country, and especially rich in the finest timber and many other vegetable products — none utilised. The only article which finds its way abroad is caoutchouc, and enormous quantities of this have been exported during the last ten years, but the export begins gradually to decrease, since the workmen, instead of only tapping the trees, destroy them completely. The province is inhabited by a population of only 10,000 natives, who live along the coast. The whole of the interior is covered by one gigantic virgin forest, and accessible only in canoes upon the rivers. Of the three months of my journey I spent more than two in canoes, which are rather small and hardly comfortable, or adapted for a travelling naturalist; the last twenty-three days I spent uninterruptedly in a canoe on the Esmeraldas River and its tributaries. The rivers are very rapid and not without dangers; but then my journey was made during the middle of the rainy season, when the rivers are very much swollen. On the Cayapas River I made the acquaintance of the wild Cayapas Indians, a very interesting tribe with a language and customs of their own. They keep in perfect isolation from other tribes, living in forests, hunting and fishing, going almost naked, and painting their bodies; on the whole they are very harmless, and may be some 2,000 in number."

In the *Nachrichten von der Gesellschaft der Wissenschaften zu Göttingen*, Herr Edmund Hoppe gives an account of some experiments he made with a view to determine the resistance offered by flames to the galvanic current. He arrived at the following results: (1) In each flame the greater galvanic conducting power depends on the greater heat and the greater quantity of burning gas. (2) With different flames the conducting power depends on the burning substances; the salts of potassium, sodium, barium, strontium, lithium, thallium, and copper in particular increase greatly the conducting power of the hydrogen flame. (3) Ohm's law applies perfectly to flames.

The additions to the Zoological Society's Gardens during the past week include a Macaque Monkey (*Macacus cynomolgus*) from India, presented by Mr. A. S. Percival; an Osprey (*Pandion haliaëtus*) from Yorkshire, presented by Mr. W. H. S. Quintin; a Common Hangnest (*Icterus vulgaris*) from South America, presented by Mr. Hamilton Dunlop; a West African Python (*Python sebæ*) from West Africa, presented by Mr. Francis Lovell; two Guilding's Amazons (*Chrysotis guildingi*) from St. Vincent, a Violet Tanager (*Euphonia violacea*), a Yellow-winged Blue Creeper (*Cœreba cyanea*), a Common Boa (*Boa constrictor*) from South America, deposited; three Capybaras (*Hydrochœrus capybara*) from South America, purchased.

INTRODUCTION AND SUCCESSION OF VERTEBRATE LIFE IN AMERICA[1]

THE origin of life, and the order of succession in which its various forms have appeared upon the earth, offer to science its most inviting and most difficult field of research. Although the primal origin of life is unknown, and may perhaps never be known, yet no one has a right to say how much of the mystery now surrounding it science cannot remove. It is certainly within the domain of science to determine when the earth was first fitted to receive life, and in what form the earliest life began. To trace that life in its manifold changes through past ages to the present is a more difficult task, but one from which modern science does not shrink. In this wide field every earnest effort will meet some degree of success; every year will add new and important facts; and every generation will bring to light some law, in accordance with which ancient life has been changed into life as we see it around us to-day. That such a development has taken place no one will doubt who has carefully traced any single group of animals through its past history, as recorded in the crust of the earth. The evidence will be especially conclusive if the group selected belongs to the higher forms of life, which are sensitive to every change in their surroundings. But I am sure I need offer here no argument for evolution; since to doubt evolution to-day is to doubt science, and science is only another name for truth.

Taking, then, evolution as a key to the mysteries of past life on the earth, I invite your attention to the subject I have chosen: The Introduction and Succession of Vertebrate Life in America.

In the brief hour allotted to me I could hardly hope to give more than a very incomplete sketch of what is now known on this subject. I shall therefore pass rapidly over the lower groups, and speak more particularly of the higher vertebrates, which have an especial interest to us all, in so far as they approach man in structure, and thus indicate his probable origin. These higher vertebrates, moreover, are most important witnesses of the past, since their superior organisation made them ready victims to slight climatic changes, which would otherwise have remained unrecorded.

In considering the ancient life of America it is important to bear in mind that I can only offer you a brief record of a few of the countless forms that once occupied this continent. The review I can bring before you will not be like that of a great army, when regiment after regiment with full ranks moves by in orderly succession, until the entire host has passed. My review must be more like the roll-call after a battle, when only a few scarred and crippled veterans remain to answer to their names. Or rather, it must resemble an array of relics, dug from the field of some old Trojan combat, long after the contest, when no survivor remains to tell the tale of the strife. From such an ancient battle-field a Schliemann might unearth together the bronze shield, lance-head, and gilded helmet of a prehistoric leader, and learn from them with certainty his race and rank. Perhaps the skull might still retain the barbaric stone weapon by which his northern foe had slain him. Near by the explorer might bring to light the commingled coat of mail and trappings of a horse and rider, so strangely different from the equipment of the chief, as to suggest a foreign ally. From these, and from the more common implements of war that fill the soil, the antiquary could determine, by patient study, what nations fought, and perhaps when and why.

By this same method of research the more ancient strata of the earth have been explored, and in our western wilds, veritable battle-fields, strewn with the fossil skeletons of the slain, and guarded faithfully by savage superstition, have been despoiled, yielding to science treasures more rare than bronze or gold. Without such spoils, from many fields, I could not have chosen the present theme for my address to-night.

According to present knowledge, no vertebrate life is known to have existed on this continent in the Archæan, Cambrian, or Silurian periods; yet during this time more than half of the thickness of American stratified rocks was deposited. It by no means follows that vertebrate animals of some kind did not exist here in those remote ages. Fishes are known from the upper Silurian of Europe, and there is every probability that they will yet be discovered in our strata of the same age, if not at a still lower horizon.

In the shore deposits of the early Devonian sea, known as the Schoharie grit, characteristic remains of fishes were preserved, and in the deeper sea that followed, in which the corniferous limestone was laid down, this class was well represented. During the remainder of the Devonian fishes continue abundant in the shallower seas, and, so far as now known, were the only type of vertebrate life. These fishes were mainly ganoids, a group represented in our present waters by the gar-pike (*Lepidosteus*) and sturgeon (*Acipenser*), but, in the Devonian sea, chiefly by the placoderms, the exact affinities of which are somewhat in doubt. With these were elasmobranchs, or the shark tribe, and among them a few chimæroids, a peculiar type, of which one or two members still survive. The placoderms were the monarchs of the ocean. All were well protected by a massive coat of armour, and some of them attained huge dimensions. The American Devonian fishes now known are not as numerous as those of Europe, but they were larger in size, and mostly inhabitants of the open sea. Some twenty genera and forty species have been described.

The more important genera of placoderms are *Dinichthys*, *Aspidichthys*, and *Diplognathus*, our largest palæozoic fishes. Others are, *Acanthaspis*, *Acantholepis*, *Coccosteus*, *Macropetalichthys*, and *Onychodus*. Among the elasmobranchs were, *Cladodus*, *Ctenacanthus*, *Machæracanthus*, *Rhynchodus*, and *Ptyctodus*, the last two being regarded as chimeroids. In the

[1] Lecture delivered at the Nashville meeting of the American Association, August 30.

Chemung epoch the great dipterian family was introduced with *Dipterus*, *Heliodus*, and possibly *Ceratodus*. Species of the European genera, *Bothriolepis* and *Holoptychius*, have likewise been found in our Devonian deposits.

With the close of the Devonian came the almost total extinction of the great group of placoderms, while the elasmobranchs, which had hitherto occupied a subordinate position, increase in numbers and size, and appear to be represented by sharks, rays, and chimeras. Among the members of this group from the carboniferous were numerous cestracionts, species of *Cochliodus* of large size, with others of the genera *Deltodus*, *Helodus*, *Psammodus*, and *Sandalodus*. Of the Petalodonts there were *Antliodus*, *Chomatodus*, *Ctenoptychius*, *Petalodus*, and *Petalorhynchus;* and of the hybodonts, the genera *Cladodus*, *Carcharopsis*, and *Diplodus*. These elasmobranchs were the rulers of the carboniferous open sea, and more than one hundred species have been found in the lower part of this formation alone. The ganoids, although still abundant, were of smaller size, and denizens of the more shallow and confined waters. The latter group of fishes was represented by true lepidostidæ, of the genera *Palæoniscus*, *Amblypterus*, *Platysomus*, and *Eurylepis*. Other genera are, *Rhizodus*, *Megalichthys*, *Ctenodus*, *Edestus*, *Orodus*, *Ctenacanthus*, *Gyracanthus*, and *Cœlacanthus*. Most of these genera occur also in Europe.

From the permian rocks of America no vertebrate remains are known, although in the same formation of Europe ganoids are abundant, and with them are remains of sharks, and some other fishes, the affinities of which are doubtful. The palæozoic fishes at present known from this country are quite as numerous as those found in Europe.

In the mesozoic age the fishes of America begin to show a decided approach to those of our present waters. From the triassic rocks ganoids only are known, and they are all more or less closely related to the modern gar-pike, or *Lepidosteus*. They are of small size, and the number of individuals preserved is very large. The characteristic genera are *Catopterus*, *Ischypterus*, *Ptycholepis*, *Rhabdolepis*, and *Turseodus*. From the Jurassic deposits no remains of fishes are known, but in the cretaceous ichthyic life assumed many and various forms; and the first representatives of the teleosts, or bony fishes, the characteristic fishes of to-day, make their appearance. In the deep open sea of this age elasmobranchs were the prevailing forms, sharks, and chimæroids being most numerous. In the great inland cretaceous sea of North America true osseous fishes were most abundant, and among them were some of carnivorous habits and immense size. The more sheltered bays and rivers were shared by the ganoids and teleosts, as their remains testify. The more common genera of cretaceous elasmobranchs were *Otodus*, *Oxyrhina*, *Galeocerdo*, *Lamna*, and *Ptychodus*. Among the osseous fishes, *Beryx*, *Enchodus*, *Portheus* and *Saurocephalns* were especially common, while the most important genus of ganoids was *Lepidotus*.

The tertiary fishes are nearly all of modern types, and from the beginning of this period there was comparatively little change. In the marine beds sharks, rays, and chimæroids maintained their supremacy, although teleosts were abundant, and many of them of large size. The ganoids were comparatively few in number. In the earliest eocene fresh-water deposits it is interesting to find that the modern gar-pike, and *Amia*, the dog-fish of our western lakes, which by their structure are seen to be remnants of a very early type, are well represented by species so closely allied to them that only an anatomist could separate the ancient from the modern. In the succeeding beds these fishes are still abundant, and with them are siluroids nearly related to the modern cat-fish (*Pimelodus*). Many small fishes allied apparently to the modern herring (*Clupea*), left their remains in great numbers in the same deposits, and with them has been recently found a land-locked ray (*Heliobatis*).

The almost total absence of remains of fishes from the miocene lake-basins of the west is a remarkable fact, and perhaps may best be explained by the theory that these inland waters, like many of the smaller lakes in the same region to-day, were so impregnated with mineral matters as to render the existence of vertebrate life in them impossible. No one who has tasted such waters or has attempted to ford one of the modern alkaline lakes which are often met with on the present surface of the same deposits, will doubt the efficiency of this cause, or the easy entombment of the higher vertebrates that ventured within their borders. In the pliocene lake-basins of the same region remains of fishes were not uncommon, and in some of them are very numerous. These are all of modern types and most of them are cyprinoids related to the modern carp. The post-pliocene fishes are essentially those of to-day.

In this brief synopsis of the past ichthyic life of this continent I have mentioned only a few of the more important facts, but sufficient, I trust, to give an outline ot its history. Of this history it is evident that we have as yet only a very imperfect record. We have seen that the earliest remains of fishes known in this country are from the lower Devonian; but these old fishes show so great a diversity of form and structure as to clearly indicate for the class a much earlier origin. In this connection we must bear in mind that the two lowest groups of existing fishes are entirely without osseous skeletons, and hence, however abundant, would leave no permanent record in the deposits in which remains of fishes are usually preserved. It is safe to infer from the knowledge which we now possess of the simpler forms of life, that even more of the early fishes were cartilaginous, or so destitute of hard parts as to leave no enduring traces of their existence. Without positive knowledge of such forms, and considering the great diversity of those we have, it would seem a hopeless task at present to attempt to trace successfully the genealogy of this class. One line, however, appears to be direct, from our modern gar-pike, through the lower eocene *Lepidosteus* to the *Lepidotus* of the cretaceous, and perhaps on through the triassic *Ischypterus* and carboniferous *Palæoniscus;* but beyond this, in our rocks, it is lost. The living chimæra of our Pacific coast has nearly allied forms in the tertiary and cretaceous, more distant relatives in the carboniferous, and a possible ancestor in the Devonian *Rhynchodus*. Our sharks likewise can be traced with some certainty back to the palæozoic; and even the *Lepidosiren*, of South America, although its immediate predecessors are unknown, has some peculiar characters which strongly point to a Devonian ancestry. These suggestive lines indicate a rich field for investigation in the ancient life-history of American fishes.

The amphibians, the next higher class of vertebrates, are so closely related to the fishes in structure, that some peculiar forms of the latter have been considered by anatomists as belonging to this group. The earliest evidence of amphibian existence, on this continent, is in the sub-carboniferous, where foot-prints have been found which were probably made by labyrinthodonts, the most ancient representatives of the class. Well preserved remains are abundant in the coal-measures, and show that the labyrinthodonts differed in important particulars from all modern amphibians, the group which includes our frogs and salamanders. Some of these ancient animals resembled a salamander in shape, while others were serpent-like in form. None of those yet discovered were frog-like, or without a tail, although the restored labyrinthodont of the text-books is thus represented. All were protected by large pectoral bony plates, and an armour of small scutes on the ventral surface of the body. The walls of their teeth were more or less folded, whence the name labyrinthodont. The American amphibians known from osseous remains are all of moderate size, but the foot-prints attributed to this group indicate animals larger than any of the class yet found in the Old World. The carboniferous amphibians were abundant in the swampy tropical forests of that period, and their remains have been found imbedded in the coal then deposited, as well as in hollow stumps of the trees left standing.

The principal genera of this group from American carboniferous rocks, are, *Sauropus*, known only from foot-prints, *Baphetes*, *Dendrerpeton*, *Hylonomus*, *Hylerpeton*, *Raniceps*, *Pelion*, *Leptophractus*, *Molgophis*, *Ptyonius*, *Amphibamus*, *Cocytinus*, and *Ceraterpeton*. The last genus occurs also in Europe. Certain of these genera have been considered by some writers to be more nearly related to the lizards (*Lacertilia*) among true reptiles. Some other genera known from fragmentary remains or foot-prints in this formation have likewise been referred to the true reptiles, but this question can perhaps be settled only by future discoveries.

No amphibia are known from American permian strata, but in the triassic, a few characteristic remains have been found. The three genera, *Dictyocephalus*, *Dispelor*, and *Pariostegus*, have been described, but, although apparently all labyrinthodonts, the remains preserved are not sufficient to add much to our knowledge of the group. The triassic foot-prints which have been attributed to amphibians are still more unsatisfactory, and at present no important conclusions in regard to this class can be based upon them. From the Jurassic and cretaceous beds of this continent, no remains of amphibians are known. A few only have been found in the tertiary, and these are all of modern types.

The amphibia are so nearly allied to the ganoid fishes, that we can hardly doubt their descent from some member of that group. With our present limited knowledge of the extinct forms, however, it would be unprofitable to attempt to trace in detail their probable genealogy.

The authors to whom especial credit is due for our knowledge of American fossil fishes and amphibians, are Newberry, Leidy, Cope, Dawson, Agassiz, St. John, Gibbes, Wyman, Redfield, and Emmons, and the principal literature of the subject will be found in their publications.

Reptiles and birds form the next great division of vertebrates, the sauropsida, and of these the reptiles are the older type, and may be first considered. While it may be stated with certainty that there is at present no evidence of the existence of this group in American rocks older than the carboniferous, there is some doubt in regard to their appearance even in this period. Various foot-prints which strongly resemble those made by lizards, a few well preserved remains similar to the corresponding bones in that group, and a few characteristic specimens, nearly identical with those from another order of this class, are known from American coal measures. These facts, and some others which point in the same direction, render it probable that we may soon have conclusive evidence of the presence of true reptiles in this formation, and in our overlying permian, which is essentially a part of the same series. In the permian rocks of Europe, true reptiles have been found.

The mesozoic period has been called the age of reptiles, and during its continuance some of the strangest forms of reptilian life made their appearance, and became extinct. Near its commencement, while the triassic shales and sandstones were being deposited, true reptiles were abundant. Among the most characteristic remains discovered are those of the genus *Belodon*, which is well known also in the trias of Europe. It belongs to the thecodont division of reptiles, which have teeth in distinct sockets, and its nearest affinities are with the crocodilia, of which order it may be considered the oldest known representative. In the same strata in which the belodonts occur, remains of dinosaurs are found, and it is a most interesting fact that these highest of reptiles should make their appearance, even in a generalised form, at this stage of the earth's history. The dinosaurs, although true reptiles in all their more important characters, show certain well marked points of resemblance to existing birds of the order *Ratitæ*, a group which includes the ostriches; and it is not improbable that they were the parent stock from which birds originated.

During triassic time, the dinosaurs attained in America an enormous development both in variety of forms and in size. Although comparatively few of their bones have as yet been discovered in the rocks of this country, they have left unmistakable evidence of their presence in the foot-prints and other impressions upon the shores of the waters which they frequented. The triassic sandstone of the Connecticut Valley has long been famous for its fossil foot-prints, especially the so-called "bird-tracks," which are generally supposed to have been made by birds, the tracks of which many of them closely resemble. A careful investigation, however, of nearly all the specimens yet discovered, has convinced me that there is not a particle of evidence that any of these fossil impressions were made by birds. Most of these three-toed tracks were certainly not made by birds: but by quadrupeds, which usually walked upon their hind feet alone, and only occasionally put to the ground their smaller anterior extremities. I have myself detected the impressions of these anterior limbs in connection with the posterior foot-prints of nearly all the supposed "bird-tracks" described, and have little doubt that they will eventually be found with all. These double impressions are precisely the kind which dinosaurian reptiles would make, and as the only characteristic bones yet found in the same rocks belong to animals of this group, it is but fair to attribute all these foot-prints to dinosaurs, even where no impressions of fore-feet have been detected, until some evidence appears that they were made by birds. I have no doubt that birds existed at this time, although at present the proof is wanting.

The principal genera of triassic reptiles known from osseous remains in this country are, *Amphisaurus* (*Megadactylus*), from the Connecticut Valley, *Bathygnathus*, from Prince Edward's Island, *Belodon* and *Clepsysaurus*. Other generic names which have been applied to foot-prints and to fragmentary remains, need not be here enumerated. A few remains of reptiles have been found in undoubted Jurassic rocks of America, but they are not sufficiently well determined to be of service in this connection. Others have been reported from supposed Jurassic strata, which are now known to be cretaceous. It will thus be seen that, although reptilian life was especially abundant during the triassic and Jurassic periods, but few bones have been found. This is owing in part to the character of most of the rocks then formed, which were not well fitted for preserving such remains, although admirably adapted to retain foot-prints.

(*To be continued.*)

ON NOCTURNAL INCREASE OF TEMPERATURE WITH ELEVATION[1]

TILL the year 1862, when my first experiments were made by the use of the balloon, our knowledge of the temperature of the air was almost entirely confined to within four or five feet of the earth's surface, and the theory that the temperature was always lower at high elevations, and that the decrease of temperature with increase of elevation was at the rate of 1° Fahrenheit for every 300 feet of elevation, was generally received and acted upon. These theories were found not to be at all times true, and the assumption of the decrease of 1° of temperature in every increase of 300 feet of elevation was proved to be erroneous in every balloon ascent I have made; in some a decrease of 1° and more than 1° was experienced within 100 feet, and there is no doubt that, considering the quickness of motion on leaving the earth, the decrease at such times was really 2° or 3°, or more, within the space of 100 feet.

In some of the ascents a difference of 10° was met with within 1,000 feet of the earth, whilst in others but little or no difference was experienced even to heights exceeding 1,000 feet.

Towards the end of my balloon experiments it was evident that a very large number more were necessary, and in my last report I said:—

From all the experiments made it would seem that the decrease of temperature with increase of elevation is variable throughout the day, and variable in different seasons of the year; that at about sunset the temperature varies but very little for a height of 2,000 feet; that at night with a clear sky the temperature increases with elevation; that at night with a cloudy sky there was a small increase of temperature as the height increased; that in the double ascent of May 29, 1866, the one just before and the other after sunset, it would seem that after radiation from the earth began, the heat passes upwards till arrested where the air is saturated with vapour, when a heat greater by 5° was experienced after sunset than at the same elevation before sunset.

This was the state of our knowledge when M. Giffard most kindly placed the great "Captive" balloon, located at Ashburnham Park, Chelsea, near London, at my disposal for a series of experiments.

This balloon could ascend to the height of 2,000 feet on a calm day; its rate of ascension could be regulated at will; it could be kept stationary at any elevation, and experiments could be repeated several times in the day.

On two different days I ascended nine times on each day; there was a decrease of temperature with increase of elevation at every ascent, but, different in amount at every hour, being less and less as the day advanced towards sunset. The results of the experiments are shown in the following table, showing the amount of decrease of temperature per 100 feet of elevation, at different hours of the day with a clear sky, and a cloudy sky, as found by experiments with M. Giffard's captive balloon.

Height above the ground.		Clear Sky.						Cloudy Sky.				
From	To	10 A.M. to 11 A.M.	3 P.M. to 4 P.M.	4 P.M. to 5 P.M.	5 P.M. to 6 P.M.	6 P.M. to 7 P.M.	About 7 P.M.	3 P.M. to 4 P.M.	4 P.M. to 5 P.M.	5 P.M. to 6 P.M.	6 P.M. to 7 P.M.	7 P.M. to 8 P.M.
feet.	feet.	°	°	°	°	°	°	°	°	°	°	°
0	100	1·0	1·4	1·2	0·9	0·5	0·0	1·2	1·2	0·8	0·6	0·5
100	200	1·0	0·8	0·7	0·7	0·5	0·1	0·9	0·7	0·6	0·6	0·5
200	300	0·9	0·7	0·6	0·7	0·5	0·2	0·9	0·6	0·6	0·6	0·5
300	400	0·9	0·6	0·5	0·7	0·5	0·3	0·7	0·5	0·6	0·5	0·5
400	500	0·8	0·6	0·4	0·6	0·5	0·3	0·5	0·4	0·5	0·5	0·5
500	600	0·7	0·5	0·4	0·5	0·5	0·3	0·5	0·4	0·5	0·5	0·5
600	700	0·6	0·5	0·4	0·4	0·5	0·4	0·4	0·4	0·5	0·5	0·5
700	800	0·6	0·5	0·4	0·4	0·5	0·4	0·4	0·5	0·5	0·5	0·5
800	900	0·5	0·5	0·4	0·4	0·4	0·4	0·4	0·4	0·4	0·5	0·5
900	1000	0·5	0·5	0·4	0·4	0·4	0·4	0·4	0·4	0·4	0·5	0·4

[1] Abstract of a paper read at the Havre meeting of the French Association by Mr. James Glaisher, F.R.S.