Chapter 4

Fishes and Amphibians

MANY factors are involved in the evolution of life-forms on earth. The soul attached to an organism through psychokinetic power has the desire to survive, the desire to reproduce, and the desire to express its potentialities through the organism. A certain life-form may have so well adapted itself to its environment that most of its individuals are quite content. As has been pointed out, certain primitive bacteria, certain primitive plants, and certain primitive animals persist in vast numbers today in practically the same state of development their ancestors had reached a billion years ago.

Also at the present day the majority of the people of the earth are making no strenuous effort to progress Those who have adapted themselves to modern conditions sufficiently that they have an ample living and can raise their children in comfort and give them the conventional schooling, as a rule make no effort to advance farther. But there are a few individuals who never are content to reach a static stage. There are a few individuals with tremendous ambition to express themselves more fully, and who develop their natural aptitudes far beyond the average level. The important inventions, the great scientific discoveries, the new ideals, and the leadership of mankind in economic, political and humanitarian progress are the work of comparatively few individuals who, irrespective of economic security, are unwilling to drift with the tide.

From our study of their birth-charts we know that these exceptional leaders were born, not from any different hereditary stock than others—for seldom is there more than one genius in the same family—but at a time when the inner-plane weather mapped unusual natural aptitudes. This means that their experiences in lower forms had given them a thought-cell organization quite different than that of the average individual. This exceptional thought-cell organization was mapped by the inner-plane weather coincident with their birth.

The other factor of significance is that subsequent inner-plane weather gave additional energy to the thought-cells endowing them with these aptitudes, and thus gave them the psychokinetic power both to develop the natural aptitudes into special ability, and to attract into their lives the physical conditions that permitted them to use these special abilities in a manner that assisted in the progress of the human race.

Heredity

The nucleus of the reproductive cells carry filament-like chromosomes, which in turn are made up of bead-like strings of smaller bodies called chromomeres. The chromosomes, which in each species are of a definite number, are thus composed of many hundred bead-like bodies, the chromomeres, strung together in a very definite order. These chromomeres not only are the physical carriers of heredity, but in a given species of animal each bead in the string always governs some particular characteristic, and always occupies the same position in the string. The hereditary characteristics which are carried by these chromomeres are called genes.

In the union of germ-cells of higher plants and higher animals, as in the union of two protozoa, when the cell divides after fusion each resulting cell contains chromosomes derived from both parents. The offspring thus obtains half its chromosomes from the mother and half of them from the father. One string of genes is supplied by the mother, and one string by the father, so that for every hereditary characteristic there are two beads, one of the pair furnished by each of the parents. Each member of any pair of genes, one of the pair being furnished by each parent, thus always has the same general function.

This doubling of the genes is nature's insurance against defectiveness; for commonly if one member of the pair is defective, the other sound gene has strength enough so that no defect appears in the offspring. The normal gene, because of its strength to impress its qualities on the offspring, is called dominant; and the defective gene, because it has much less power to influence the offspring, is called recessive. How from the combinations of dominant and recessive genes offspring inferior to both parents, offspring like superior parent, offspring like inferior parent, offspring superior to both parents, and genius may be born to the same parents is explained in Chapter 4, Course 17, *Cosmic Alchemy*.

These results are in conformity to Mendel's Law, which has a purely physical basis. But why certain chromosomes pair in one mating and other chromosomes, with dominant and defective genes different, pair in another mating is determined by the desires of the parents exerting a psychokinetic effect upon the germ-cells as they thus unite.

But entirely apart from the chromomeres or genes that thus pair to continue hereditary traits, changes in the physical beads on the chromosome string often change the characteristics of the offspring markedly. These radical changes from the characteristics of any of their ancestors are called mutations. Such mutations are now induced by plant breeders for the purpose of developing new species.

A mutation exhibits some characteristic different from any in the ancestry of the individual displaying it, which breeds true. It once was thought that mutations were fortuitous changes issuing from heritage, but in recent years it has been found possible to increase their appearance by treating breeding stock with X-rays, radium, heat and other environmental factors. As there are radioactive minerals in the earth in certain regions, these radiations are probably responsible for physical changes in the hereditary genes which gave rise to important mutations in the past.

In addition to mutations, now that experiments with colchicine has demonstrated that acquired characteristics can be inherited, it must be taken into consideration that if the parents were successful in changing either structure or habits sufficiently to meet new conditions, some of the offspring would be likely to inherit the same traits. Furthermore, not only heat and other external environmental conditions are capable of producing mutations, but in like degree so is the inner-plane weather.

The glands of internal secretion manufacture complex hormones from materials which they get from the blood and lymph. These hormones are released into the blood by nerve impulses. These nerve impulses which thus release the hormones may have their origin in the objective mind, in the desires and emotions of the unconscious mind without any objective awareness of them, or be stimulated by progressed aspects which constitute the chief inner-plane weather affecting an individual.

That a given hormone commonly is released in unusual abundance in human beings during the time a certain planet forms a progressed aspect has been thoroughly demonstrated. In fact, such endocrine reaction is one of the outstanding observed factors upon which Stellar Diagnosis is based. The other outstanding observed factor is the thousands of statistically analyzed birth-charts and progressed aspects of people who have suffered from given diseases. And these hormones, which have been proved to be so susceptible to the influence of inner-plane weather, determine the size, shape and texture of the body, make for intelligence or its lack, give courage or cowardice, imbue with ambition or saturate with laziness, and in general force the given attitude toward life.

Thyroxin deficiency, for instance, in a child produces a condition in which it fails to grow. Except the skull, the bones and cartilage fail to develop, the abdomen projects, the skin is rough, dry and bloated, the temperature is low, the hair is thin, the nose is flattened, and the hands and feet are clumsy. If the thyroid gland is removed from a tadpole it grows to large size but never becomes a frog. On the other hand, a tadpole less than a day old may be transformed into a frog by feeding with thyroxine. It will retain its small size, but will have all the characteristics of a mature frog. Tadpoles and rats given the growth hormone of the front pituitary gland grow to huge size. When at puberty the gonad stimulating hormone of the front pituitary gland which responds to Pluto fails to increase its secretion, an adolescent boy becomes excessively fat with folds of tissue around his girdle and with prominent breasts, and his sexual organs remain infantile.

Without indicating the physiological changes that other endocrines inaugurate when in excess or deficient, it will be apparent that astrological energies through thus stimulating or depressing the secretion of various hormones can exercise a powerful influence over structural changes of a life-form. And it will be apparent that through influencing these secretions the soul has at its disposal agents through which important physiological changes intensely desired can be brought about either in itself or in its offspring. Any such marked progress of its own can be handed down through heredity to its progeny; and any change far beyond its power to bring about in its own physical structure, through mutation due to a variety of influences can be brought about in some of its posterity.

But it should not be concluded that each effort of this kind results in progress or the desired adaptation. Even as the diffused primal sense of touch became canalized and specialized, so extrasensory perception by which the unconscious mind of creatures apprehends things on the inner plane, to become serviceable must have exercise in effort and discrimination. Both it and psychokinesis in the lower forms of life are much like the faculties of a child soon after birth. The child sees something it wants. But as yet its experience has not taught it how to reach for the desired object or if it is at a distance how to walk or crawl to it. But it does make random movements, and when these random movements bring success it learns how to touch the things within reach which it wants, and later how to move to a desired object at a distance.

When it is stuck by a pin in its diaper it does not know how to remove the pin. But it thrashes about and yells, and as a result its attendant searches to find what the difficulty is and removes the pin.

And in much the same manner a life-form dimly sensing changed environmental conditions and impelled by the desire to survive, uses its psychokinetic power in a haphazard manner. Most of the improvisations better to adapt itself or its offspring to the changed condition—even as most of the experiments of a scientist in trying to make a new discovery or of an inventor trying to devise a new gadget—result in failure. The record of the rocks reveals innumerable changes in form and function which have proved successful only for a limited period and then in the long run have proved disastrous. One after another life-form has moved up a blind alley only to be stopped by a wall it could not surmount.

But a few of these attempts to adapt to new conditions have been successful. And these life-forms have continued, and their progeny have made further useful adaptations, so that the line of progress unbroken still continues. It moved upward until it reached the form of man, a miniature copy of the universe. Then it continued upward, not through further development of form, but through progress in knowledge.

Co-operation Between Plants and Animals

But even forms of life lower than man have not confined their efforts to survive, to reproduce, and to express more fully, to changing form and function. Even as man makes use of other life-forms so plants often make use of animals and animals often make use of plants. Plants in general found it of great advantage to reproduce by means of seeds instead of 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, using such inner-plane intelligence as they possessed, 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, required 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 gradually was adopted of using these 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 well 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 carry out 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 degrees 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 differently shaped corollas, were evolved. Flowers that originally had numerous petals, and numerous pistils and stamens, securing fertilization in some few by sheer 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, sheaths, 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. At the time of bloom the air for miles around is full of this minute pollen dust. These plants, of which the goldenrod and ragweed are typical examples, are finding this new method even superior to depending on insects. They are, therefore, abandoning the use of insects and returning to the use of 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, but on the female part of some other flower of the same species. This objective 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 part, protecting it; yet at the same time exposing the pollen on the anther to the insect which 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 gets 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 fertilize other flowers with its pollen, those that visit it several days after this get still another load of fresh pollen. The larkspur, too, belongs to the buttercup family, and practically all of our wildflowers 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. Here another problem arises; for if a bee visits one kind of flower and then another kind of 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 upon them progressed in 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 were 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 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, lets them sprout until they burst, then exposes them to the sun to prevent further germination, after which it carries 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 extrasensory perception combined with experiences stored as knowledge within the soul, directing psychokinesis in response to the desire to live and express more fully.

Fishes Were the First Truly Vertebrate Animals

Now moving back in time before there were any land plants and before there were any insects, in the Archaeozoic era there were only single-celled animals and single-celled plants. Then came the Proterozoic era, which commenced about a billion years ago, and during which invertebrate animals developed innumerable forms which dominated the world. Following this was the Cambrian period of the Paleozoic era which commenced about 550 million years ago, during which the trilobites became the dominant life-form. These are segmented animals belonging to the phylum Articulata, having for ancestors the segmented 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 life. Then let us imagine the condition, as actually transpired, when numerous land areas the world over commenced to rise. Instead of placid lakes, large areas tilted up to form highlands and were drained by swift flowing rivers. At the same time the lake and sea expanses, 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 to 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 mollusks, like the mussel, 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.

When the segmented worms took to a life in the river to escape their numerous enemies and to find food, 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 movement 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 side, 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 enclosed in a sheath. This was the commencement of a lengthwise 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 larva, 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 small shell or stone, and then degenerates rapidly as it reaches the adult state. Next 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 are believed to 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 true 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 the 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 animals, including man, belong to this group, it may be well to mention these characteristics. In the first place, in the earlier forms 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 otherwise would take place when the muscles are contracted. 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 vertebra column.

A second characteristic 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 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 pairs of gill-slits are always well defined in the embryo, but as the form develops they are modified until a single pair are 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.

Most scientists believe the first fishes probably were not bony, but were gristly, with a mouth on the front side, like the sharks of today. Dr. W. K. Gregory, however, has advanced a theory according to which the Ostracodermi, which are fishes with an armor of large bony plates around the head, were the first vertebrates. Up to the present time no fossils of the earliest true fishes have been found. The earliest fossil fishes had traveled a long way along the road of vertebrate progress. The mentioned Ostracodermi left their fossils in the Middle Ordovician rocks, formed about 445 million years ago near Canon 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 the Proterozoic era, which commenced about one billion years ago, 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 mollusks.

Certain of these mollusks, the cuttlefishes, dominated the sea during the Ordovician period. 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.

Intelligent Adaptations

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 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 kangaroo—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 waterplants which he sticks together with glue-like threads which are secreted at this time by his kidneys. This nest has two 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 protected from other fish, and kept from being washed out by the dam just above them. Innumerable other examples of extrasensory intelligence as exhibited by fishes might be cited, but these two no doubt will suffice to show that the intense desire of the soul, even the soul of a fish, at times is able to find a means to the sought for end.

I have mentioned that the 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 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 of its head for the purpose of breathing. There is also a climbing catfish in the upper Andies of South America.

In an environment such as the present African mud-fish live in, where the dry season lasts nearly half 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 brought psychokinesis into play and 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, which commenced about 350 million years ago. 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, embracing the Mississippian and Pennsylvanian, during which the great coal marshes were laid down. Unlike the Devonian period, which was marked by aridity, there was a mild, moist climate that encouraged luxurious 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 which followed them over the land. It was no doubt at that time that the flowers first began to gain their colors and attract insect visitors. There were also land snails at this time. But perhaps of chief importance were the amphibians, some of which grew as large as a donkey.

The paired fins of the lung fishes, in response to the desire to facilitate eating, were gradually—or perhaps more abruptly—developed into limbs with fingers and toes, by which things might be grasped and food placed in the mouth. There was the development of an ear of three chambers, a movable tongue, true lungs, a drum to the ear and lids to the eyes, none of which a fish has. Furthermore, 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 (tree toads), 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 voices 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, newts and salamanders, are air breathers in the adult stage. 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.

The Record of the Rocks

I have already been compelled to use geological eras and periods to designate the 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 comparative ages of these periods, and how we know that certain life-forms first occurred at stages of the earth's history corresponding to them in time.

We have all watched, during a rain, the tiny rivulets running down a hillside, cutting little gutters in the soil and carrying sand 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 often are carried into the sea and buried beneath the sand and mud. As time flows 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 becomes mudstone 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 cannot 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 encased 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 encloses 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 effectively preserves them. They then become fossil insects.

The process of erosion, and 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 deposits 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 previously formed by the preceding rain. The oldest layer of sand and mud always is 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.

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. Furthermore, the layers laid down at different times 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 are next formed, etc.

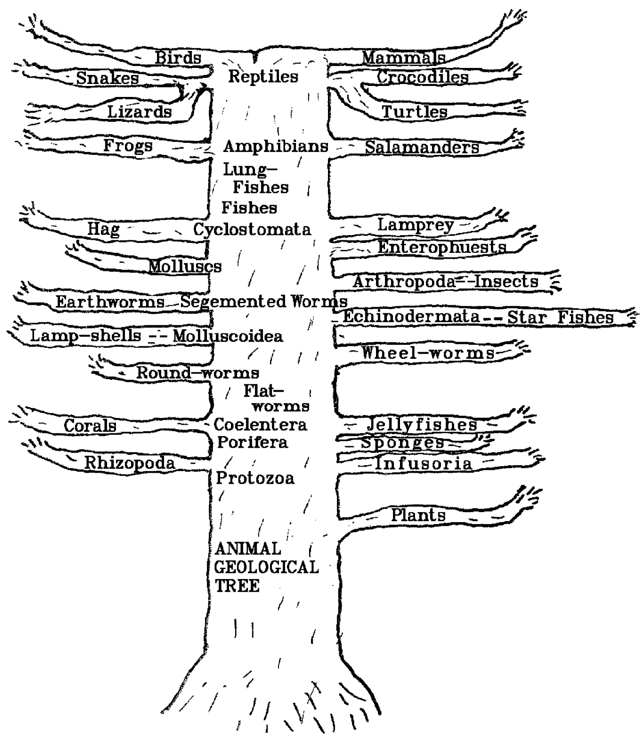
The various layers of rock that were formed by sedimentary deposits in

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, Canada, the sedimentary rocks are 18 miles thick, but throughout one-third of North America whatever sedimentation there was has been eroded away, leaving igneous, or crystalline rocks at the surface. And it is known that at the present time it takes 8,600 years to denude North America one foot. The igneous rocks left bare by erosion—and the tops of the Sierras in California are thus bare, such gold as their previously overlying sedimentary rocks contained having been carried down the streams to be found in part by those who stampeded west in 1849—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.

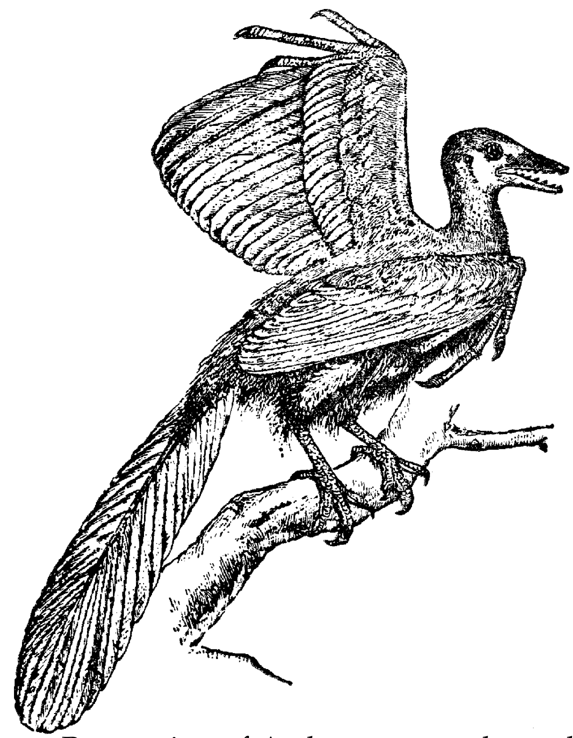
These layers of rock have certain structural characteristics by which they can be recognized. The order in which they were laid down has been determined by careful study of the relative positions of their layers. For convenience in speaking of them the whole system of rocks has been divided into five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

The rocks of these five geological eras have been carefully measured. The earliest era, the Archaeozoic, commencing about 1,750 million years ago and lasting about 750 million years, consists of 9 miles of limestones and 9 miles of mud-and-sand-stones. The next era, the Proterozoic (sometimes called the Algonkian), commencing about one billion years ago and lasting about 450 million years, consists of one mile of limestones and 13 miles of coarse mud and sandstones. The rocks above these are the Paleozoic, which commenced about 550 million years ago and lasted about 360 million years. It consists of 3.4 miles of limestones and 4.6 miles of mud-and-sandstones. Next higher is the Mesozoic, which commencing about 190 million years ago lasted about 135 million years, and embraces 1.25 miles of limestones and 6.25 miles of coarse mud-and-sand-stones. The latest era, the Cenozoic, which commenced about 55 million years ago and lasted about 55 million years, consists of 5 miles of coarse mud and sandstones. The other half-mile to make up the 53 miles of thickness consists of small and undetermined formations.


Birds
Mammals
Snakes
Reptiles
Crocodiles
Lizards
Turtles
Frogs
Amphibians
Salamanders
Lung-
Fishes
Fishes
Hag
Cyclostomata
Lamprey
Enterophuests
Molluscs
Arthropoda--Insects
Earthworms
Segemented Worms
Echinodermata--Star Fishes
Lamp-shells -- Molluscoidea
Wheel-worms
Round-worms
Flat-
worms
Corals
Coelentera
Jellyfishes
Porifera
Sponges
Rhizopoda
Infusoria
Protozoa
Plants
ANIMAL
GEOLOGICAL
TREE

Recorded in the Rocks

Years Ago	Era or Period	The Record
1,750,000,000	Archaeozoic era	First record of bacteria.
1,350,000,000	Archaeozoic era	First single-celled plants.
1,250,000,000	Archaeozoic era	First animals- protozoa.
1,000,000,000	Proterozoic era	First record of marine algae, worms, sponges, crustaceans.
550,000,000	Cambrian period	Record of main invertebrates.
440,000,000	Middle Ordovician	First vertebrates- fishes.
440,000,000	Middle Ordovician	First land plants.
410,000,000	Silurian period	First air breathers; scorpions.
410,000,000	Silurian period	First lung fishes.
350,000,000	Devonian period	First record of amphibians.
350,000,000	Devonian period	First record of flowering plants.
300,000,000	Mississippian	Abundant sharks.
255,000,000	Pennsylvanian	First record of insects.
255,000,000	Pennsylvanian	First indication of reptiles.
215,000,000	Permian period	First metamorphosed insects.
215,000,000	Permian period	Indisputable reptile records.
215,000,000	Permian period	Indisputable records of modern ferns and conifer trees.
190,000,000	Triassic period	First record of dinosaurs.
170,000,000	Upper Triassic	Record of flying reptiles.
170,000,000	Upper Triassic	First record of mammals.
135,000,000	Upper Jurassic	First record of birds.
120,000,000	Comanchean period	Rise of flowering plants; extinction monster dinosaurs.
90,000,000	Cretaceous period	Record of first placental mammals; extinction all dinosaurs.



Restoration of Archaeopteryx, the earliest fossil bird. It lived about 135 million years ago in the Upper Jurassic period.