

A Short History of the World.

of getting water from the swampy ground below to the tissues of the plant, now that it was no longer close at hand. The two problems were solved by the development of woody tissue which both sustained the plant and acted as water carrier to the leaves. The Record of the Rocks is suddenly crowded by a vast variety of woody swamp plants, many of them of great size, big tree mosses, tree ferns, gigantic horsetails and the like. And with these, age by age, there crawled out of the water a great variety of animal forms. There were centipedes and millipedes; there were the first primitive insects; there were creatures related to the ancient king crabs and sea scorpions which became the earliest spiders and land scorpions, and presently there were vertebrated animals.

Some of the earlier insects were very large. There were dragon flies in this period with wings that spread out to twenty-nine inches.

In various ways these new orders and genera had adapted themselves to breathing air. Hitherto all animals had breathed air dissolved in water, and that indeed is what all animals still have to do. But now in divers fashions the animal kingdom was acquiring the power of supplying its own moisture where it was needed. A man with a perfectly dry lung would suffocate to-day; his lung surfaces must be moist in order that air may pass through them into his blood. The adaptation to air breathing consists in all cases either in the development of a cover to the old-fashioned gills to stop evaporation, or in the development of tubes or other new breathing organs lying deep inside the body and moistened by a watery secretion. The old gills with which the ancestral fish of the vertebrated line had breathed were inadaptable to breathing upon land, and in the case of this division of the animal kingdom it is the swimming bladder of the fish which becomes a new, deep-seated breathing organ, the lung. The kind of animals known as amphibia, the frogs and newts of to-day, begin their lives in the water and breathe by gills; and subsequently the lung, developing in the same way as the swimming bladder of many fishes do, as a baglike outgrowth from the throat, takes over the business of breathing, the animal comes out on land, and the gills dwindle and the gill slits disappear. (All except an outgrowth of one gill slit, which becomes the passage of the ear and ear-drum.) The animal can now live only in the air, but it must return at least to the edge of the water to lay its eggs and reproduce its kind.

All the air-breathing vertebrata of this age of swamps and plants belonged to the class amphibia. They were nearly all of them forms related to the newts of to-day, and some of them attained a considerable size. They were land animals, it is true, but they were land animals needing to live in and near moist and swampy places, and all the great trees of this period were equally amphibious in their habits. None of them had yet developed fruits and seeds of a kind that could fall on land and develop with the help only of such moisture as dew and rain could bring. They all had to shed their spores in water, it would seem, if they were to germinate.

It is one of the most beautiful interests of that beautiful science, comparative anatomy, to trace the complex and wonderful adaptations of living things to the necessities of existence in air. All living things, plants and animals alike, are primarily water things. For example all the higher vertebrated animals above the fishes, up to and including man, pass through a stage in their development in the egg or before birth in which they have gill slits which are obliterated before the young emerge. The bare, water-washed eye of the fish is protected in the higher forms from drying up by eyelids and glands which secrete moisture. The weaker sound vibrations of air necessitate an ear-drum. In nearly every organ of the body similar modifications and adaptations are to be detected, similar patchings-up to meet aerial conditions.

This Carboniferous age, this age of the amphibia, was an age of life in the swamps and lagoons and on the low banks among these waters. Thus far life had now extended. The hills and high lands were still quite barren and lifeless. Life had learnt to breathe air indeed, but it still had its roots in its native water; it still had to return to the water to reproduce its kind.

VI. The Age of Reptiles

THE ABUNDANT life of the Carboniferous period was succeeded by a vast cycle of dry and bitter ages. They are represented in the Record of the Rocks by thick deposits of sandstones and the like, in which fossils are comparatively few. The temperature of the world fluctuated widely, and there were long periods of glacial cold. Over great areas the former profusion of swamp vegetation ceased, and, overlaid by these newer deposits, it began that process of compression and mineralization that gave the world most of the coal deposits of to-day.

But it is during periods of change that life undergoes its most rapid modifications, and under hardship that it learns its hardest lessons. As conditions revert towards warmth and moisture again we find a new series of animal and plant forms established. We find in the record the remains of vertebrated animals that laid eggs which, instead of hatching out tadpoles which needed to live for a time in water, carried on their development before hatching to a stage so nearly like the adult form that the young could live in air from the first moment of independent existence. Gills had been cut out altogether, and the gill slits only appeared as an embryonic phase.

These new creatures without a tadpole stage were the Reptiles. Concurrently there had been a development of seed-bearing trees, which could spread their seed, independently of swamp or lakes. There were now palmlike cycads and many tropical conifers, though as yet there were no flowering plants and no grasses. There was a great number of ferns. And there was now also an increased variety of insects. There were beetles, though bees and butterflies had yet to come. But all the fundamental forms of a new real land fauna and flora had been laid down during these vast ages of severity. This new land life needed only the opportunity of favourable conditions to flourish and prevail.

Age by age and with abundant fluctuations that mitigation came. The still incalculable movements of the earth's crust, the changes in its orbit, the increase and diminution of the mutual inclination of orbit and pole, worked together to produce a great spell of widely diffused warm conditions. The period lasted altogether, it is now supposed, upwards of two hundred million years. It is called the Mesozoic period, to distinguish it from the altogether vaster Palaeozoic and Azoic periods (together fourteen hundred millions) that preceded it, and from the Cainozoic or new life period that intervened between its close and the present time, and it is also called the Age of Reptiles because of the astonishing predominance and variety of this form of life. It came to an end some eighty million years ago.

In the world to-day the genera of Reptiles are comparatively few and their distribution is very limited. They are more various, it is true, than are the few surviving members of the order of the amphibia which once in the Carboniferous period ruled the world. We still have the snakes, the turtles and tortoises (the Chelonia), the alligators and crocodiles, and the lizards. Without exception they are creatures requiring warmth all the year round; they cannot stand exposure to cold, and it is probable that all the reptilian beings of the Mesozoic suffered under the same limitation. It was a hothouse fauna, living amidst a hothouse flora. It endured no frosts. But the world had at least attained a real dry land fauna and flora as distinguished from the mud and swamp fauna and flora of the previous heyday of life upon earth.

All the sorts of reptile we know now were much more abundantly represented then, great turtles and tortoises, big crocodiles and many lizards and snakes, but in addition there was a number of series of wonderful creatures that have now vanished altogether from the earth. There was a vast variety of beings called the Dinosaurs. Vegetation was now spreading over the lower levels of the world, reeds, brakes of fern and the like; and browsing upon this abundance came a multitude of herbivorous reptiles, which increased in size as the Mesozoic period rose to its climax. Some of these beasts exceeded in size any other land animals that have ever lived; they were as large as whales. The *Diplodocus Carnegii* for example measured eighty-four feet from snout to tail; the *Gigantosaurus* was even greater; it measured a hundred feet. Living upon these monsters was a swarm of carnivorous Dinosaurs of a corresponding size. One of these, the *Tyrannosaurus*, is figured and described in many books as the last word

in reptilian frightfulness.

While these great creatures pastured and pursued amidst the fronds and evergreens of the Mesozoic jungles, another now vanished tribe of reptiles, with a bat-like development of the fore limbs, pursued insects and one another, first leapt and parachuted and presently flew amidst the fronds and branches of the forest trees. These were the Pterodactyls. These were the first flying creatures with backbones; they mark a new achievement in the growing powers of vertebrated life.

Moreover some of the reptiles were returning to the sea waters. Three groups of big swimming beings had invaded the sea from which their ancestors had come: the Mososaurs, the Plesiosaurs, and Ichthyosaurs. Some of these again approached the proportions of our present whales. The Ichthyosaurs seem to have been quite seagoing creatures, but the Plesiosaurs were a type of animal that has no cognate form to-day. The body was stout and big with paddles, adapted either for swimming or crawling through marshes, or along the bottom of shallow waters. The comparatively small head was poised on a vast snake of neck, altogether outdoing the neck of the swan. Either the Plesiosaur swam and searched for food under the water and fed as the swan will do, or it lurked under water and snatched at passing fish or beast.

Such was the predominant land life throughout the Mesozoic age. It was by our human standards an advance upon anything that had preceded it. It had produced land animals greater in size, range, power and activity, more "vital" as people say, than anything the world had seen before. In the seas there had been no such advance but a great proliferation of new forms of life. An enormous variety of squid-like creatures with chambered shells, for the most part coiled, had appeared in the shallow seas, the Ammonites. They had had predecessors in the Palaeozoic seas, but now was their age of glory. To-day they have left no survivors at all; their nearest relation is the pearly Nautilus, an inhabitant of tropical waters. And a new and more prolific type of fish with lighter, finer scales than the plate-like and tooth-like coverings that had hitherto prevailed, became and has since remained predominant in the seas and rivers.

VII. The First Birds and the First Mammals

IN a few paragraphs a picture of the lush vegetation and swarming reptiles of that first great summer of life, the Mesozoic period, has been sketched. But while the Dinosaurs lorded it over the hot selvas and marshy plains and the Pterodactyls filled the forests with their flutterings and possibly with shrieks and croakings as they pursued the humming insect life of the still flowerless shrubs and trees, some less conspicuous and less abundant forms upon the margins of this abounding life were acquiring certain powers and learning certain lessons of endurance, that were to be of the utmost value to their race when at last the smiling generosity of sun and earth began to fade.

A group of tribes and genera of hopping reptiles, small creatures of the dinosaur type, seem to have been pushed by competition and the pursuit of their enemies towards the alternatives of extinction or adaptation to colder conditions in the higher hills or by the sea. Among these distressed tribes there was developed a new type of scale-scales that were elongated into quill-like forms and that presently branched into the crude beginnings of feathers. These quill-like scales lay over one another and formed a heat-retaining covering more efficient than any reptilian covering that had hitherto existed. So they permitted an invasion of colder regions that were otherwise uninhabited. Perhaps simultaneously with these changes there arose in these creatures a greater solicitude for their eggs. Most reptiles are apparently quite careless about their eggs, which are left for sun and season to hatch. But some of the varieties upon this new branch of the tree of life were acquiring a habit of guarding their eggs and keeping them warm with the warmth of their bodies.

With these adaptations to cold other internal modifications were going on that made these creatures, the primitive birds, warm-blooded and independent of basking. The very earliest birds seem to have been seabirds living upon fish, and their fore limbs were not wings but paddles rather after the penguin type. That peculiarly primitive bird,

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the New Zealand Ki-wi, has feathers of a very simple sort, and neither flies nor appears to be descended from flying ancestors. In the development of the birds, feathers came before wings. But once the feather was developed the possibility of making a light spread of feathers led inevitably to the wing. We know of the fossil remains of one bird at least which had reptilian teeth in its jaw and a long reptilian tail, but which also had a true bird's wing and which certainly flew and held its own among the pterodactyls of the Mesozoic time. Nevertheless birds were neither varied nor abundant in Mesozoic times. If a man could go back to typical Mesozoic country, he might walk for days and never see or hear such a thing as a bird, though he would see a great abundance of pterodactyls and insects among the fronds and reeds.

And another thing he would probably never see, and that would be any sign of a mammal. Probably the first mammals were in existence millions of years before the first thing one could call a bird, but they were altogether too small and obscure and remote for attention.

The earliest mammals, like the earliest birds, were creatures driven by competition and pursuit into a life of hardship and adaptation to cold. With them also the scale became quill-like, and was developed into a heat-retaining covering; and they too underwent modifications, similar in kind though different in detail, to become warm-blooded and independent of basking. Instead of feathers they developed hairs, and instead of guarding and incubating their eggs they kept them warm and safe by retaining them inside their bodies until they were almost mature. Most of them became altogether viviparous and brought their young into the world alive. And even after their young were born they tended to maintain a protective and nutritive association with them. Most but not all mammals to-day have mammae and suckle their young. Two mammals still live which lay eggs and which have not proper mammae, though they nourish their young by a nutritive secretion of the under skin; these are the duck-billed platypus and the echidna. The echidna lays leathery eggs and then puts them into a pouch under its belly, and so carries them about warm and safe until they hatch.

But just as a visitor to the Mesozoic world might have searched for days and weeks before finding a bird, so, unless he knew exactly where to go and look, he might have searched in vain for any traces of a mammal. Both birds and mammals would have seemed very eccentric and secondary and unimportant creatures in Mesozoic times.

The Age of Reptiles lasted, it is now guessed, eighty million years. Had any quasi-human intelligence been watching the world through that inconceivable length of time, how safe and eternal the sunshine and abundance must have seemed, how assured the wallowing prosperity of the dinosaurs and the flapping abundance of the flying lizards! And then the mysterious rhythms and accumulating forces of the universe began to turn against that quasi-eternal stability. That run of luck for life was running out. Age by age, myriad of years after myriad of years, with halts no doubt and retrogressions, came a change towards hardship and extreme conditions, came great alterations of level and great redistributions of mountain and sea. We find one thing in the Record of the Rocks during the decadence of the long Mesozoic age of prosperity that is very significant of steadily sustained changes of condition, and that is a violent fluctuation of living forms and the appearance of new and strange species. Under the gathering threat of extinction the older orders and genera are displaying their utmost capacity for variation and adaptation. The Ammonites for example in these last pages of the Mesozoic chapter exhibit a multitude of fantastic forms. Under settled conditions there is no encouragement for novelties; they do not develop, they are suppressed; what is best adapted is already there. Under novel conditions it is the ordinary type that suffers, and the novelty that may have a better chance to survive and establish itself.

There comes a break in the Record of the Rocks that may represent several million years. There is a veil here still, over even the outline of the history of life. When it lifts again, the Age of Reptiles is at an end; the Dinosaurs, the Plesiosaurs and Ichthyosaurs, the Pterodactyls, the innumerable genera and species of Ammonite have all gone absolutely. In all their stupendous variety they have died out and left no descendants. The cold has killed them. All their final variations were insufficient; they had never hit upon survival conditions. The world had passed through a phase of extreme conditions beyond their powers of endurance, a slow and complete massacre of