evidence of transition from one animal into another. The truth is that metamorphosis, like all embryonic growth, is a normal process of development, moving in regular cycles, returning always to the same starting-point, and leading always to the same end; such are the alternate generations in the lower animals and the metamorphoses in higher ones, as in the butterflies and other insects, or in certain reptiles, frogs and toads, salamanders, and the like. In some of these types the development lasts for a long time and the stages of embryonic growth are often so distinct that, until the connection between them is traced, each phase may seem like a separate existence, whereas they are only chapters in one and the same life. I have myself watched carefully all the successive changes of development in the North American Axolotl, whose recently discovered metamorphoses have led to much discussion in connection with the modern doctrine of evolution. I can see no difference between this and other instances of metamorphosis. Certain organs, conspicuous in one phase of the animal's life, are resorbed and disappear in a succeeding phase. But this does not differ at all from like processes in the toads and frogs, for instance; nor does it even differ essentially from like processes in the ordinary growth of all animals. The higher Vertebrates, including man himself, breathe through gill-like organs in the early part of their life. These gills disappear and give place to lungs only in a later phase of their existence. Metamorphoses have all the constancy and invariability of other modes of embryonic growth, and have never been known to lead to any transition of one species into another.

Another fertile topic in connection with this theory is that of heredity. No one can deny that inheritance is a powerful factor in the maintenance of race and in the improvement of breeds and varieties. But it has never been known that acquired qualities, even though retained through successive generations, have led to the production of new species. Darwin's attractive style is never more alluring than in connection with this subject. His concise and effective phrases have the weight of aphorisms and pass current for principles, when they may be only unfounded assertions. Such is "the survival of the fittest." After reading some chapters of The Descent of Man, could any one doubt, unless indeed he happened to be familiar with the facts, that animals, possessing certain advantages over others, are necessarily winners in the race for life? And yet it is not true that, outside of the influence of man, there are, in nature, privileged individuals among animals capable of holding on to a positive gain, generation after generation, and of transmitting successfully their peculiarities until they become the starting point for another step; the descendants losing at last, through this cumulative process, all close resemblance to their progenitors. It is not true that a slight variation, among the successive offspring of the same stock, goes on increasing until the difference amounts to a specific distinction. On the contrary, it is a matter of fact that extreme variations finally degenerate or become sterile; like monstrosities they die out, or return to their type.

The whole subject of inheritance is exceedingly intricate, working often in a

seemingly capricious and fitful way. Qualities, both good and bad, are dropped as well as acquired, and the process ends sometimes in the degradation of the type and the survival of the unfit rather than the fittest. The most trifling and fantastic tricks of inheritance are quoted in support of the transmutation theory; but little is said of the sudden apparition of powerful original qualities which almost always rise like pure creations and are gone with their day and generation. The noblest gifts are exceptional, and are rarely inherited; this very fact seems to me an evidence of something more and higher than mere evolution and transmission concerned in the problem of life.

In the same way, the matter of natural and sexual selection is susceptible of very various interpretations. No doubt, on the whole, Nature protects her best. But it would not be difficult to bring together an array of facts as striking as those produced by the evolutionists in favor of their theory, to show that sexual selection is by no means always favorable to the elimination of the chaff and the preservation of the wheat. A natural attraction, independent of strength or beauty, is an unquestionable element in this problem, and its action is seen among animals as well as among men. The fact that fine progeny are not infrequently the offspring of weak parents and *vice versa* points perhaps to some innate power of redress by which the caprices of choice are counterbalanced. But there can be no doubt that types are as often endangered as protected by the so-called law of sexual selection.

As to the influence of climate and physical conditions, we all know their power for evil and for good upon living beings. But there is, nevertheless, nothing more striking in the whole book of nature than the power shown by types and species to resist physical conditions. Endless evidence may be brought from the whole expanse of land and air and water, showing that identical physical conditions will do nothing toward the merging of species into one another, neither will variety of conditions do anything toward their multiplication. One thing only we know absolutely, and in this treacherous, marshy ground of hypothesis and assumption, it is pleasant to plant one's foot occasionally upon a solid fact here and there. Whatever be the means of preserving and transmitting properties, the primitive types have remained permanent and unchanged — in the long succession of ages amid all the appearance and disappearance of kinds, the fading away of one species and the coming in of another — from the earliest geological periods to the present day. How these types were first introduced, how the species which have successively represented them have replaced one another, — these are the vital questions to which no answer has been given. We are as far from any satisfactory solution of this problem as if development theories had never been discussed.

This brings us to the geological side of the question. As a palæontologist I have from the beginning stood aloof from this new theory of transmutation, now so widely admitted by the scientific world. Its doctrines, in fact, contradict what the animal forms buried in the rocky strata of our earth tell us of their own introduction and succession upon the surface of the globe. Let us therefore hear them; — for, after all, their testimony is that of the eye-witness and the actor in the scene. Take first the type to which we ourselves belong. If it be true that there has been a progressive transmutation of the whole type of Vertebrates, beginning with the lowest and culminating in the highest, the earlier should of course be structurally inferior to the later ones. What then is the lowest* living Vertebrate? Every zoölogist will answer, The Amphioxus, that elongated, worm-like Vertebrate whose organization is nothing more than a dorsal cord, with a nervous thread above, and a respiratory and digestive cavity below, containing also the reproductive organs, the whole being clothed in flesh. Yet low as it is in the scale of life, the Amphioxus is, by virtue of its vertebral column, a member of the same type as ourselves. Next to the Amphioxus come

* I use the terms low and high, throughout, in the zoölogical sense; with reference to specialization of structure, as comparative anatomists understand it

the Myxinoids, structurally but little above them, and the Lamper-eels. These are the animals which Hæckel places at the base of his zoölogical tree, rooting the whole Vertebrate branch of the animal kingdom in the Amphioxus as the forefather (Stamm-Vater) of the type. Let us look now at the earliest Vertebrates, as known and recorded in geological surveys. They should of course, if there is any truth in the transmutation theory, correspond with the lowest in rank or standing. What then are the earliest known Vertebrates? They are Selachians (sharks and their allies) and Ganoids (garpikes and the like), the highest of all living fishes, structurally speaking. I shall be answered that these belong to the Silurian and Devonian periods, and that it is believed that Vertebrates may have existed before that time. It will also be argued that Myzonts, namely Amphioxus, Myxinoids, and Lamper-eels, have no hard parts and could not have been preserved on that account. I will grant both these points, though the fact is that the Myzonts do possess solid parts, in the jaws, as capable of preservation as any bone, and that these solid parts, if ever found, even singly, would be as significant, for a zoölogist, as the whole skeleton. Granting also that Amphioxus-like fishes may have lived and may have disappeared before the Silurian period; the Silurian deposits follow immediately upon those in which life first appeared, and should therefore contain not the highest fishes, but the fishes next in order to the Myzonts, and these are certainly neither the Ganoids nor the Selachians. The presence of the Selachians at the dawn of life upon earth is in direct contradiction to the idea of a gradual progressive development. They are nevertheless exceedingly abundant in the Palæozoic beds, and these fossil forms are so similar to the living representatives of the same group that what is true of the organization and development of the latter is unquestionably equally true of the former. In all their features the Selachians, more than any other fishes, resemble the higher animals. They lay few eggs, the higher kinds giving birth only to three, four, or five at a brood, whereas the common fishes lay myriads of eggs, hundreds of thousands in some instances, and these are for the greater part cast into the water to be developed at random. The limitation of the young is unquestionably a mark of superiority. The higher we rise in the scale of animal life the more restricted is the number of offspring. In proportion to this reduction in number, the connection of the offspring with the parent is drawn closer, organically and morally, till this relation becomes finally the foundation of all social organization, of all human civilization. In some Selachians there is an actual organic connection between parent and progeny, resembling the placental connection which marks the embryonic development of the higher Vertebrates. This feature is in harmony with the sexual relations among them; for it is of all facts in their organic history the most curious, that, among Vertebrates, the Selachians are the only ones with whom the connection of the sexes recalls that of the human family. Now, these higher fishes being the first representatives of the Vertebrates on earth, or at least those next following their earliest representatives, where do we find the Myzonts, fishes which are structurally inferior to all others, and of which the Amphioxus is the lowest member? They come in during the latest period of our world's history, with what is called the present period, to which we ourselves belong. This certainly does not look like a connected series beginning with the lowest and ending with the highest, for the highest fishes come first and the lowest come last.

The companions of the Selachians in the earlier geological periods, the Ganoids, belong also to the higher representatives of the class of fishes. Some of them have the ball-and-socket vertebral joint of the reptiles and birds, enabling the head to move upon the neck with greater freedom than in the lower fishes. I am aware that these synthetic and prophetic types, which I have myself been the first to point out, and in which features of higher and later groups are combined or hinted at in lower and earlier ones, have been interpreted as transition types. It has even been said that I have myself furnished the strongest

evidence of the transmutation theory. This might perhaps be so, did these types follow, instead of preceding, the lower fishes. But the whole history of geological succession shows us that the lowest in structure is by no means necessarily the earliest in time, either in the Vertebrate type or any other. Synthetic and prophetic types have accompanied the introduction of all the primary divisions of the animal kingdom. With these may be found what I have called embryonic types, which never rise, even in their adult state, above those conditions which in higher structures are but the prelude to the adult state. It may, therefore, truly be said that a great diversity of types has existed from the beginning.

The most advanced Darwinians seem reluctant to acknowledge the intervention of an intellectual power in the diversity which obtains in nature, under the plea that such an admission implies distinct creative acts for every species. What of it, if it were true? Have those who object to repeated acts of creation ever considered that no progress can be made in knowledge without repeated acts of thinking? And what are thoughts but specific acts of the mind? Why should it then be unscientific to infer that the facts of nature are the result of a similar process, since there is no evidence of any other cause? The world has arisen in some way or other. How it originated is the great question, and Darwin's theory, like all other attempts to explain the origin of life, is thus far merely conjectural. I believe he has not even made the best conjecture possible in the present state of our knowledge.

The more I look at the great complex of the animal world, the more sure do I feel that we have not yet reached its hidden meaning, and the more do I regret that the young and ardent spirits of our day give themselves to speculation rather than to close and accurate investigation.

I hope in future articles to show, first, that, however broken the geological record may be, there is a complete sequence in many parts of it, from which the character of the succession may be ascertained; secondly, that, since the most exquisitely delicate structures, as well as embryonic phases of growth of the most perishable nature, have been preserved from very early deposits, we have no right to infer the disappearance of types because their absence disproves some favorite theory; and, lastly, that there is no evidence of a direct descent of later from earlier species in the geological succession of animals.

Louis Agassiz.

AN OLD-YEAR SONG.

As through the forest, disarrayed
By chill November, late I strayed,
A lonely minstrel of the wood
Was singing to the solitude:
I loved thy music, thus I said,
When o'er thy perch the leaves were spread;
Sweet was thy song, but sweeter now
Thy carol on the leafless bough.
  Sing, little bird! thy note shall cheer
  The sadness of the dying year.

When violets pranked the turf with blue
And morning filled their cups with dew,