Natural Alchemy of Religious Opinion
Fishes and Amphibians

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Before taking up the development of still higher life-forms, it will repay us to glance at the mutual dependence of plants and Insects.

Plants in general found it of great advantage to reproduce by means of seeds instead of by spores; and they found it a further marked advantage when the male element from one flower could find its way to the female element of another flower and thus prevent inbreeding. Consequently, the plants, in their own subconscious, but nevertheless intelligent, way, sought how this vitally important cross-fertilization might be accomplished.

The first expedient was to use the wind and water to carry the fine grains of pollen, which contain the male sexual element, to adjoining or distant flowers. To insure pollination in this hit or miss manner, however, requires great quantities of pollen; for much is sure to be wasted. Therefore, as insects were in the habit of visiting the plants, which they used for food, the expedient was gradually adopted of using the, insects to carry the pollen from one flower to another.

The problem then arose of making sure that insects would come to the flower. This was solved by secreting a substance, such as the nectar found in most flowers, that would serve the insect especially wall for food. Next the problem arose of attracting the insect from a distance. This was accomplished by coloring the flower, or by giving it a pleasing odor, that might be noticed_ by the insect at a distance. The color of a flower, and its odor (unless this is offensive and used for protection) have been developed for a single purpose and no other-- to act as advertisements that -a banquet awaits the particular insect best suited to affect its cross-fertilization. These advertising banners have been subject to a special evolution. Thus, the most primitive color for a flower, aside from the original green, is yellow. Later, plants developed red blossoms, and finally, as the very latest color scheme, and one that is recognized farther than the others, the blue and violet colors have been evolved. In some way, although not exactly in the way we discern colors, but perhaps by perceiving decrees of brilliancy, insects are able to distinguish the blossoms of their favorite flowers at long distances.

With the problem of attracting insects solved, the next step was to make absolutely certain that the insect securing the repast of nectar should pay for its meal by being dusted with pollen. Gradually an infinite number of cunning devices, in the form of' different shaped corollas, were evolved. 'lowers that originally had numerous petals, an numerous pistils and stamens, securing fertilization in some few by shear numbers, reduced the number of parts in favor of some shape that would permit the insect to enter, but which also insured that it carried away pollen. All the innumerable forms of our bright-colored flowers; tubes with little landing platforms, hoods, sheathes, and what-not; have been evolved in response to the plant's intense desire to compel the insect upon which it depends for cross-pollination, to carry pollen from the male portion of one flower to the female portion of another flower.

All those plants then, that have Small greenish inconspicuous flowers, like the grasses, depend upon the wind for pollination. The bright ones invariably depend upon insects or birds. Nevertheless, some, that in the past depended on insects, have now devised an unusually fine light pollen which is produced in enormous quantities. et the time of bloom the air for miles around is full of this minute pollen dust. These plants, of which the goldenrod is a typical example, are finding this now method even superior to depending on insects. They are, therefore, abandoning the use of insects, and are returning to the use of the wind, being now in the state of transition.

The problem of dusting an insect with pollen solved, the next thing was to make sure that the pollen would be deposited not on the female part of the same flower, on the female part of some other flower of the same species. This object is attained in many unique ways. For instance, the little filaments, or stalks, of the stamens of the cornflower, when touched, contract and draw instantly down over the stigma: or female party protecting it; yet at the same time exposing the pollen on the anther to the insect that has touched it, The diplacus, or monkey flower, common on our California hills, has a stigma of two flat lobes that snap together tightly when touched. The stigma is placed so prominently that an insect visiting the flower is sure to touch it when alighting. It snaps shut on the pollen dusted from the startled insect, and the insect then guts covered with the pollen from the anthers of this flower with no danger that any of it will find its way into its own stigma.

To insure that they shall not be fertilized by their own pollen, the pollen of many flowers ripens only at a time, either before or after, when the stigma is not yet able to receive pollen, The larkspur has still another device. It bends down certain of its stamens on different days) so that if the bees that visit it do not on one day visit and fertilized other flowers with its pollen, those that visit it some days later get fresh pollen, and those that visit it several days after this got still another load of fresh pollen. The larkspur, too, belongs to the buttercup family, and practically all of our wild flowers and garden flowers are thought to be descendants of a primitive buttercup. This early buttercup had numerous petals, numerous pistils, and numerous stamens; which were gradually sacrificed in the interest of greater efficiency. The modifications, in each instance, were toward securing pollination through the aid of some special insect or bird.

The hummingbird sage, common about Los Angeles, has developed such a long-tubed corolla that few insects can reach the nectar in the bottom. It is a favorite flower of the hummingbirds, however, which its crimson blossoms attract from long distances; and it depends chiefly upon these for carrying its pollen. Other flowers depend upon bees. But hero another problem arises; for if a bee visits one kind of a flower and then another kind of a flower, the pollen so carried will not fertilize. The pollen from white clover, for instance, will not fertilize the buckwheat flower which next may be visited. In this case it is the bee that has learned something; for as plants have progressed, so have the insects that live on them progressed in a parallel manner. Bees are absolutely dependent upon nectar and pollen for food. It is to their advantage that flowers shall be pollinated properly, thus providing for new plants to blossom the next year. And it has been definitely determined that bees do not indiscriminately visit different kinds of flowers. During the work of a morning a bee will confine its attention to one kind of flower. It does this even though it visits different colored flowers of the same species. On the next day it may turn its attention to a different species of flower, but it is too good a gardener to mix the pollen of a daisy with that of a dandelion.

Flowers that open by day depend upon day-flying insects. Those that open at night depend upon insects that fly by night. Those with the nectar in short tubes depend upon bees and small insects. Those with long tubes depend upon butterflies and insects with long probosces. The red-clover, for instance, depends entirely upon the Bumble-Bee. Efforts to raise red-clover in New Zealand Wore a failure until some naturalist suggested importing Bumble-Bees. Plenty of Bumble-Bees insured proper pollination and made the venture a success.

One might write on indefinitely of the manner in which flowering plants and insects have helped each other solve the problem of life and progress. One might also write on indefinitely of the shrewdness of insects, such as the common harvesting ant of South Europe, which collects the seeds of clover-like plants, lots them sprout until they burst, then exposes them to the sun to prevent further germination, after which it carried them under ground. Still later it chews them into dough and makes them into little biscuits which it bakes in the sun. These it then stores for winter use. Such wonderful habits, which in many cases parallel the efforts of humanity after reaching some degree of culture, are the outcome of subconscious mind response to the desire to live and express life more fully

But we must now return to a time before there were any insects, and before there were any land plants. In the Archeozoic age there were only single-celled animals and single-celled plants. The following geological age, the Proterozoic, brought a development of the invertebrate animals into innumerable forms which dominated the world. In the beginning of the first age that clearly shows fossil remains, the Cambrian period of the Paleozoic age, the trilobites came to be the dominant form. These are segmented animals belonging to the Phylum Articulata, having for ancestors the segmentated worms. They are primitive crustaceans; and other crustaceans, like the lobster, crayfish, and shrimp, developed from them. The trilobites are the transitional form between the segmented worms and the insects; for after land plants developed the descendants of the trilobites took to the land to get a food supply and gradually became insects as we know them.

But before the trilobites, undoubtedly, there were segmented worms. Let us now, therefore, visualize a world covered with shallow seas and lakes, crowded with innumerable kinds of invertebrate water life. Then let us imagine the condition; as actually transpired, when various land areas the world over commenced to rise. Instead of placid lakes, large areas tilted up to form highlands were drained by swift flowing rivers. At the same time the lake and sea expanse, already crowded, were greatly reduced in area, and forms of life that had found a living there were sorely pressed for food. Many such forms finding the competition too keen, died out and became extinct. But other more progressive kinds tried to adapt themselves to the new condition by finding a habitat in the rivers.

Rivers have a persistent and rather rapid flow of water in a fixed direction. To be able to live in a river, and not be washed down it and out to sea, an animal must either have some means of clinging to the bottom or some means of locomotion sufficiently effective to overcome the current of the stream. Except for certain minor instances there are only three large groups of animals that have solved this problem. Some of the molluscs, like the muscle, are able to crawl along the bottom through firm contact with it. Certain crustaceans, like the crayfish, can crawl along the river bottom by means of many sharp claws that they hook into the river bed. The fish solve the problem by a mode of propulsion through the water.

Now when the segmented worms, to escape their numerous enemies and to find food, took to a life in the river, they found that the position enabling them best to meet the current is to keep the head directly upstream. They found also, by degrees, that a rhythmical undulation, similar to that of grass growing in the stream, is the movements best suited to overcome the momentum of the current. A fish moves by alternate rhythmical contractions of the side muscles, so that the pressure of the fish's body is brought to bear, first on one side and then on the other, against the water of the incurved section. Such motion is not possible to most invertebrates of the sea; for usually they have compact or rotund bodies that make them sluggish. But the segmented worms had a suitable linear form, and already had a bundle of fibres running lengthwise with a nerve chain inclosed in a sheath. This was the commencement of a lengthwise wise supporting tissue that would prevent the shortening of the body due to the pressure of the water against the head.

There developed, therefore, such creatures as the Enteropneusts, which are vertebrate-like worms. They have numerous gill-slits opening from the pharynx to the back surface of the body, and a body cavity similar to true vertebrates. They live at present off the coasts and eat their way through the sandy mud to get the small organisms living in it. A somewhat further development from the segmented worms is shown in the sea-squirt. It begins life as a free-swimming larvae, like a small tadpole, with a brain and spinal-cord, a notochord, or primitive vertebra, a brain eye, and a heart. It fastens itself to a shell or stone, and then degenerates rapidly as it reaches the adult state. Not above these come the lancelets, such as Amphioxus, that are found in most seas. They have no skull, no jaws, no limbs, no brain, no heart, and no eye; but they do have a spinal cord, a notochord, and gill-clefts. They are translucent spindle shaped creatures about two inches long, that evidently have a worm ancestry, but which have developed the ability to swim with some speed.

A still more advanced transition type between segmented worms and trees fishes are the Round Mouths, such as the Lampreys and Hags. The lamprey looks something like an eel, but has no jaws, no limbs and no scales. It does have, however, a gristly skeleton, something of a skull with horn-like teeth, and a number of gill-pockets. Some live in fresh water; and some live in the sea, ascending the rivers to spawn. The hag is another eel-like creature, one, the Bdellostoma, living off the California coast.

The first truly vertebrate animals were the fishes. These vertebrates are that group embraced in Phylum XII, the Chordata. They have several distinct characteristics that separate them from all other forms of life, and as all the higher animate including man, belongs to this group, it may be well to mention them. In the first place there is a notochord, or primitive backbone, running lengthwise of the body, serving to stiffen it, and thus prevent the shortening of the body, which would otherwise take place when the muscles are contracted. In the primitive forms this notochord is composed of membranous connective tissue, in more advanced forms it is formed of cartilage, and in those forms still higher it becomes a bony vertebral column

A second character of all vertebrate animals is the development of gill-slits through the walls of the throat cavity. We have already seen that these gill-slits are present in the vertebrate-like worms. They are quite obvious in the true fishes, the gills being surfaces of considerable area where the blood is exposed to the oxygen contained in the water, and respiration accomplished. In the mammals, including man, several pair of gill-slits are always well defined in the embryo, but as the form develops are modified until a single pair is left, and these are no longer used for respiration, but form the eustachian tubes which connect the middle ear with the throat cavity and thus equalize the air pressure on either side of the ear drum.

All vertebrates also have a spinal cord, are usually segmented, and when paired limbs are present there are never more than four.

The first fishes probably were not bony, but were gristly, with a mouth on the front side, like the sharks and skates of today. Up to the present time no fossils of these early true fishes have been found. The earliest fossil fishes had traveled far along the road of progress. They are certain armored fishes, the ostracoderms, found in Middle Ordovician rocks near Canyon City, Colorado, in the Big Horn Mountains of Wyoming, and in the Black Hills of South Dakota. The Ordovician period is the period immediately following the Cambrian period in which the trilobites dominated the earth. Before the Cambrian, in the rocks of Proterozoic age, there are traces of one-celled marine animals, the Radiolarians, with shells of flint that could be preserved. And there are also traces of worms that burrowed in the mud, for these burrows are sometimes preserved as fossils. But with the coming of Cambrian times the seas and shores the world over began to swarm with sponges, jellyfishes, crustaceans, worms, lamp-shells and molluscs.

Certain of these molluscs, the cuttlefishes, dominated the seas during Ordovician times. They were fierce predatory creatures, even as is the octopus at this day, but their place as masters of the sea was disputed by the true fishes that developed at this time, and they finally had to yield to them. These first fishes were fresh-water fishes, and it is thought that the habit of many marine fishes today, such as the shad, sturgeon, and salmon, of leaving the sea and ascending rivers to spawn is the following of a custom established early in fish history. After developing locomotion: and the typical fish form, the fishes were better adapted not only to a life in swift moving streams, where they had their origin, but to water life in general. As a consequence they sought out every available nook of lake, sea, and river, and so modified their structure as to make them specially suited to survive in the chosen habitat.

Space will not permit of even a superficial enumeration of the various wonderful adaptations accomplished by fishes. Many are quite unique, such as the one called "the angler" which has a fishing rod and tempting looking bait which it dangles in front of a cavernous mouth lined with teeth that are hinged at the base so as to bend backwards, permitting other fish to enter but quite preventing their exit. The eggs of the sea-horse are placed in a skin pocket, bringing to mind the skin pocket of the kangaroos among mammals, where they are sheltered until developed. Some fishes also make nests, anticipating the birds in this respect. The stickleback, for instance makes an elaborate nest of leaves and stems of water plants which he sticks together with glue-like threads which are secreted at this time by his kidneys. This nest has doors, and by coaxing and by using a certain amount of force, he persuades one female after another to pass into the nest by one door and out of it by the other, depositing her eggs in the nest as she goes. After this he sets himself to guard the nest, and drives away all other fishes that approach. After the young are hatched he is kept very busy herding the little ones together and keeping them out of danger until they are old enough to shift for themselves. This he does with the utmost diligence and solicitude.

Another male fish, the scientific name of which is Semotilus Atromaculatus, takes stones from the bottom of a stream, gripping them in his mouth, and builds them into a dam. Below the dam he builds an egg depository of stones so formed that the eggs when deposited by the female are held in the spaces between the stones, thus protect from other fishes, and kept from being washed out by the dam just above then. Innumerable able other examples of instinctive intelligence as exhibited by fishes might be cited, but these two no doubt will suffice to show that subjective intelligence, at least, is surging to find expression, even in the fishes.

I have mentioned that earlier fishes had a gristly structure and that those more developed had provided themselves with a bony skeleton. But there is yet another group of fishes that now needs to be mentioned. These are the Dipnoi, or double breathers, represented by the Bony Pike in the United States, and by the lung fishes of Africa, Australia, and South America. These lung fishes live today in regions where the lakes and ponds at one season of the year dry up. No doubt, in answer to the desire to survive in such an environment, fish were developed with the air-bladder connecting with the gullet. In other fishes the air-bladder serves as a means by which the fish rises or descends in the water, expanding the sack to rise and compressing it to sink. But in the lung-fishes, when the pool in which they are living dries up, it is used as an accessory apparatus by which the blood is given oxygen from the air. These lung fishes can successfully weather long periods of drought.

There is also a fish, the "Climbing Perch", which abounds in fresh water throughout out the Malay countries, Ceylon, India and Burma, that has the habit of leaving the water and traveling across the land, even over high hills and broad prairies, not infrequently climbing up trees on the way, to other water. This fish carries water in chambers in its head for the purpose of breathing (See Nature Magazine, Jan. 1923). There is also a climbing catfish in the upper Andes of South America.

In an environment such as the present African mud-fish lives in, where the dry season lasts nearly half of the year, a great premium is placed upon the ability to breathe air, and also to move about on land, for the water completely dries up. The persistent desire to survive and express more fully undoubtedly developed the first amphibian, or land vertebrate, from the lung fishes.

In the Ordovician period the first fossil fish are found. In the next period, the Silurian, are found primitive Scorpions, some of immense size, and it is quite certain that some of these took to life on the land; the segmented worms probably accomplishing this at an even earlier date. The oldest fossil amphibian is the footprint of Thinopus, found in the period following the Silurian, the Devonian period. During this period, also, for the first time, flowering plants became established.

The next period after the appearance of the Amphibians is the Carboniferous period, during which the great coal measures were laid down. Unlike the Devonian period, which was marked by aridity, there was a mild moist climate that encouraged luxuriant vegetable growth on low swampy ground. This vegetation was mostly club-mosses and horsetails, that grew to immense size. Their spores and other debris is the source of the present day coal supply. The first fossil insects are found in the same period; and undoubtedly the land swarmed with them. They provided certain cross-fertilization for the flowering plants that had now become established, and they became a food supply for the amphibians that followed them over the land. It was no doubt at this time that the flowers first began to gain their colors to attract insect visitors.

There were also land snails at this time. But perhaps of chief importance were the amphibians, some of which grew to be as large as a donkey.

The paired fins of the lung-fishes were gradually developed into limbs with fingers and toes, by which things might be grasped and food placed in the mouth. There was the development of a heart of three-chambers, a movable tongue, true lungs, a drum to the ear and lids to the eyes, none of which a fish has. Further, for the first time, there was developed a voice.

At first the voice served as a sex call, as it does today with our toads, hylas, and frogs. The piping and croaking of these amphibians, so noticeable in the spring of the year, are love calls. As higher forms of life developed the voice came to be used to express a call for help, to convey the notion of danger, and to express other emotions.

The amphibians, represented by our frogs, neuts, and salamanders, are air breathing in the adult stage. But they must return to the water to lay their eggs. The young are hatched in the water, and pass through a fish-like period of infancy, breathing by means of gills. They thus, in the early stage of their lives, recapitulate their development from fish ancestors. Every schoolboy is familiar with the tadpole that lives in the water and later absorbs its gills and tail, gains four legs, and transforms into a frog or toad able to travel and live on the land.

I have already been compelled to use geological ages and periods to designate time in the earth's history when certain forms of plants and animals first developed. It will be well, therefore, before going further, to explain how we know the derivative ages of these periods, and how we know that certain life forms first occured at stages of the earth's history corresponding in time to them.

We have all watched, during a rain, the tiny rivulets running down a hillside, cutting little gutters into the soil and carrying sand and mud from the hill to a creek, thence into the river, and finally to the sea. This process is going on yearly and at times great rivers go on a rampage and in a short while cut down their banks and carry great quantities of mud and sand into the ocean. Creatures that have died during such a flood are often carried by the current into the sea and buried beneath the sand and mud. As time goes on they are buried deeper and deeper, until a great quantity of material lies above them. This material is compressed and hardened by the accumulating weight above it, until the sand becomes sandstone and the mud become mud-stone or shale. If the creature thus buried has a bony skeleton, or other hard parts, and is buried in a deposit of lime forming near the shore, or in mud, so that air and water can not reach it, these hard parts are preserved in the forming rock as fossils. Sometimes, also, insects are caught in the resin exuding from trees, and incased in it. These trees then may be torn from the banks of streams by a raging torrent and buried in the mud. The mud then becomes stone, preserving the tree in it, and the resin turns to amber which incloses and effectually preserves even delicate insects. Volcanic dust occasionally overwhelms insects flying above shallow pools of water, bearing them down into the water and covering them with a layer of powdered stone that solidifies, encasing them in a hard shroud that effectually preserves them. They then become fossil insects.

The process of erosion, the deposition of sand and mud in the sea, is not uniform, but periodic. At more or less regular intervals great quantities of silt are deposited, and at other periods there is very little. Thus the sand and mud is laid down in layers, for deposits of one period often harden somewhat before the deposit of the next period is put down. The succession of layers is easy to determine, as one will learn by watching the fan-like deposit of a hillside rivulet when it fails to reach a larger stream and must drop its load. Every rain increases the thickness of the deposit by one layer,' and this new layer is always laid down on top of the layer laid down by the last rain. The oldest layer of sand and mud is always on the bottom and the newest always on top. Thus it is also with the mud and sand laid down in the sea. Those layers on the bottom are the oldest, those next above these are next oldest, and so on, until the top layer is reached, which is the newest.

Now if fossil remains are found in the oldest strata, those creatures were buried at the time the oldest layer was laid down, and must have lived at that time. If other creatures in a fossil state are found several layers up from the bottom, these creatures were buried at a later date than those buried in the bottom layer, and consequently lived at a later date, Those found buried in the top layer were buried at the very latest period during which the deposit was formed, and thus must have lived at the latest time during which the deposit was formed. All sandstones and shales and other sedimentary rocks were formed by being laid down as fine material in water and later solidified by pressure. They form definite layers, one above the other, and even though at a later date these layers are tilted up by the elevation of a portion of the area they cover into hills, the order in which they were laid down is not difficult to ascertain if cuts have been made through them, if they are broken so the layers are exposed, or if holes are drilled through them. Further, the layers laid down at different periods of time will vary; not only in the kind of life found fossilized in them, but also in their structure and mineral composition; so that it becomes possible for one skilled in such work to say with great precision just which of these layers of sedimentary rocks are oldest, which the next formed, etc.

The various layers of rock that were formed by sedimentary deposits in North America have been carefully measured. Their combined thickness is estimated by some authorities to be as much as 67 miles, but an average of the estimates of the various authorities gives their total thickness as 53 miles. Most experts believe this to be very close to the correct figure. It should not be thought, of course, that in any one spot the sedimentary rocks are 53 miles thick. This is the thickness of all sedimentary rocks in all localities that have been deposited at different times. In Ontario the sedimentary rocks are 18 miles thick, but throughout one third of North America whatever sedimentation there has been has been eroded away leaving igneous, or crystaline, rocks at the surface. These igneous rocks have cooled to their present state from a molten or plastic state. Over the balance of North America the sedimentary rocks are from one mile to twenty miles thick; perhaps but one eighth of the area along the troughs adjoining such mountains as the Appalachian and Rocky mountains, attaining the greater thickness.

These layers of rock have certain structural characteristics by which they can be recognized. The order in which they were laid down has been determined by careful study of the relative positions of their layers. For convenience in speaking of them the whole system of rocks has been divided into five great groups, classified according to their age. The great groups are called Ages, and are each divided into several periods.

Geologists do not speak of the age of a fossil as so many million years old. In fact, because there is such a wide discrepancy among them as to the length of time since erosion begun, they usually refuse to assign the age in terms of years. They are content to determine that it belonged to a certain period in a certain Age. To say to a geologist that a fossil belongs to the Permian Period conveys accurate knowledge to his mind. But the lay reader gets no definite conception from such a statement. He is accustomed to use years as a time measure. Therefore, that the lay reader may get a fair picture, I shall do what can be done, in the present state of knowledge, to give a just estimate of these Ages in terms of years.

A number of methods have been resorted to by eminent men of science to try and determine the age of the earth since sedimentation started. The biologist has felt that he must have not less than 50 million to 200 million years to account for the development of life, which began at a much later period than sedimentation. Huxley believes life to have existed on the earth 1,000 million years. Lord Kelvin, in 1862 supposing the earth to be a self-cooling body, argued that since it ceased to be molten between 20 million and 4,000 million years must have elapsed. A later study of tides caused him to cut this estimate down in 1897 to over 20 million years and less than 40 million years. Biologists and geologists have since had a difficult time trying to crowd their periods into this short time allowed by the great physicist.

Walcott, in 1803, estimated the age of the first sediments, basing his calculations on the known discharge of sediments by rivers, to be 70 million years. Sir Archibald Geikie, one of the most eminent geologists of the old school, estimated it as 100 million years. Now it is known that at present it takes 8,800 years to denude North America 1 foot. If this rate of sedimentation was uniform throughout the past, by measuring the area and depth of all sedimentary deposits, a true estimate might be given. But there have been times when the country was mostly low, and sedimentation therefore slow, and other times when a glacier two miles thick came down across, the northern United States from Canada planing off the mountains at a great rate. So nothing very definite can be determined from this although it shows that a prodigious amount of time must have elapsed since sedimentation began.

Another method of estimation is to calculate how long it took for the sea to receive its salt. The salt in the sea is formed from sodium which has been leached out of the rocks and brought by rivers to the sea to there join with chlorine, forming sodium chloride. It is estimated that the sea receives 63,000,000 tons of sodium in solution each year. The time thus calculated for the total amount of salt to have been brought from the rocks varies, but an average of the estimates, considering that in the early days when the earth's surface was composed of granite and other igneous rocks there was a greater abundance of sodium, is 100 million years.

Still another method has been the computation of the time it takes radium to form a given amount of helium gas. Thus if a rock in the earlier strata contains a radium mineral and also helium gas, which is its product, from the known rate of transformation it may be determined how long it took for the amount of helium gas present in the rock to have been formed. The result of using this method gives 1,000 million years as the age since sedimentation began; but very recent experiments show possible flaws in this method which make it no more reliable than the method of computing from the salt in the sea. A very eminent geologist at the present day, however, holds that sedimentation must have begun 861 million years ago. H.G. Wells, in The Outline of History, after considering various authorities, states that sedimentation commenced not less than 80 million years ago, and not over 800 million years ago. A fair average of the present day opinion of eminent authorities, using all methods of computation is 500 million years.

Before settling upon a provisional time when sedimentation began I shall have recourse to one more source of information--to tradition. At the present time, and for a long time past the inclination of the pole of the earth to the plane of its orbit has been lessening at the rate of 50 seconds per century. Modern astronomers mostly believe this motion to be a wobble, and that, after the pole tips so far it will reverse and tip back again. Nothing absolutely conclusive, from an astronomical standpoint, as to this is known. If, however, the earth continues to tip at its present rate without reversing its motion, the earth would turn completely over polar wise in 2,592,000 years. This number is included in the measurements of the Great Pyramid of Gizah. Probably, where such great cycles are concerned, the ancients were no more infallible than are we. Observing the inclination of the pole to get less and less they may have jumped at the conclusion, as we also might, that it would tip continuously in one direction. As far as that is concerned it may actually do so. It is probably beyond absolute proof one way or the other at the present day. But whether true or false the ancients considered this period of 2,592,000 years as the average duration of the life-wave traversing any one of the 7 planets. It was thus allegorically incorporated into the various scriptures, and forms the key to the cycles and periods there recorded.

According to these ancient oriental cycles after the first life-wave water and fire began their conflict and erosion began. The life-wave traversing the 7 planets is one round of 18,144,000 years. 7 rounds, or 127,008,000 years is One Group of Planetary Families. After One Group comes a round of the Jubilee of Nirvana, of 18,144,000 years. One Group, plus its Jubilee round, therefore, is 145,456,000 years.

We are in the Fourth group, therefore 3 Groups and Jubilees have passed, or 3 times, 145,152,000 or 435,456,000 years. We are in the Fourth round of the Fourth Group, therefore 3 rounds of 18,144,000 years have passel, or 54,432,000 years more. We are in the Fifth Root Race, nearing the Sixth Root Race. Nearly 5 life waves (root races) or 5 times 2,592,000 years, more have passed, or nearly 12,960,000 years more. Adding the time of Three complete Groups, Three complete Rounds, and Five complete Root Races, as given above, and the figure is 502,848,000 years. Subtract from this the One Life-Wave--2,592,000 years--before erosion started and we have 500,256,000 years. This gives the duration to the commencement of the 6th. Root Race. But we are now only in the latter half of the 5th. Root Race. Let us assume, then, that we have slightly less than one eighth of a life-wave to go, before reaching the 6th. Root Race, a figure which is not far from correct, as a few 6th. Root Race people are already among us. For the sake of having a round number to deal with, let us call this time yet to go to the 6th. Root Race 256,000 years. Subtracting this from our 500,256,000 years and we have in round numbers 500 million years. This figure is based entirely on tradition. It may be wide of the fact. But at the present state of physical science it is apt to be quite as correct as any estimate hitherto given. It is not at variance with any present well recognized scientific fact.

The rocks of the various geological ages have been carefully measured. The earliest Age, the Archaeozoic, consists of 9 miles of limestone and 9 miles of mud- and sandstones. The next later Ages the Proterozoic, consists of 1 mile of limestone and 13 miles coarse mud- and sandstones. The rocks above these are the Paleozoic, consisting of 3.4 miles of limestone and 4.6 miles of mud- and sandstones. The Age above these is the Mesozoic, embracing 1.25 miles of limestone and 6.25 miles of mud- and sandstones. The latest Age; the Cenozoic, consists of 5 miles of coarse mud- and sandstones. This totals a thickness of 52.5 miles, the other half mile to make up the 53 miles in thickness being smaller and as undetermined formations.

The earlier geologists gave a longer period of time to the Archaeozoic and less to the Paleozoic period. Schuchert worked out the percentage in 1917 geologically, and Barrell working with the radio-active method, using a Uranium basis, obtained practically the same result. Using Schuchert's ratio, and the total time as 500 million years since sedimentation began, we have the following data.

Sedimentation began 500 million years ago. The Archeozoic Age (meaning age of primal life) lasted 25% of this time, or 125 million years (older geologists gave it 46%, or 230 million years). There were bacteria during this age, and single-celled plants and animals, such as the algae and the protozoa, developed. No creatures with hard parts lived then, consequently no real fossils have been found in the 18 miles thickness of rock belonging to this Age.

The second Age, the Proterozoic (meaning the Age of primitive life), divided equally into an Early Proterozoic and a Late Proterozoic, lasted 30% of the total time, or 150 million years (older geologists give 18%, or 90 million years). In this Age there is positive evidence of the algae among plants, and radiolarians, and the tubes and burrows left by segmented worms. The fossils are rare and rather imperfect, but some are found. It is inferred there were also sponges and coelentera and other worms. The latter half of the Age was dominated by invertebrate animals.

The third Age is the Paleozoic (meaning age of Ancient life). It lasted 28% of the time, or 140 million years (older geologists give 19%, or 95 million years). This Age is divided into Seven important Periods.

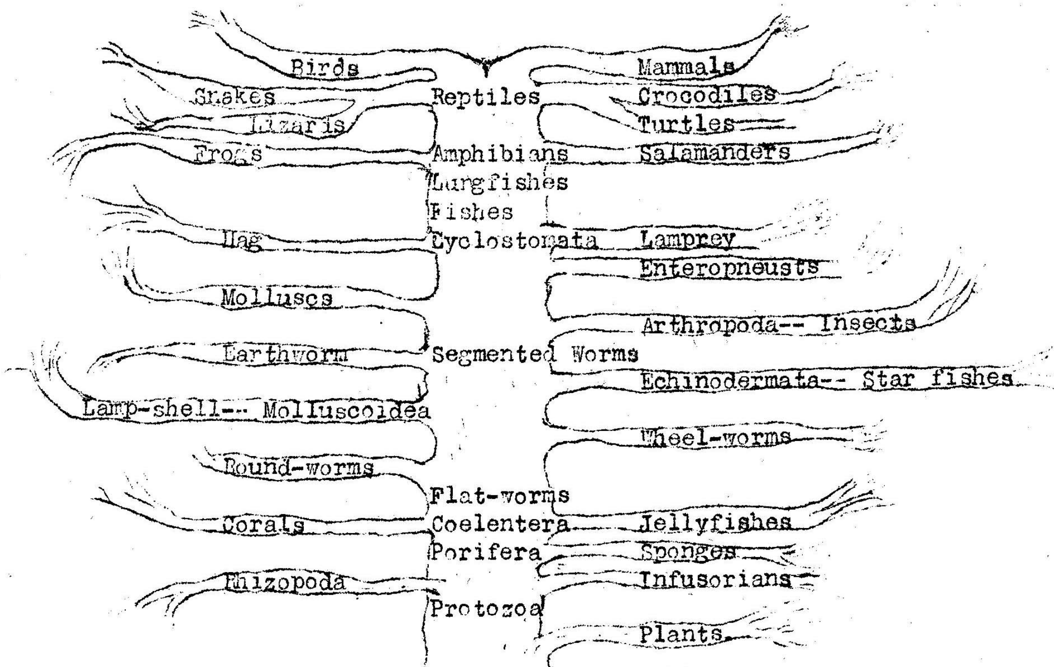
The first of these periods, the Cambrian commencing 225 million years ago contains the first numerous fossils, showing that animals had abundantly developed hard parts at that time. Even at its commencement fossil remains are found showing that all the main invertebrate phyla had been developed, and it is quite likely that the first vertebrates were developed during this period, for in the following period we find the fossils of highly evolved fishes.

The second period of the Paleozoic Age, commencing about 200 million years ago, is the Ordovician. During this period the dominant form of the Cambrian period, the Trilobites, began to wane, and we find the first fossils of true fishes. There is evidence of some land plants, and by the close of the period the woody kinds put in an appearance.

The third of the Paleozoic periods commenced about 177 million years ago. It is the Silurian period. In rocks of this age are found the first Air Breathers, Fossils are found of Scorpions that breathed air, and fossils are found of double breathing Lung-Fishes that greatly resemble those of the present day.

The fourth Paleozoic period, the Devonian, commenced about 157 million years ago. The first record of an Amphibian is found in this rock in the form of a single footprint. During this period the fishes developed into a great number of Shark-like forms and Armored kinds. Due to their number this is often called the Age of Fishes.

Having now arrived at the period when Amphibians developed, I will reserve the narration of the next chapter of the world's development for the following lesson.



ANIMAL GENEAOLOGICAL TREE.

Years Ago	Age or Period	
450 million	Archeozoic Age	First record of Bacterial life
400 million	Archeozoic Age	First single-celled plant life
400 million	Archeozoic Age	First single-celled Animal life-- Protozoa
300 million	Proterozoic Age	First record of marine algae, radiolarians, segmented worms, and it is inferred the first sponges jellyfishes and other worms.
225 million	Cambrian Period	First records of all main Invertebrate animals
190 million	Middle Ordovician Period	First Vertebrate animals-- first Fishes
190 million	Middle Ordovician Period	First Land Plants
170 million	Silurian Period	First Air-breathing Invertebrates-- Scorpions
170 million	Silurian Period	First record of Air-Breathing Vertebrates-- Lung-fishes
150 million	Devonian Period	First record of Amphibian
150 million	Devonian Period	First record of Flowering plants
130 million	Mississippian Period	Abundant Sharks that fed on shell-fish
105 million	Pennsylvanian Period	First record of Insects
105 million	Pennsylvanian Period	First indirect evidence of Reptiles
90 million	Permian Period	First Insects that undergo Metamorphosis
90 million	Permian Period	First Indisputable records of Reptiles.
90 million	Permian Period	First record of modern Fern and Conifer Trees
78 million	Triassic Period	First record of Dinosaurs
75 million	Upper Triassic	First record of Flying Reptiles
75 million	Upper Triassic	First record of Flying Fish

75 million	Upper Triassic	First record of Mammals
60 million	Upper Jurassic	First record of Birds
50 million	Comanchian Period	Rise of Flowering Plants. Extinction of the Monster type of Dinosaur
30 million	Cretaceous Period	First record of Placental Mammal--Extinction of all Dinosaurs