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From the Author
with Compliments
to Rev. Prof. McKnight

EVOLUTION.

BY

ANGUS ROSS,
Sec. N. S. Ins. Natural Science.

(*Read before the N. S. Ins. Nat. Sci. on May 11th, 1874.*)

EVOLUTION.

EACH animal* begins life at the same point of departure—the egg—with every other, and certainly all the *Vertebrata*, in the early stages of their development, pass through apparently precisely the same transformations, but all except man at some stage become specialized: he alone continuing a course of harmonious development until arriving at maturity; and all that is known of the animals that have existed on the Earth indicate that the metamorphoses, which each mature animal now living has undergone, (in its individual development,) are types of the changes which have taken place in the Kingdom, Sub-kingdom, Class, Sub-class, Order, Sub-order, Family, Sub-family, Genus, Sub-genus, Species, Sub-species, Variety, and Sub-variety, to which it may belong.

The distinctive peculiarity of existing animals as compared with those of past Epochs, therefore, is that their organization is more specialized, so that as we go backward in time the distinctive peculiarities of the natural groups gradually disappear, intermediate forms and increasingly generalized or "synthetic" types continually appear, bridging over apparent chasms. Thus the Genera *Equus* and *Elephas*, each consisting of but a few existing Species and widely separated from each other, and from every other Genus of living animals, are found to be in close relation with many allied and intermediate forms, the remains of which are found in the rocks of the Recent, the Quaternary, and the Tertiary Periods; the types becoming more and more synthetic as we go backward in time, and the relative size of the brain cavity gradually diminishing, until in the earliest Tertiary it becomes comparable to that of the Reptilia. The most remarkable differentiation in the Equine family is in the

* Except certain of the lower Grades in which a whole community is developed from the product of a single egg, by budding, subdivision, &c.

structure of the foot; passing gradually from the four toed Genus *Orohippus* of the Eocene, through such intermediate forms as the three-toed genus *Anchitherium* of the Miocene, and *Hipparion* of the Pliocene, which had three toes, but only the middle one well developed, the other two not reaching the ground, to its present representative Equus, including the Horse, Zebra, &c., with its single toed foot.

Birds are a highly specialized Class of *Vertebrata*, having however closer structural affinities with the *Chelonia* than would be supposed from external appearance. One of their marked peculiarities is that they are all toothless. Few remains of the earlier Birds have yet been found, but among them is *Ichthyornis dispar*, of the Cretaceous Period, which shews a complete set of teeth! The embryo of certain living Birds also have teeth, thus illustrating the law that the metamorphoses which the existing individual undergoes are representative of those which the group to which it belongs has undergone. In other respects *I. Dispar* had well marked Reptilian and even Ichthic characteristics, in other words was of a very synthetic type. The *Archæopteryx macrurus* of the Jurassic Period had, in accordance with the same law, still more marked Reptilian characteristics.*

Of all Vertebrates the Sub-class Amphibia is the most obviously suggestive and instructive in the metamorphoses which it undergoes after leaving the egg, shewing, in the common Frog, for example, how a creature approximating to the typical organization of the earlier Fishes, living only in the water, breathing by means of gills, subsisting chiefly on vegetable food, without limbs but with a muscular system adapted to use the tail in swimming as the sole means of locomotion, develops into an Amphibian without a tail, possessing true limbs of indeed remarkable homological symmetry, well developed lungs and voice, all the change in the circulation of

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* "The tail is 11 inches long, and 3½ inches broad. It consists of 20 vertebræ, and has a row of feathers along the sides. These few feathers are in pairs corresponding with the number of the vertebræ, and diverge from the axis at an angle of 45°; the last pair extends backwards nearly in a line with the last vertebrae, and 3½ inches beyond it. The wing appears to have a two jointed finger. The breadth of the wing was made by feathers as in birds, and not as in a Pterodactyl by an expanded membrane. The feet are like those of Birds."

the blood implied by the presence of the lungs, and all the great changes in the muscular and other systems of organs implied in the use of well developed limbs and in making insects its only food, while other Families of this same Class illustrate, in the mature condition, almost every stage of the process by which so great a change is accomplished. Nor can it be without a deep significance that in all the higher Vertebrates—in Man himself, somewhat similar metamorphoses take place in intra-uterine life—the embryo having gills (not fully developed) before it has lungs, although as the blood is not aerated within the embryo they can have no direct use.

All Vertebrates are Quadrupeds, and each limb, if complete, has five digits, but while in the *Ungulata* many have but two well developed digits to each limb, and in the Equine Family all but one have become atrophied, in the Order Ophidia, the limbs are completely atrophied and functionless (with rare exceptions), and not apparent externally, that Order being in this as in the "vegetative repetition" of vertebrae, the most asymmetrical and specialized of the land Vertebrates, so that the poison bag possessed by some of them, was scarcely needed to make the "Serpent" the fitting emblem of Evil in every Mythology. In accordance with the general law which I have indicated, this highly differentiated Type does not appear among the early representatives of the Class, not having yet been found earlier than the Cretaceous Period.

The remains of Fishes, the lowest and earliest, the most numerous and the most various or differentiated Class of Vertebrates, are found in rocks of the latest Silurian Epoch (and upwards), of two Orders, the Selachians or Placoids, and the Ganoids. The first of these, of which the Port Jackson Shark is one of the best living, representatives, was approximately homologically * symmetrical, had an internal cartiloginous skeleton, and was covered externally with shagreen or roughened skin, protected by a spine at each fin, and had teeth consisting of broad bony plates, somewhat similar to those which formed a complete bony external skeleton in the only other then existing Order of Fishes—the Ganoids. These last were less symmetrical than the Selachians, and although at first the

* Man being taken as the type.

internal skeleton was cartalaginous, yet afterwards in the Devonian the *Coccosteus*, has the internal skeleton osseous in the jaws and vertebræ, and afterwards other families have internal skeletons still more ossified. The *Coccosteus* and *Pterichthys* Families are remarkable as being the first examples of asymmetry, by the limbs being functionless, the former having no apparent fore limbs, and the latter no hind ones. The Teliosts, or Fishes with true bony skeletons and covered with scales externally, appear for the first time in the Cretaceous Period, and are the predominant Type among living Fishes. Some existing Families have no functional limbs, while others are distorted in the most remarkable manner. Thus the Flounder, as also the Plaice, Halibut, &c., "is twisted half around and laid on its side. The tail too is horizontal. Half the features of its head are twisted to one side, and the other half to the other, while its very mouth is in keeping with its squint eyes. One jaw is straight and the other like a bow, and while one contains from four to six teeth, the other contains from thirty to thirty-five."

It is interesting to note the development of true teeth among the oldest, so far as is known, of Vertebrates—the Skarks, for while the earliest had pavement teeth—broad plates like the dermal plates of their contemporaries the Ganoids, other Families of Sharks in the Carboniferous had narrower and sharper teeth, while in some existing Families they are quite sharp. In the Ganoids the dermal plates vary much in character and disposition. Some of them had pavement teeth. The Sturgeon, an existing Ganoid, has no teeth. Most Ganoids since about the close of the Palæozoic Period, have shortened and bilobed or hetrocereal tails when mature, but when young have homocereal tails, like the ancient Ganoids. The *Pterosauria*, higher *Batrachia*, later *Aves*, higher *Simiadæ*, and the *Anthropidæ*, have the tail completely atrophied.

The Teleosts deposit their spawn before fecundation takes place, while the Shark is in fact placental, bringing forth its young in a well advanced condition. Other existing Orders, of which however there are but few living representatives, show how exceedingly varied and wide in its limits is the organization of Fishes, for while the "Mud Fish" has a heart with two auricles, external rudimentary branchiæ, internal functional branchiæ, and *true lungs*, being thus much above the ordinary level of Fishes, the *Amphioxus lanceolatus* has no heart but only contractile arteries, no kidneys, a sac like liver, no vertebral arches, no distinct brain, no auditory organs, neither a cartilaginous nor an osseous skull, nor a mandible, nor any limbs, and even the Order represented among living Fishes by the Lampreys and Hags, though much more highly organized than the last mentioned, seem devoid of any indurated tissue. And here I would remark the great imperfection of the Geological Record, since generally speaking only highly indurated tissue could be preserved, and thus whole Orders, even, of Cartilaginous Fishes have probably perished, leaving no fossil trace, and if they should happen to have no living representatives, as is known to be the case with some Orders among the Reptilians, then no definite record of their existence may now remain. And if whole Orders have no fossil representative, because devoid of well indurated tissue is it not probable that the earliest representatives of some existing Orders may have left no remains, especially as we have seen that the earliest fishes were devoid of any internal indurated tissue, and in the case of one of the earliest known Orders the Selachians, there was not much well indurated tissue in the exo-skeleton; so that it is probable that it will ever remain impossible to trace back the various Orders of Fishes until they approximate so closely as do the earliest known representatives of the *Sauropsidia* or the *Mammalia*.

The *Labyrinthodontia*, an Order of extinct Amphibians which flourished abundantly throughout the Carboniferous Period, combine characteristics of existing Orders of Amphibians with those of the early Ganoids, while the *Ichthyosauria*, the *Plesiosauria*, the *Pterosauria*, and the *Dinosauria*, are extinct Orders of Reptilians, which connect together the various Orders of existing Reptiles, and these again with Amphibians on the one side and birds on the other, so that all non-Mammalian Vertebrates are thus connected, and considering how imperfect the Geological Record as now known is, not only from its necessary imperfection, but also from the limited character of explorations yet made, enough is known to suggest, if not to warrant, the opinion that originally the differences were only "Generic" or even "Specific" in value.

The interval which separates the non-Mammalian Vertebrates from the *Mammalia* as found on the great Continents, that is Asia, Europe and Africa, is wide indeed. for of the three Sub-classes into which, from their structure the *Mammalia* are naturally divided, only one—the farthest removed—is found there, the *Monodelphia* or true *Mammalia*. Of the two remaining Sub-classes *Didelphia* or *Marsupialia*, and *Ornithodelphia*; the first, though once abundantly represented on each of the Continents, is now nearly extinct in America, and is found abundantly represented only in Australia, where its isolated position has protected it from the results which elsewhere have followed its contact with the more differentiated and with the more highly organized tribes of the greater Continents; and it is here also that the surviving representatives—the *Ornithorhyncus* and the *Echidna*—of the *Ornithodelphia* are found.

If the interval separating the *Marsupialia* from the *Sauropsidia* seems insufficiently bridged by the two Genera, only, which are known of a single Order, the *Monotremata*, the only surviving Order of the Sub-class *Ornithodelphia*, it should be remembered that every principle of analogy would lead us to anticipate, that when that Island Continent shall have been well explored geologically, the remains of other Genera, Families, and even Orders will, as in the case of the *Ganoidia* and *Labyrinthodontia* among the *Ichthyopsidia*, restore to us the connecting links which in Mesozoic Periods gave an easy transition from the *Sauropsidia* to the *Mammalia*.

Of *Mollusca*, the Tetrabranchiate Cephalopods, of which the Genus *Nautilus* is the only living representative, possesses some points of very special interest, as having chambered shells and continually moving outward as they grow, the shells, which have also the very great advantage of being exceedingly well preserved as fossils, present an epitome, perfect, so far as it goes, of the entire life of the individual; so that there exists a singularly well preserved representation of the entire Order,—from its apparent origin in the Lower Silurian to the present day, when it has almost become extinct,—alike as regards the successive Species and the successive phases in the development of the individual of each Species. *Orthoceras*, of the lowest Silurian Epoch, the earliest and simplest known type, had a shell in shape a straight cone, and had simple concave septa. It was followed by such forms as *Cyrtoceras* and *Phragmoceras*, with shells resembling a bent cone, and with septa having shallow lateral lobes. After these comes *Gyroceras*, in which the bending of the shell has so much increased as to give it the form of a loose coil, and in which the lobes have become deeper, followed by others in which the coil has become close, and the latter lobes more angular, until the shell has become involute and the umbilicus has been obliterated, as in *Nautilus ziczac*, of the Tertiary, and the living representatives of the Family.

The Ammonite series, in which a similar succession of forms occur, are remarkable for complication of their septa and the profusion of their ornamentation at the time of the Jurassic Period, when they had the greatest number of Specific forms. But this is true only of the adult individual, for the earlier stages of the life of the individual represented accurately in a modified form, the earliest Species of the Series to which it belonged taking on successively the characteristics of the successive Species of such series until it arrived at maturity; in the keeled group changing from four rounded to eighteen foliated lobes, and in form from an open coil to a completely covered umbilicus, while in regard to ornament it takes on the characteristics of the Series to which it belongs in regular succession during the successive stages of its growth: "In other words there is an unceasing concentration of the adult characteristics of lower Species in the young of higher Species, and a consequent displacement of other embryonic features which had themselves, also, previously belonged to the adult periods of still lower forms." While the shell-covered Tetrabranchiates, have long been continually decreasing in numbers, in specific forms, in size and in ornamentation, the naked Dibranchiates, rival in size the largest of the extinct Tetrabranchiates, or the largest existing Fishes or Reptilians. Many existing Dibranchiates (such as the Cuttle fishes and Squids) have an internal skeleton or osselet, either calcareous, horny or membranous. The *Connularia*, fossil osselets, which occur from the Trenton Epoch (of the Lower Silurian) to the Liassic Epoch (of the Jurassic Period,) inclusive, are still abundant and are represented at present by such huge forms as *Megaloteuthis harveyi*, the oldest remains of the Dibranchiates; but since only the osselets are preserved it is plain that if the earliest Cephalopods, like the earliest Fishes, had no indurated internal skeleton, (and we know that in the Calamaries it is often not calcareous, and that the *Octopidæ* are destitute of it, the shell being represented by two small rudimentary stylets encysted in the substance of the mantle), they may have existed abundantly without having left any definite traces. It is for a similar reason, doubtless, that the Ascidians though their structure would seem to indicate that they had a very remote origin, have never been recognized as fossils. Indeed it is probable that up to the time—the Devonian Period—when the highest of the then existing *Ichthyopsidia* began to have osseous tissue developed in their internal skeletons, no internal indurated tissue ever existed in the highest or central type of any Epoch, and it is probable that such highest type was always naked, or nearly so as at present, but possessed teeth, pavement or plate like at first, but gradually acquiring the more differentiated forms since the later Silurian Epochs. Now if this were so, it satisfactorily accounts for the fact that previous to the time of the Fishes with an exo-skeleton in part at least osseous, no animals so far as known, at all approaching to homological symmetry in type, have left recognizable remains; and that while the early Ichthiopsidians (in their grade) of remarkably homological symmetry, are well represented, the earlier (and more homologically symmetrical) representatives of the various Orders of the *Sauropsidia*, and of the *Monotremata* aud *Marsupialia*, and of the true *Mammalia*, until the beginning of the Tertiary Period, are so very sparsely and imperfectly known to us, is doubtless due to the fact that these last inhabit dry land and could only be preserved when some accident burried their remains in strata of such a character as would preserve them, so that not one of them would be preserved for every thousand that would be preserved of the marine Species. It must also be remembered that they were probably much more limited as to habitat and numbers. Doubtless similar reasons account for the comparative scarcity of fossil remains of *Quadrumana*, known to have existed throughout the Tertiary and Post-Tertiary, and of

Man, known to have existed in Britain before the last Glacial Epoch there, and in France during the Epoch characterized by the existence of the cave bear. It should be well understood that Man differs physically in no way from the other Mammals, except that he is more advanced and is the central and only completely symmetrical existing type.

With regard to the other Orders of Mollusks, I will only remark that all the marine types are, at an early period of their development, free swimmers and possessed of functional eyes, although many afterward become sessile, and many blind before they reach maturity. And if the land Species do not so apparently exhibit this phase of development, it is because they pass through the corresponding transformations before leaving the egg.

The *Pteropoda* which swarm about the great banks of floating seaweed of the mid-Atlantic, and form in the open seas of the North the food of the Whalebone Whale, represent (approximately) in their adult form the free swimming stage of the *Gasteropoda.*

The *Tunicata* (Ascidians) perhaps the most synthetic type known to us among the *Mollusca*, are remarkable as containing the proximate principle, cellulose, the basis of *vegetable* structures, and also as being, perhaps, the highest type of animal life in which individuals are reproduced by *budding*, so characteristic of the *Radiates*, both animal and vegetable. They have also peculiarities of structure which ally them with *Amphioxus lanceolatus*, the lowest known Vertebrate. The lowest known Genera of the *Tunicata* are the *Appendicularia*, resembling a tadpole externally, and swimming freely by means of the tail. These when mature represent the immature forms of the higher *Tunicata*, before they become fixed or attached to rocks and their tails are absorbed; thus shewing the same tendency to shortening of the caudal extremity which is found in the higher and later representatives of almost every organic type. The *Appendicularia* then at the base of the *Tunicata*, are perhaps the most synthethic of organic types having structural peculiarities which ally them to the *Vertebrata*, the *Mollusca*, the *Articulata*, and the *Radiata*, through the lowest types of each of these respectively.

The common Ant, after reaching the three stages successively, in which it represents the three classes of *Articulata—Vermes*, *Crustacea*, and *Insecta*—loses its wings before it begins to find food for itself or for the community. To what purpose then does it possess so exquisitely complicated an apparatus by which it sports for a few hours in the sunshine only to have its wings dried up and destroyed, thus not only losing any advantage from the expenditure of vital force necessary to the production of wings and muscles, nerves, &c., necessary to use them, but also exposed to all the dangers of becoming the prey of insectivorous creatures while on the wing and afterwards, before being cared for by the parent ants, or of being carried out of reach of the community by the winds, &c.? To what purpose unless it be merely because it is impossible for it to reach its adult condition except through those phases which characterized the adult condition of its predecessors, just as all Vertebrates are furnished at one time in their development with gills, though at the present day only the lowest Classes have any use for them, and many of the Amphibia only before reaching the adult state. In succeeding Species of Ants the wings may become embryonic and functionless.

In the *Radiata*, the planula (egg) of the Polyp, the Jelly-fish, and the Star-fish, (representing the three chief divisions) are quite similar, and in its early development a jelly-fish resembles a polyp, while a star-fish passes through stages in which it resembles first the polyp and then the jelly-fish.

The earliest (and lowest) known representatives of the Echinoderms were the Crinoids, whose remains are found abundantly in every formation from the Lower Silurian to the present day, when they are represented by such Genera as *Pentacrinus*. All existing Echinoderms pass through a Crinoid stage, and the higher and later Families pass through grades, representing the lower and older successively until they attain their own proper grade at maturity, when reproduction by the production of planulæ occurs. In *Pentacrinus*, again, the individual, after reaching its Crinoid stages, passes through stages representing successive crinoid Genera leading up to itself.

The mode in which most individuals of this Class are produced, not by direct development from the egg, but by budding from other individuals, so that a whole community has its origin in a single egg, shews that in this as in some other respects the Radiata have structural peculiarities akin to Plants. It is perhaps worthy of remark that in Madrepores the top animal is always larger than the side animals, whether in the stem or the branches, as are the buds of a tree, the buds in either case being most vigorous in the most direct line, or in other words, *less vigorous in direct proportion to the number of differentiations from the direct line of the original polyp.*

At the base of the lower Silurian, the Cephalopods, Articulates, and Radiates, disappear together, and save a few Fucoids a little lower, no well ascertained organic remains have been found in examining the rocks downwards through several miles in thickness. It was for this reason that Hugh Miller perceiving that the lines of organization (if I may use the expression) approximate as we trace them downwards in the rocks—backwards in time—speaks of the life of the past as suggesting the idea of an *inverted truncated cone.*

Dana estimates the maximum thickness of the Tertiary rocks at two miles, the Mesozoic at two miles, the Carboniferous at two two-thirds miles, the Devonian at two two-thirds miles, and the Silurian at four miles—thirteen and one-third miles in all. According to Sir Wm. Logan the Cambrian and Laurentian Formations have in Canada a thickness of about seven one-half miles, and it is at the base of these that *Eozoon* (so called) has been found, forming a fitting apex to the cone.

The *Protozoa,* at the base at once of the animal and vegetable Kingdoms, are found, if *Eozoon canadense* and *Eozoon bavaricum* are really of organic origin, as claimed by Dr. Dawson and others, far below, that is, of an earlier period, than any other well recognized organic remains. Most of the existing Protozoans are microscopic. They have been classified as Plant-like, Radiate-like, Mollusk-like, and Articulate-like; a classification which indicate plainly in these—which it can scarcely be doubted are representative of the earlier organisms in the same sense that the Fishes of the present day are representative of the earlier Fishes, that is differentiated asymmetrical modifications of the earlier types—there exists a tendency to the differentiations which are fully developed in the great groups of organic structure next above the *Protozoa*, alike in rank and in the period of their development.

The lowest Plants (*Algæ*) are reproduced by spores (seeds or eggs) which develope powers of motion, swimming about freely by means of vibratile cilia, until, after a time, each attaches itself to a rock or other object, and develops into a plant which has no longer the power of voluntary motion, even in its free extremity. Very similar is the planula of the Polyp, having like locomotive powers until it too fixes itself on some object, retaining, however, the power of motion in its free extremity. Indeed very many forms that were once classed with the *Protozoa*, are now known to be only the mere embryonic forms of the lowest Plants, Radiates, or Articulates, just as the embryonic forms of the higher Radiates have been classed as Polyps, and of the higher Articulates as Worms.

The simpler Protozoans seem to consist of a single cell or of an aggregation of simple cells, without any of that differentiation of tissue which characterizes the higher Orders of animals, and though some of the higher Protozoans *secrete* silica, and others, carbonate of calcium, yet not so as to form a *tissue;* so that these first of Animals exhibit a protoplasmic basis for animal life such as exists in the earliest stage of each individual animal (or community of individuals in the case of such animals as are produced in numbers from the product of a single egg) in the earliest stage of the egg. As we rise in the scale of animal life, or, as we follow the succession of fossils upwards in the formations, or as we follow the progress of differentiation in the egg (in the higher animals) we find in each a corresponding localization of function, and suitable specialization of tissue. It is true that in comparing the first two it is necessary to allow for the greater specialization of the later animals as compared with the earlier of approximately the same grade, while we labor under the serious disadvantage of having so little of the tissue of earlier animals well preserved or in any way directly indicated; and that in comparing the latter with the others it is necessary to allow for the fact that in the egg neither armor for defence nor weapons for attack are needed, nor is there any *functional* organization for reproduction. But allowing for all these the analogy seems perfect.

Dana estimates the comparative duration of the Post Tertiary, Tertiary, Mesozoic, and Palæozoic Periods, as approximately expressed by the numbers 1, 2, 4, 14, respectively. Sir Wm. Logan's estimate of the thickness of the Cambrian and Laurentian rocks of Canada, be taken as the maximum thickness of these, it is probable that they represent a period equal in duration to the Palæozoic Period. So that the various fossiliferous rocks may be estimated to have occupied a Period equal to thirty-five times that of the Post Tertiary, which was probably *not less* than half a million years, so that for the accumulation of the twenty-one miles in the thickness of the various *Zoic* Formations, it will be safe to estimate the minimum duration at fifteen millions of years, though it may have greatly exceeded even this immense Period. But was the Epoch of *Eozoon*, indeed that of the "dawn" of life? and are we to consider this large and very complex *community* of animals as the primordial type? or should we not look rather for a series of types of increasingly complex, and numerous communities of Protozoans leading up to this? and is it not probably that for no inconsiderable period previous to the existence of *Eozoon Canadensis*, *Protozooa* flourished in great numbers and of great size, the sole living occupants of the Earth?

The obscurities of embryology may be enlightened wonderfully (though I do not remember ever to have seen it remarked) by studying carefully the embryology of that Class of each Sub-kingdom in which individuals of certain Orders change or partially change their habitat, during the free life of each, from water to land, since in those Orders in which the young are brought forth on land, they must have reached a very much more advanced stage before leaving the egg, than in those in which the young become free in the water; and there is thus afforded admirable opportunity of comparing allied forms in the same stage of development, in the one case within the egg, whether intra- or extra-uterine, and in the other while living an active free life in the water; these last occupying, from every point of view, an intermediate position between the first and the Species in the past history of the Earth in which the mature individuals, living of course in the water, represented the same stage of development.

All existing Radiates have these remarkable peculiarities, that they are all sessile at some stage of the life of the individual, and that none of them exhibit any of what we call the five senses, but only simple sensation—the common basis of them all. All Radiates that live in the water, when they first leave the planula are free swimmers, and all the higher Orders of them become free again and continue so during their mature life. Land Plants of the higher Orders, which are radiate in structure, and *competely* sessile in habit, seem almost destitute of sensation, and of the power of motion in their free extremity, and also of the power of digestion, although *Drosera* and some other Genera exhibit all three. The sessile Orders of *Articulata* and *Molluscoida* are remarkable for the fact that as each individual reaches the sessile stage it loses its sight, and the tendency to *Cephalization*, which is a marked characteristic of the Orders of Animals, which preserve the power of free motion, and which progresses in each in time from the earliest period in which we can trace it as a distinct Order, by means of its fossil remains, to the present day. This is manifested by the increasing comparative size of the brain cavity, the lessening and sometimes complete atrophy of the posterior extremity or tail, also by the concentration of the limbs around the anterior extremity and their adaptability to serve its purposes. A shortening of the jaws and increase of the facial angle is also usually characteristic of progress in time among higher Orders of Animals; and in Man, as is well known, it is one of the most obvious distinctions of the higher Races.

In Man the process of cephalization has its fullest realization. The facial angle, that is, the angle made by a line passing from the forehead over the upper jaw, meeting another line passing along the base of the skull, is in the best developed specimens, nearly a right angle. It is true that in the lower Races it is considerably less than this. In the most anthropoid of the Apes it is still less, and it is remarkable that it is less in these when mature than when young, shewing that they in common however, as has been already shewn, with all Vertebrates lower than Man differentiate from homological symmetry as they approach maturity. Next to these come successively other groups of Monkeys of the great Continent, all of which have the same number of teeth as Man, and comparatively narrow noses, hence called *Catarrhines*, while the Monkeys of America, except a peculiar group, have one tooth more, a grinder, on each side above and below, longer jaws and broader noses, hence called *Platyrhines*. In Man only is the attitude entirely erect, the fore limbs being thoroughly adapted for use as prehensile organs,—instruments of wonderful adaptability as ministers to his will. In these respects there is a corresponding gradation among the monkeys, the *Catarrhines* having the thumb opposable to the fingers, and the hand generally rather adapted for use as a hand than a foot, and many species are like man without a caudal appendage, while the *Platyrhines* have not the thumb opposable, but have long prehensile tails. Other groups of Monkeys are still more differentiated, and have been described as Squirrel-like or as Fox-like—these last being somewhat carnivorous in their habits. The remains of Monkeys have been found in the Eocene in America, and these are found to be of less differentiated types than existing American Monkeys, and have characteristics which ally them to the existing forms of the next lower grades of the *Mammalia*, the *Carnivora* and the *Ungulata* or *Herbivora*, and it is a curious and instructive fact that each of these Orders was at first, without exception, plantigrade, that is, walked on the entire foot as does man and do Monkeys, so that the later digitigrade types were reached in each case by a gradual differentiation. Insectivores, Rodents, and Marsupials present a similar series of types, the lower being plantigrade and the higher, and later, digitigrade. All the *Edentata* and *Monotremata* are plantigrade. All the Mammalian remains of the Eocene are of highly generalized types.

Didelphia consists of Series differentiated so similarly to those of *Monodelphia* as to have the same names applied to them, viz: Marsupial Monkeys, Carnivores, Herbivores, Insectivores, and Rodents. That *Didelphia* had at the time of its greatest expansion marine representatives, corresponding to *Cetacea* and *Sirenia* among the *Monodelphia* is altogether probable. A somewhat similar parallelism exists between the various Orders of Reptiles and Amphibians. Indeed as we trace each great group forwards in time we find a constantly progressive differentiation outward from the general to the particular, or special, from the ominivorous for example, to the more and more completely herbivorous, carnivorous, or insectivorous, and from these to others having still more *specialized* habits as to food, and all the corresponding peculiarities of organization and instinct.

Again there is the tendency outwards as to habitat—to occupy the land, the water, or partly each of these, and that in every climate. Each of these differentiate into flying and non-flying, and some of each of these into climbers, and some into burrowers; in fact each subordinate group as it expands has a tendency to repeat from its own starting point all of these differentiations, and a thousand minor ones; so that each of these differentiations may be more or less fundamental than other co-existing ones. Thus in the *Chieroptera* the adaptability for flight seems more fundamental than that for a particular variety of food, since some exist on almost every variety, while in the Flying Squirrel, and *Galeopithecus* the adaptability for flight seems of a much less fundamental character.

There seems to have been a steady increase in the size of the larger animals of each succeeding grade, corresponding to the increasing induration of tissue; in the water from the Selachian or Shark of the Upper Silurian to the hugh Cetaceans of the Recent Period; and on land from the *Labyrinthodontia* of the Devonian to the Recent Mastodons. The larger animals of each grade seem to have been exterminated by the larger animals of the succeeding higher grade, these having the advantage in the struggle for life in respect of intelligence, activity, strength and ultimately even of bulk. Thus the largest types of each grade, except the highest, have been constantly and successively in every sense undergoing extermination, so that, as we go downwards in grade, we find the existing representatives smaller until we reach the *Protozoa* where they are mostly Microscopic, although when each grade was in maximum it had representatives comparable in size, though not quite equal, to the largest of the succeeding grades. Now as we have seen that directions taken by the different Orders of each Grade, have been approximately parallel or similar, each to each, and as the lower and earlier grade had begun to differentiate soonest it is plain that only its more differentiated types would be well out of reach of this competition of the higher, and that thus the less differentiated types of the lower would be constantly and successively undergoing extermination, and thus only the most differentiated types continue to exist, except when the more synthetic types are preserved, by *isolation* from the access of types of a higher grade, or by a difficulty of access arising from any other cause.

The Great Continent, particularly the northern Grand Division of it, Asia-Europe, has been during the later Tertiary, the Post Tertiary and Recent Epochs the theatre *par excellence* of progress in every organic type, which is represented there. It was not always so, however for North America in the Eocene seems, both in regard to its Plants and Animals, to have reached a stage only reached in Europe and Asia in the Miocene, no doubt by a migration thither of the Plants and Animals of North America, implying, of course, a continuity of the Continents at that time. But while North America has made little progress comparatively in the differentiation of its Plants since the Eocene, it has been far different on the Great Continent, which is consequently now far in advance of North America, and though the differentiation of the higher Animals in North America has been much greater comparatively than of its Plants, yet in this respect also it is in every way inferior and *behind* the Great Continent. South America may be said to represent in a general way the Eocene of North America, and Australia the Cretaceous of North America and the Cretaceous and the Eocene of the Great Continent, while New Zealand with its gigantic birds as the highest type, represents an earlier Mesozoic Epoch, and the Gallapagos Islands with their gigantic Reptiles, probably represent a still earlier Epoch. In each of these cases the comparative cessation of progress referred to, seems to have been the result of isolation from the *then* Great Continents—the chief centre of progress and of differentiation, or in other words, of progress upwards and of progress outwards,—outwards, not only in space but in those adaptations which have given to each great group representatives suited for every possible mode of existence.

South America has more recently been again united to North America, but climatic causes have prevented a rapid migration of North American types.

These are a few typical illustrations of a principle illustrated everywhere, since in fact every considerable Island or Archipelago illustrates it, and even on the Continents, great mountain ranges, deserts, &c. serve as barriers to the migrations of land Species, and the Continents themselves to those which inhabit the sea, while to those which inhabit the shallow waters, the ocean depths present a barrier hardly less impassable than to land Species. It must be remembered too that each great group has its own centres, and subordinate groups theirs also, and that these all vary in position with the varying changes of climate, elevation, &c. As a single example of local centres for subordinate groups, the Humming-bird may be given, of which more than a thousand Species inhabit South America, though none are known ever to have existed out of America. Species of the same Family found in localities long isolated from the chief existing centre of differentiation, for that family are usually smaller, less vigorous, and less fully differentiated than the others, resembling the immature forms of the more differentiated Species.

A most interesting and suggestive fact in the distribution of Organic Types is the existence in Regions more or less recently isolated from each other, of representative Families, Sub-families, Genera, Sub-genera, Species, or Sub-species, according apparently to the length of time the isolation has existed, and to the rapidity with which differentiation takes place in the particular Group selected for comparison, and that in lands long isolated from each other the Organic Types are very different, however similar may be the climatic and other conditions. In Europe and North America, which have probably been separate since the Miocene Epoch, many Genera exist having a certain number of Species in the one corresponding to a certain number in the other, *each to each.*

I quote from Prof. Wyville Thompson: "On either side of the Isthmus of Panama the Echinoderm order *Echinidia*, the sea-urchins, are abundant; but the species found on the two sides of the Isthmus are distinct, although they belong almost universally to the same Genera, and in most cases each is represented by Species on each side which resemble one another so closely in habit and appearance as to be at first sight hardly distinguishable, I arrange a few of the most marked of these from the Caribbean and Panamic sides of the Isthmus in parallel Columns.

EASTERN FAUNA.	WESTERN FAUNA.
Cidaris annulata. GRAY.	*Cidaris thouarsii*, VAL.
Diadema antillarum, PHIL.	*Diadema mexicanum*, A. AG.
Echinocidaris punctulata, DESML.	*Echinocidaris Stellata*, AG.
Echinometra michelini, DES.	*Echinometra van brunti*, A. AG.
Echinometra viridis, A. AG.	*Echinometra rupicola*, A. AG.
Lytechinus variegatus, A. AG.	*Lytechinus semituberculatus*, A. AG.
Tripneustes ventricosus, AG.	*Tripneustes depressus*, A. AG.
Stolonoclypus ravenelii, A. AG.	*Stolonoclypus rotundus*, A. AG.
Mellita testudinata, KL.	*Mellita longifica*, MICH.
Mellita hexapora, A. AG.	*Mellita pacifica*, VER.
Encope michilini, AG.	*Encope grandis*, AG.
Encope emarginata, AG.	*Encope micropora*, AG.
Rhyncholampas caribbœarum, A. AG.	*Rhyncholampas pacificus*, A. AG.
Brissus columbaris, AG.	*Brissus obesus*, VER.
Meoma ventrosa, LIITK.	*Meoma grandis*, GRAY.
Plagionotus pectoralis, AG.	*Plagionotus nobilis*, A. AG.
Agassizia excentricia, A. AG.	*Agassizia scrobiculata*, VAL.
Mœra atropos, MICH.	*Mœra clotho*, MICH.

The Isthmus must have been raised into dry land in Tertiary or Post Tertiary times. It is difficult to doubt that the rising of this natural barrier isolated two portions of a shallow water fauna which have since slightly diverged under slightly different conditions. I quote A. Ag.: "The question naturally arises, have we not in the different Faunæ on both sides of the Isthmus, a standard by which to measure changes which these species have undergone since the raising of the Isthmus of Panama and the isolation of the two Faunæ?"

But it is not only in distinct "areas" that we find "representative" Groups, but they occur successively in the same area, since in successive strata are found representative groups of Species, at wider intervals, of Genera, and at still wider of Families. It is interesting to note in this connection the gradual differentiation of a Sub-kingdom by the steady increase of its Families, Genera, &c., the expansion and differentiation occuring in its central and *characteristic* types, while those types of a more intermediate, synthetic, or connective character, tend to become extinct unless saved by some exceptional circumstance, as isolation, &c.

No Sub-kingdom has left so good a record of itself in the Rocks as the *Mollusca*, and according to Woodward the number of Families for the Formations is approximately as follows: Silurian 20, Devonian 24, Carboniferous 30, Triassic 35, Jurassic 49; Cretaceous 56, Tertiary 62. The Genera for the same Formations in the same Order were 53, 77, 79, 81, 108, 148, and 192 respectively. The decrease of such Families as have become extinct, or seem in process of extinction, is a similarly gradual process, and occurs first in the Genera, least typical of the Family, or most synthetic in type; so that both increase and diminution seem to follow an organic law, which may be illustrated (though of course the analogy is far indeed from being perfect) by the growth of a branch of say a fir tree, and in the case of the Families which have become extinct the gradual withering and successive death of the branchlets, until finally the topmost bud, and with it of course, the branches succumbed to the crowding and pressure of the superior and surrounding branches. Of course the regularity of this process in the family is interrupted by the fact that in isolated areas the older types may be preserved and even extended.

Another difficulty in defining the limits of Species arises from the fact of the intercrossing of Species of the same Genus, and although the product is usually sterile except with either of the original Species, yet the incorporation by this means of an element from one Species into another, seems incompatible with the idea of the two Species having been originally distinct and without any generic affinity; but the difficulty of entertaining such a supposition becomes still more striking when the product of such intercrossing of Species is fertile *inter se*, as in a case described by the late Prof. Agassiz, and where it is evident that the new Species (shall I say since there is no other possible way of classifying it) might continue to exist, in its entirely distinct form, throughout a Geological Epoch, if brought to a South Pacific Island, where it would be alike free from competition and from admixture with allied Species; indeed in the case referred to below it seems likely to be continued as such in a domestic condition for economic reasons. Agassiz says: "There are, however, two animals entirely distinct as to specific characters —the hare and the rabbit of Europe; (I do not speak of those of the United States, respecting which such observations have not yet been made): these animals have been crossed and offspring has proved to be fertile, not only with the original Species, the hare and the rabbit, but the cross breeds themselves, the individuals derived from the crossing of hare and rabbit have been fertile among themselves. Thus a new breed, which thus far exists only in domesticity, has been produced and is known under the name of leporide in the Paris market, where it is as common now as the hare or rabbit. This new breed differs in the colour of the flesh from both hare and rabbit, the former being dark the latter white, while the leporide has an intermediate condition of meat much esteemed for its flavor and delicacy."

The total number of known distinct existing Species (so called) of Animals and Plants is about half a million. Of these it may be said that the higher the grade to which they belong, and the higher the group within that grade, the shorter lived or less persistent is the Species, and the wider the limits of its variation, so much so that in the case of many it is difficult or *impossible* to decide as to the limits of each. Indeed every attempt to define absolutely what constitutes a Specific distinction, has resulted in failure, and we are left to accept the opinion of Agassiz, that a Species is an ideal "entity," in no way different in kind, but only in degree, from Genera, Family, Order, &c. A hundred illustrations might be given of the difficulty, or rather the impossibility of determining absolutely whether certain groups should be considered as constituting a Genera consisting of a number of Species, or a Species consisting of a number of Varieties. I avail myself of the case of *Rubus*, so well elaborated by Prof. Lawson, and doubtless fresh in the recollection of members. (See Trans. pages 364–6.) "This is particularly the case with regard to the European *Rubi fruticosi*, many of the long recognised species of which are so closely related, that some of our best botanists now rank upwards of twenty forms that are too well marked and too constant to be mere varieties, as so many sub-species under the specific type of *Rubus fruticosus*."

In estimating then the total number of existing Species, the impossibility of defining the limits of each Species is in itself an insuperable barrier to complete success. It must also be remembered that while the land surface of the Earth, and the shallow seas are far from having been completely explored, the deep sea forms are almost unknown, although the researches of the "Challenger" Expedition has shewn that they are abundant, and as the nature of their habitat must effectually prevent the rapid ingress of later, more highly differentiated, and more typical forms, that is, forms typical of a *larger* group, they will be fouud to be more synthetic, and antique in their more general characteristics, such as those pertaining to Order and Family, but at the same time more differentiated iu their more specific characteristics, such as those pertaining to Genera and Species, as was found to be the case with those already discovered. The wonderful development of the organs of vision of the more predatory and active Types and their atrophy in the case of the others, is a striking illustration of the possibilities of differentiation in adaptation to circumstances, though paralleled by the differentiation of the imperfectly sighted types of earlier times into the (usually) better sighted, higher, and more active Types of the present day on the one hand, and into the sightless sessile Types on the other. Any attempt to estimate the numbers of extinct Species must necessarily be very vague from the necessary imperfection of the Geological Record, as well as our as yet imperfect acquaintance with it; but enough is known to make it certain that the extinct Species were many times more numerous than those now existing, so that it is clear that many millions of Species have been created, during a period of millions of years; and this was all accomplished in the most gradual and systematic manner possible, both as to creation and extinction; the apparent exceptions occurring in exceptional circumstances, and themselves conforming to their appropriate laws, and being therefore of that kind which have been said to "prove the rule." It is not therefore surprising that while all, who have any considerable knowledge of the subject, are Evolutionists in the sense of comprehending that creation of the successive types exhibit the gradual evolution or unfolding of certain ideas, a very large majority of the leading Men of Science of the present day believe that the Creator formed the various Species, so called, by the operation of His Laws from a single protoplasmic primordial Type, rather than by a direct, miraculous (in the ordinary sense of that word) creation of, as I have said, ~~of~~ many millions of Species spread over many millions of years, and governed in the minutest particular by laws involving complications, a few of which I attempted to indicate. It is perhaps worthy of remark that if Species were created by an immediate act instead of by a continuous process, and each put into a particular spot of the land or water, which was to become its home, they must, unless created in considerable numbers, have been miraculously preserved also, inasmuch as otherwise, in many cases, they would be sure to be exterminated almost immediately. Again, a belief in the miraculous creation of each Species almost necessarily leads to a belief in the creation of representatives of it in distinct and often widely distant centres, as was held by the late Prof. Agassiz, and also to this difficulty, that since the various Races of Mankind, exhibit differences equal to and even greater than those which are considered Specific in the lower animals, we are driven to the conclusion, which was reached by Agassiz, viz.: that Man consists of distinct Species and may have had many while he must have had several distinct centres of creation. I quote the words of Agassiz: "Now, then, what do we find among men? Similar differences again. For men have not all the same complexion, nor do they all exhibit the same characteristic features. And here let me urge upon you this fact, for we cannot consider the relations of mankind to monkeys unless we are aware how widely men differ from one another. While they have all the characteristics of humanity there are yet among them differences about as striking as the differences which distinguish some of these genera of monkeys from one another—as striking unquestionably as the differences of some of the species of monkeys from one another. And I am bound to say that unless we recognize the differences among men, and we recognize the identity of these differences with the differences which exist among animals, we are not true to our subject. And whatever be the origin of these differences, they are of some account, and if it ever is proved that all men have a common origin, then it will be at the same time proved that all monkeys have a common origin, and it will by the same evidence be proved that men and monkeys cannot have a different origin. This is the appalling feature of the subject —that the characteristices which distinguish the different races of men are of the same nature as the characteristics which distinguish the different kinds of monkeys. And it was for that reason that early I maintained that the different races of men must have had an independent origin, because I saw the time coming when the question of the origin of man would be mixed up with the question of the origin of animals, and a community of origin might be affirmed for all. Now, I hold that the idea of the community of origin of man and monkeys and the other quadrupeds is a fallacy, the foundation of which I shall try to explain presently. But if it is error to consider man as derived from monkeys, we must admit that men are not derived from a common stock, because the differences which exist among men are of the same kind and quite as striking as the differences which exist between monkeys, and between the lower animals."

Now, I need not say that a disbelief of the original unity of Man is irreconcileable with Christianity, so that if as Agassiz affirms, a common origin for the Races of Mankind necessarily implies a common origin for the various Species of each Genera of Monkeys, and for each of these Genera and Man, then, from a theological point of view, we would be driven to accept the view which assigns a common origin to Man and the Monkeys, and if to these then to all the Vertebrates, and ultimately to all organic Types.

I have thus endeavored, in intervals snatched from professional study and daily avocations, to sketch in outline this great subject, in undoubting faith that fidelity to truth is the only true fidelity to Religion and to God.

When Man began to arm himself with weapons against the greater Animals within his reach, these had reached their *maximum*, and began to be speedily exterminated before his attacks, for while in the earlier Post Tertiary the greater Continent and North America were the homes of the greatest Megasthenes (or higher Vertebrates) that ever lived, almost equally great Edentates flourished in South America, and similarly vast Marsupials in Australia, while Cetaceaans probably the largest, without exception, of animals that ever lived, flourished in the Polar Seas. Of all these most of the largest have perished already, while as Man improves his arms and adds to his intelligence, the greater animals which he refuses to take under his protection are rapidly disappearing before him.

The process of extinction, therefore, has been proceeding during the Recent or Human Epoch with a constantly accelerating and unparalleled rapidity. But while Man is rapidly exterminating *most* Species which are within his reach, and which he does not choose to protect, the number which he takes under his protection is continually increasing, and it so happens (though of course there is no chance in the matter) that the Species, which for economic purposes he takes under his protection, are precisely those which are the representative types of the Families or great Groups to which they belong,—the topmost buds of the greater branches of the tree of life. They are thus the natural centres of differentiation, possessing at once the greatest vital power and the greatest possibilities of variation, hence also of cultivation and of naturalization on ~~of~~ every part of the Earth,—processes which I need not say are being accelerated yearly, almost daily, with the increasing facilities for locomotion which are so characteristic of the current century,—processes which have already afforded results the most invaluable to Mankind, and promise incalculable advantages in the future.

But it is in Man, himself, the representative of the entire Group of organic Types,—the topmost "upright" stem of the Tree of Life, that all the possibilities of differentiation and of culture culminate, and I do not therefore share the gloomy anticipation of Prof. Dawson, that there will "ensue a period of decadence until it (the human race) becomes extinct," but believe that in Man as in the lower Animals, while the inferior and more synthetic types will be successively exterminated, the higher and more differentiated types will be continually expanding, and that the "meek sha'l inherit the Earth," and rejoice in the life that now is and th assurance of that which is to come, by faith in Him, who is the Way and the Life—the Son of Man and the Son of GOD.

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