THE ORIGIN OF LIFE.

IV.

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ALTHOUGH the Permian sediments continued uninterruptedly upwards from the Carboniferous, yet there were large tracts of country where the rocks laid down in the latter period were raised above the sea-level. These rocks consequently afford an opportunity of obtaining a general idea of the distribution of land and water after the Carboniferous period. This distribution can be mapped out roughly to-day wherever two conditions of the crust can be recognised; one where sedimentation continued from the Carboniferous through the Permian to later rocks indicating that a region presenting such a condition remained beneath sea-level; another where sedimentation did not occur over certain large areas of rocks of Carboniferous and preceding formations for a longer or shorter period.

The latter condition is well illustrated in the region of the modern Sahara and Soudan, where Cretaceous rocks lie upon marine Carboniferous. It is obvious, therefore, that the Carboniferous rocks were not covered by water during the interval between them and the overlying Cretaceous; in other words, a continent existed there during that interval.

On the northern edge of Africa, in the region of the Atlas range, rocks of all the geological periods, from the Permian onwards to the Eocene, are visible, showing the presence there of a sea continuously during that time. This condition illustrates the former series above referred to.

Perhaps the most striking illustration—the word startling may even be applied to it, showing as it does how the seas of old are now at elevations seldom excelled by mountains in any other part of the world—is the region to the north of Peninsular India, where the mountains show marine strata of periods extending in unbroken succession from the oldest rocks, which here are Pre-Cambrian, up to the later Eocene. We have here presented to our vision the evidence of a great sea which continued undisturbed until that post-Eocene epoch when the lands and seas of the earth underwent an almost complete bouleversement.

Peninsular India, including Ceylon, has probably always been a land; there are no deposits to show that it was ever completely
Plan of the Post-Carboniferous Land.

Shading indicates known land areas. Pointing indicates probable land areas.
submerged. Further, it is a portion of land which extended west and south-west, to Southern Arabia, Abyssinia, and the Zanzibar coast, including the Seychelles, and sending out a peninsula in the region now occupied by Madagascar. From Abyssinia westwards this land was connected with the Saharan continent after the Carboniferous period.

From the Zanzibar coast the land extended southwards to the Transvaal, Damaraland, and the Cape of Good Hope, enclosing an area within which there was a large inland sea; the sediments formed in this sea are without any marine fossils, but contain the remains of animals and plants whose characters are those of the Trias of Europe.

The Carboniferous rocks which help to form the margin of this inland sea of South Africa contain some traces of the flora of that period. They were deposited in close proximity to land. After their deposition came the period of their displacement. By this means the basin was formed within which were laid down conglomerates of enormous rocks, the early débris of the crumpled marginal land. Contemporaneous deposits found in India (Tâlichir) possess a somewhat similar conglomerate. In South Africa the Triassic deposits succeeded the conglomerates. (See Journal, vol. ii., p. 261.)

This basin of deposits, generalised under the name “Karoo,” contains reptiles and trees washed down from the adjacent land; the trees are represented sometimes by coal, sometimes by masses of silica preserving the forms entire of uprooted trunks, which have lain undisturbed upon the mud-banks to which they drifted in that far-back time. The reptiles we shall refer to shortly; but it may here be noted that the crocodiles, first found in the Triassic deposits of the North, do not occur in the Karoo, though they had reached the next higher series (Upper Gondwâna) of India. If the crocodiles succeeded in reaching South Africa in the Jurassic period, their remains are not found as fossils in deposits either of the Karoo, or above it. Soon after the deposits immediately succeeding the Karoo had been completed, the portion of the continent composing modern South Africa was raised so as to become entirely land; there remained no inland sea to preserve fossils of any description. Further, the elevation of South Africa was accompanied by volcanic conditions. The outpourings of vast sheets of lava which then took place covered over the deposits containing the strange reptiles, some of which may be seen in the Natural History Museum, and rendered this country one to be avoided by all animal life. A later and more tranquil age was required for its repopulation by newer races travelling south from other lands.
After the Triassic period the eastern side of this southern part of the continent became further submerged; the sea above it became ultimately connected with that Cretaceous sea which later extended up the Madagascar Straits to the eastern coast of India.

From the attached plan a rough idea may be acquired of the continents of the Permian period. This will prove of assistance in considering the geological distribution of the animal life of the periods immediately following the Carboniferous. The deposits on the margins of the continental and insulated land surfaces are those from which we obtain the fossils of the Reptile life of this time. There appears to have been a northern and a southern continent, the nearest communication between which was by land extending southwards from the vicinity of the Adriatic, over the Eastern Mediterranean to the north coast of Africa.

From the distribution of the land here shown may be seen the routes by which the reptiles travelled, dispersing themselves over the world in such manner that similar reptilian remains have been discovered in widely separated regions. By comparing the dates of appearance of the orders of animals in the rocks of various localities, it is possible to obtain a fair idea of their progression from the northern continent to outlying places. It is perhaps necessary here to remind the reader that the land forms would be preserved only in the fluviatile or lacustrine deposits of the periods during which they lived. Unfortunately many such deposits have either disappeared in the course of the changes which have occurred in the geography of the world, or if they exist they have not yet been adequately explored.

The Amphibia, previously noted (Journal, p. 390) as occurring in the Carboniferous period, continued up to the end of the Triassic. They then disappeared. Their distribution is shown in Chart II. The modern Amphibia belong to other orders which do not appear as fossils until the Cretaceous period; from this period they continue to the present day.

But though the older Amphibia died out at the end of the Triassic period, they had extended as far south as Australia and South Africa. The genus found in Australia occurs also in South Africa.

The latest family of the Amphibia occurs in the Trias of Germany and Upper Trias of England, India, and South Africa; the members of this family are the possessors of teeth with an elaborately labyrinthine arrangement of the dentine. The earliest Amphibia had smooth conical, hollow teeth.
CHART II.

Amphibia

1. Carboniferous.
2. Permian.
3. Trias.
4. Lower Permian.
5. Middle and Upper Permian.
6. Trias.
7. Jurassic to Lower Eocene.
8. Recent.

Time and Place Distribution of Earlier Reptiles

1. Carboniferous.
2. Permian.
3. Trias.
4. Lower Permian.
5. Middle and Upper Permian.
6. Trias.
7. Jurassic to Lower Eocene.
8. Recent.
The Origin of Life

We have now to sketch a new class of beings—the Reptiles. Of these, the first order (the earlier reptiles) is first found in the Lower Permian of Germany and of Central France. The members of this order are found in later Permian rocks in other countries of the North, and in still later rocks in outlying countries, as shown in Chart II. One family is limited to Brazil and South Africa; the two genera allotted to this family (one in each country) appear to be similar. After the Lower Eocene period in France, Belgium and the United States, they are no longer found fossil, but they have a living representative in some islands off New Zealand in the lizard, Tuatara (Hatteria), specimens of which are to be seen in the Zoological Gardens.

Another order of the Reptiles appeared in the Permian period. This order may be called "Beast-like," as it occupies an anatomical position between the labyrinthine-toothed Amphibia and the lowest mammals. It will be remembered that the Amphibia with this special characteristic appeared in the Triassic period, that is, some time after the advent of the Beast-like reptiles; but the teeth of some of the earlier Amphibia showed an infolding of the dentine, which has been taken as an early stage of the labyrinthine structure, and as an index of their community of characteristics.

Chart III shows the distribution of the Beast-like Reptiles. They evidently originated on the ancient northern continent, their remains being buried in the Permian of Texas, Württemburg and Russia. Thence they spread to South Africa and Peninsular India. The South African forms were numerous and varied, some being of the same genera as specimens found in Scotland, Russia and India, others being forms not found elsewhere. Their presence in South Africa in great profusion without intermediate forms between them and the two families of Amphibia, and one of the earlier Reptiles found in that country, indicates that they did not originate there.

These Beast-like Reptiles show so great a variety of forms that we must note their distribution in greater detail than has been done with other orders. The first suborder contains two families originating in, and confined to, the Permian of Texas, and one family found first in the Permian of Saxony, and later in Scotland, Switzerland, Russia and South Africa. One genus living in the two latter countries was the same.

In the second suborder, called the "Dog-toothed," the South African Triassic families are different from those found in the Permian of Russia, the only other country where this suborder has been found, excepting some teeth in the Upper Trias in Ger-
CHART III.

Time and Place
Distribution of
Beast-like Reptiles
2. Permian
3. Marine Trias
2. Trias

Dinosaurs
4. Trias
5. Jurassic
6. Cretaceous
7. Miocene
8. Lower Jurassic
9. Upper Jurassic
10. Cretaceous
The Origin of Life

many. The time-origin indicates that this suborder originated in the North, and differentiated as it extended South.

A third suborder, the members of which possessed teeth of anomalous arrangement, occurs only in the Trias of Scotland, Russia (Ural Mountains), South Africa and India. No complete forms of this order have been found; but one genus, found plentifully in the Karoo, occurs also in all the other countries just named.

A fourth suborder, a marine form with plates instead of teeth, is found only in France, Southern Germany, and the Alps.

This distribution is interesting from our present point of view, in that it indicates a northern locality as the station of origin of the order, whence offshoots spread in the first place to Texas and Europe. From Europe, the Scottish families spread southwards, by a route possibly to the west of Spain. There is no physical evidence, however, of continuity of the continents on the western side of the Mediterranean. Some of the Russian families went south through Asia Minor, or across the east of the modern Mediterranean, to South Africa and India. We may consequently anticipate that their remains may some day be found in such of the sandstones of Abyssinia and other parts of Africa as may be of Triassic or somewhat later date.

The next terrestrial reptilian order which appeared is that of the Dinosaurs. The lowest Triassic rocks of Württemburg and the Trias of Connecticut have furnished the earliest complete remains of these animals, imperfect specimens of which have been found in the Trias of France, Bristol, Peninsular India, and the African Karoo. The remains are those of genera allied to that found in Württemburg. No later forms are found in South Africa, but in England, Europe, and the Western United States they underwent in later times an immense development in numbers and varieties, and in the enormous size attained by individuals. In Cretaceous times Dinosaurs are found also in India and Madagascar; in Patagonia they occur in Miocene beds. The anatomical characters of Dinosaurs indicate alliance with Amphibia, Crocodiles and the Beasts-like Reptiles. Their dentition shows them to have consisted of a carnivorous section and an herbivorous section, the former being the earliest Triassic forms, the others later in date.

The Crocodiles first appear in the Trias of Elgin, Central Germany, Alps, and the Western United States. In India they appear in the Lower Jurassic. They have continued right on to the present day, when they are found as Gavials in India, Crocodiles in all tropical rivers, and Alligators in America and China. The
genus *Crocodilus*, now so widely distributed, first appeared in the Cretaceous of Europe.

In the Triassic period two orders of aquatic reptiles appeared. The first, called Ichthyosaurs, or fish-lizards, were marine forms, breathing by means of lungs. Fragmentary remains of Ichthyosaurs have been recovered from the Lower Trias of Württemburg and the Middle Trias of Nevada. The earliest typical forms are from the Upper Trias of Lombardy and Northern California. In the next period, the Jurassic, they are found in England, France, Germany and Wyoming. The genus *Ichthyosaurus* is first found in the bottom of the Jurassic beds in Dorsetshire, and other parts of England. It spread to Northern France, Württemburg and Franconia; it continued in England till the end of the Cretaceous, during which period it appeared in New Zealand, Australia, India and Chili. Bearing in mind that this is a marine reptile; whose origin was in the vicinity of the Northern Continent shown in Chart I, its extension in the Cretaceous period to the Indian Ocean is an index of a vast change in the distribution of land and water in the latter period. The sea then covered the modern Sahara. This illustrates the truth that the appearance of orders and even families of animals in any locality with which we are familiar is dependent, upon dispersal through a congenial medium, and not to origination in every site where found.

The other aquatic order comprised long-necked sea-lizards, which may be exemplified by the well-known genus *Plesiosaurus*. These sea-lizards first appeared in the Trias of Germany, whence they spread to Switzerland, France, England, Russia, India and the United States, reaching New Zealand in Cretaceous times, that is, after the land-barrier between the North Atlantic and the Indian Ocean had broken down.

The period called Jurassic succeeded the Trias, and brought with it the winged reptiles. Their first appearance was at the bottom of the Jurassic rocks of Dorsetshire, whence they spread to Central France, Württemburg, Bavaria, and the west of the United States, that is to say, they were buried in the deposits which now constitute those countries. This order presents us with a complete novelty in the means of locomotion; it is remarkable for its sudden appearance with completely developed arrangements for flight. Each fore-limb was furnished with an elongated digit, on the ulnar aspect, arranged for the support of a membranous wing. The bones were hollow. It will be observed that the distribution of the winged reptiles was very limited, being confined entirely to the Northern
Atlantic Continent. So far as is known they disappeared before the end of the Cretaceous period.

The group of toothless reptiles, which includes the tortoises, is first found in the upper portion of the Trias of Würtemburg. The earliest members are fully developed forms of their order, and their successors have not shown any essential change of structure. They are found next in the Upper Jurassic of other parts of Germany, in France (North), England, and the United States, extending subsequently to other countries in later periods (India, Australia, New Zealand).

There is yet another order, the scaly reptiles, which embraces the lizards and the snakes. But besides the latter there were two marine forms of this order; one, confined to the Cretaceous period, was found in England and on the eastern shores of the Adriatic. The other marine suborder, possessing like the last, two pairs of paddles, bore a strong resemblance to whales as regards the body. Its members had lizard-like heads. Their fossils are confined to the upper Chalk of Belgium, Holland, North Germany, France, and the United States.

The Lizards are first found at the top of the Jurassic in England, but the remains here and elsewhere are fragmentary. They occur in France, Germany, Wyoming and Colorado in Tertiary deposits. Two genera gigantic in form have been found in Pleistocene deposits in Queensland. The family to which belongs the well-known Iguana of America appeared first in the Tertiary rocks of Europe.

Snakes are first found as complete skeletons in certain deposits of the Miocene age of Switzerland, Greece and Germany; detached snake-like vertebrae have been found earlier than this (Eocene) in England, France, Switzerland, New Jersey, Wyoming and New Mexico, Colorado and Oregon. All the fossil forms are much the same as those of the present day.

Abbreviated as is the above sketch of the Reptiles, sufficient has been mentioned to indicate that the class first appeared on the Northern Atlantic Continent, on the fringe of which, whether in modern America or modern Europe, the different orders were buried at periods which were for each order approximately contemporaneous, and that they required time and favourable physical conditions to enable them to reach lands more distant.

Although the Birds are more independent of breaks in the continuity of land, yet the same central origin is apparent from the study of their geological distribution.
Owing to the want of variation in the endoskeletal arrangements of birds as compared with the numerous variations in their colours and plumage, their fossil remains do not provide us with the immense variety apparent in the present day. Another fact militates against the completeness of the record we are searching for, and that is the comparative rarity with which their forms have been preserved. Several causes have been assigned for this; perhaps one potent cause may be the large amount of lime contained in their bones; this being easily washed out, would lead to the crumbling and disappearance of the skeleton. But we have sufficient to show the first appearance of birds in the northern continent and their subsequent spread to the south.

The earliest known bird occurs in the Upper Jurassic strata of Solenhofen in Germany. Its main difference from modern birds consists in its having teeth, and further in its probably not possessing a beak, as it has teeth in the pre-maxilla. Its vertebrae are prolonged into a remarkably lengthy tail. The bones are not hollowed for air.

This ancient bird is succeeded after an interval by the "Toothed Birds"; among the earliest forms of these are some which have no wing, the fore-limb being represented by a rudimentary humerus. The foot is four-toed, the outer digit being of great length. They occur in the Cretaceous (upper) of Kansas. A member of the same order is found in the lowest Cretaceous of Cambridge, England. Some of the toothed birds possessed wings; a further distinction among these is that their teeth were placed each in a socket, instead of being arranged in a groove, as was the case with the wingless forms. This form is also found in the Cretaceous of Kansas.

Probably descended from the above toothed birds are the flightless birds. These, in the south, follow a course analogous to that we have seen obtaining with the Reptiles when they reached the final stage of their existence, namely, enormous size and anomalous development.

A bird which though not toothed, has serrations of the margins of the jaws, perhaps belongs to the same order as gannets, and occurs in the Lower Eocene of England.

But in the Cretaceous period the modern birds were appearing. Thus we find a member of the order to which belong ducks and flamingoes in the Cretaceous of Sweden. This order then appears in the Eocene of France, whence it spreads through Europe, a member arriving in New Zealand in the Pleistocene period. With the exceptions noted the various orders of modern birds are first
The Birds
1. Upper Jurassic.
2. Cretaceous.
3. Eocene.
4. Miocene.
5. Pliocene.
6. Pleistocene.

Flightless Birds
7. Eocene.
8. Lower Pliocene.
0. Recent.
found in the Eocene and Miocene of Europe, France being especially rich in their remains, while Wyoming also possesses a liberal supply of forms of the same period.

Many of these forms have been driven out of Europe. Some have, through the agency of man, since returned; for instance the pheasant, which has been introduced into Europe from Asia, is found fossil in the Miocene of France.

A glance at Chart IV. will show the dispersion of the Birds. It may be noted here that the birds of the so-called Eocene of Patagonia and New Zealand belong to the Penguins.

(To be concluded.)