THE PALEONTOLOGIST'S VIEW OF EVOLUTION

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To the paleontologist, evolution means the progressive change in the life of the earth from age to age, as a result of natural causes. Just as the life of today developed out of the life of yesterday, the life of the present year was derived in a natural way from that of last year; so the life of the present age evolved in a natural way by slow progressive changes out of the age that preceded, and so on back to the earliest appearance of life on the earth, several hundred million years ago. The causes of these changes were partly inherent in the organisms, but were largely a result of responses to changes in the external environment. There are three main lines of evidence which practically compel the student of fossils to believe in the doctrine of evolution. These are (1) the geologic succession of life on the earth, (2) the numerous transitional or connecting forms and (3) the law of recapitulation in the life history of the individual.

1. The fossils preserved in the rocks show us the actual types of life that existed during the time the successive rock formations were deposited. It is significant that these fossils show a constant advance in the life as we pass from lower to higher, i. e. from older to younger rock strata. For example, the earliest known plants are found in rocks of pre-Cambrian age, and are algae and related forms, representatives of the lowest Phylum or group of plants. The higher, fern-like plants did not appear until much later (Silurian) time; and the highest group, the seed bearing plants, were not developed for a long time later than the ferns.

Likewise, the earliest animal fossils preserved in the rocks are the lower invertebrate types, which preceded the vertebrate forms by several million years. Of still greater significance is the fact that within any Phylum or group of animals or plants, it is the lowest members of the group that appear earliest, successively higher types being developed later in time, just as among the Vertebrata the fishes appeared before the Amphibia, the Amphibia before the reptiles, and the reptiles before the

birds or mammals; and among seed plants the Gymnosperms appeared before the higher Angiosperms.

2. The connecting or transitional characters possessed by the earliest representatives of any class of plants or animals present still more definite evidence of evolution. For example, the earliest birds are found in rocks of Jurassic age. These first bird forms had teeth in both lower and upper jaws, like reptiles, a long vertebrated tail, like reptiles, and, like reptiles had separate toes, ending in claws, on their front limbs or wings. In fact they show so clearly their reptilian relationship that if it were not for the feathers with which these birds were scantily clothed, there would be no hesitation in calling them reptiles.

A somewhat different kind of connecting or transitional forms is shown in the classic example of the evolution of the horse, of which a most complete series of skeletons has been found in rocks ranging from Eocene to Pliocene in age. These show every step in the change from the small Eocene horse, about as large as a fox terrier, and having four toes and a rudiment of another toe on each front foot, and three toes and a splint on each hind foot, to the full size modern horse found in late Pliocene rocks, having one functional toe and two splints or rudiments of other toes on each foot. The evolution of the elephant and camels is known by series of skeletons almost as complete as that of the horse.

3. The evidence of evolution shown by the law of recapitulation is possibly even more conclusive than that already cited. This law states that the life history of each individual recapitulates, or repeats in a shortened way, the evolutionary history of the race to which it belongs. A clear illustration of this law is shown in the life history of the frog, the young stage of which is a tadpole having no lungs or legs, but breathes by means of gills, swims by movements of its tail, and is a fish in all its main characteristics and habits. Later it develops legs and lungs; absorbs its gills and tail; leaves the water, and is adapted to life on land. According to the law of recapitulation, the fish stage in the early life of the frog indicates a fish ancestry for the class Am-

phibia to which the frogs belong. This law was first discovered by students of embryology, but the paleontologist has in some ways a better opportunity to test its validity than the embryologist, especially as regards stages in the life history somewhat later than the truly embryonic. This is because, according to this law, the mature shells of any age should be found to correspond with immature growth stages of shells of their descendants occurring in rocks of later age, and this has proven true in a wonderful variety of fossil forms. An example will suffice from the Cephalopoda, or animals which have their shells separated into a number of chambers by partitions like the chambered nautilus. The earliest forms with chambered shells were straight. Later, some of these developed curved shells, and later still the loosely coiled, and finally shells closely coiled in one plane, like the Nautilus, were evolved. Now the remarkable thing is that when this closely coiled Nautilus shell is carefully sawed lengthwise through the middle, it is seen that the curvature in the oldest part or apical end of the shell is not symmetrical. The shell begins to grow straight at the tip, later becoming only slightly curved till the first three septa are formed, then becomes loosely coiled, but does not become closely coiled until the end of the first volution. This remarkable manner of growth results in leaving an empty space between the two halves of the first volution, and repeats perfectly the order in which the various degrees of curving and coiling of the Nautilus type were developed successively in time.

Now as if Nature was afraid this record was not sufficiently clear, she has made the evidence of evolution still more definite. In all of the closely coiled chambered shells, like Nautilus, the septa or partitions were evenly curved plates which joined the inner side of the shell along straight regular lines called sutures. In Devonian time there began to be developed in some of these shells irregular wrinkling of the septa, causing the bending backward and forward of the suture lines as in the Goniatites. As time progressed the lobing of the suture lines became more and more complex, as in the Ceratites, and reached its culmination in the later Ammonites. During

the Triassic and Jurassic periods the Ammonites with very complex suture lines reached the climax of their careers. Now at the apex of each of these Ammonite shells the first sutures were simple, like those of the adult Nautilus. These were followed in the first half of the coil by sutures with simple lobes, as in Goniatites; and farther forward the lobes of the later sutures became more complex, until the true Ammonite type of suture is attained about the time the first whorl is completed. Thus, each individual Nautilus shell repeats in its growth the successive stages of curvature and coiling that the Nautilus group passed through in its development from straight-shelled ancestral forms; and in a similar way each individual Ammonite shell repeats in its growth the successive stages of complexity of suture line that the Ammonite group passed through in its development from the simple-sutured Nautiloid ancestors.

In their growth the shells in many of the classes of fossils repeat in their young stages adult characters of their earlier ancestors so that the paleontologist does not doubt the general validity of the evidence of the law of recapitulation with regard to evolution.