ANIMALS BEFORE MAN IN NORTH AMERICA

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ANIMALS BEFORE MAN IN NORTH AMERICA

Triceratops, the Great Horned Dinosaur.

From a painting by Charles R. Knight.

ANIMALS BEFORE MAN IN NORTH AMERICA

THEIR LIVES AND TIMES

BY

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WITH MANY ILLUSTRATIONS

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LIST OF FULL-PAGE ILLUSTRATIONS

INTRODUCTION

It is the aim of this book to picture the early life of our continent, to tell something of the fishes that once swam about its shores, the reptiles that splashed through the swamps, and the mammals that long ago roamed the Western plains. Books and museums and zoological gardens have made us familiar with the animals of the present, but we are apt to have rather vague ideas of the animals of the past. Whirling through New Jersey, the traveler notes in the morning paper that a mastodon has just been unearthed near New Brunswick, and may wonder how the landscape would look with herds of mastodons in place of the familiar cattle. The geologist might say that this was the case only a short time ago, while long before the same land was occupied by huge, unfamiliar reptiles. The life of our continent has indeed changed, and some of these changes have taken place in our own day and almost under our very eyes. The bison has been practically swept out of existence, and his doom was sealed when the white man first settled here. But other and different bison had lived and died before this one came upon the scene, and these in turn took the place of other creatures. For there has been a constant change among the animals of this country, and they have been very different at different periods. Could one see examples of them in some great zoological garden, it might be imagined not only that they had been brought together from very remote regions, but that some of them had come from quite another world. Museums have done a great deal of late years to make us acquainted with these extremely ancient animals, but much of the knowledge thus acquired is fragmentary in every sense of the word. It is one of the purposes of this book to clothe such fragments, so far as may be, with flesh and blood, and make the reader acquainted with some of these early animals of the continent. For these objects are not merely so many specimens of fossil shells and pieces of petrified bones: they represent the life of their day, and this life was quite as real as that now about us.

There are several ways in which this ancient natural history might be written: one would be to start with the animals found in the lowest rocks and mention the various species or groups of animals which occur in the formations as we come upward. This, it has been thought, would give a somewhat mixed and disconnected view of the life of our continent, and would result, moreover, in the frequent repetition of names and the unavoidable scattering of information. Still another method would be to tell the history of each group as a whole; of its origin, rise, period of supremacy, and final decline; and this has many things to recommend it. But the plan finally adopted has been to treat the history of the past by periods, and endeavor to sketch the characteristic or more striking features of the life of well-marked epochs; to tell something of the habits, appearance, and relationships of the more conspicuous animals. In doing this, an effort has been made to call attention to some of the causes that are believed to have brought about the marked changes that have taken place in the life of our continent and of the world generally, as well as to impart some of the varied information that has been obtained from the study of fossils. Something, too, has been said of the localities where are to be found the fossils from which the life of the past has been reconstructed, and the methods followed in reproducing the appearance of these animals and interpreting their habits from a study of their bones.

The preference has naturally been given to the larger animals. As a rule, not only do we know them better, but they are likely to be more impressive and interesting than their small associates. Just as to-day the larger animals give us our clearest impressions of the differences between the animals of different parts of the earth, so do they mark most plainly the distinctions between the life of the present and that of the past.

For many reasons this book is not confined entirely to the animals of this country, but deals to some extent with those of other parts of the world as well. We know how the history of the United States has more or less to do with that of England, Holland, and France; and just so the story of the past can not be told without referring to that of other regions than ours. No animal nor any group of animals stands by itself; each and all have somewhat in common with others.

Nowadays the animals of different parts of the earth are so unlike, that its surface may be mapped into regions each distinguished by particular kinds of animals: Africa has its antelopes, North America its deer and bison, South America its monkeys with prehensile tails. But it was not always so: far back in the past, when conditions appear to have been much the same throughout the world, many animals were similar. More than this: the so-called solid earth is not so stable as it seems, and there have been times in the past when lands now separated by the sea have been so joined that there was an interchange of animals. So it frequently happens that where some pages of our own history are lacking we can make good the loss by borrowing a few pages from that of our neighbors.

Finally, it may be said that the author has tried to tell the story of the past life of our continent in as plain language as possible; and while the use of some scientific names and technical terms has been unavoidable, it is hoped that these may not be found so formidable as many suppose.

CHAPTER I

HOW THE HISTORY OF THE PAST IS READ

Very little of really ancient history is to be learned from books, very little of it is even recorded in written language. The stories of Assyria and Babylonia, it is true, are partly deciphered from strange characters impressed on tablets of clay and partly from inscriptions carved on monuments and statues. But Assyria and Babylonia were highly civilized nations; and while they may be ancient as we compute time, they are modern if judged by nature’s standards, and there are many far older races that had no written language and left no inscribed tablets nor sculptured stones to tell of their life and achievements. For any knowledge of the history of these very ancient peoples we are wholly dependent upon such articles of every-day use as were made of materials sufficiently enduring to last through long centuries of time. And in like manner our knowledge of the many animals that lived still more remotely is derived mainly from the study of their hard parts, such as shells, teeth, or bones, that have been preserved for countless ages in the shape of fossils; and this study of the life of the past is known as Paleontology.

Literally, a fossil is “something dug up”; but in actual use the word has a much more restricted meaning. No one would think of calling diamonds, or gold, or fire-clay fossils, although they are things dug up; neither would we speak of the bones of the horse Farmer Jones buried in the pasture twenty years ago as fossils. The term is applied only to the remains of animals or plants that have been buried by natural causes and preserved for long periods of time,[1] or to such indications of former life as natural casts and impressions of shells, leaves, footprints, and the like.

In a few very exceptional cases animals have been preserved entire, but this is where they have lived at a comparatively recent date, and were entombed in ice or frozen ground immediately after death. A few specimens of the mammoth and one or two of the woolly rhinoceros are all that have been thus preserved, and both these animals lived in Europe with early man; and although this was thousands of years ago, from a geological standpoint it is but as yesterday.

Even the hard parts of animals have become changed by the dissolving of some portions—particularly of the animal matter—and the filtering in of other substances, until through this process of replacement the shell or bone has become changed to stone, or, as it is often termed, petrified; and the older these objects are and the deeper they lie in the rocks the more complete are the changes they have undergone.

So completely, though gradually, do these changes take place, that even the minute structure of wood or bone may be seen under the microscope, the exact shape of each little cell having been retained, although the original material of which it was composed has been replaced by silica, or flint, as it is more familiarly called.

Since these changes require certain favorable conditions and take place very slowly, only objects that retain their shape for a considerable time can be thus altered; so, flesh can never be turned into stone, and consequently there is no such thing as a "petrified body."

The familiar experiment of soaking a bone in weak muriatic acid shows how much animal matter there is in a skeleton; and it will surprise any one who will try a tooth—that of a horse, for example—in place of a bone, to find how much of this, too, is made up of gristle-like material. There is so much of this in the tusks of elephants or teeth of sperm whales that they can be made into gelatin, and this might be used for making elephant or whale jelly. This is the reason why the tusks of ancient elephants are so rarely found; the soft material of the tusks washed out so much more rapidly than mineral substances filtered in to replace it, that they crumbled to pieces and disappeared. There is another class of fossils in a measure intermediate between the actual preservation of a bone or shell and its mere impression; and this is where such objects as the shell of a crab or the leaf of a tree have been pressed extremely thin, but have left their exact outline in color on the rock, as if painted by the hand of nature. This color-printing is usually due to the presence of iron in the soil in which the object was buried, and its combination with organic matter makes a stain.

But if flesh and animals of soft texture perish completely so far as actual substance is concerned, the impressions such objects made in the sand or mud on which they rested, and the casts formed by the mud which settled about or in them may remain; and it is wonderful to find that such delicate creatures as soft-bodied jelly-fish, or sea-nettles, have left traces of their former presence even in some of the most ancient rocks. This, of course, could happen only where the water was quiet and soft mud plentiful, so that these delicate animals were buried immediately after death. If we imagine a host of jelly-fish resting on the shallows of some quiet little Cambrian bay, and that into this poured a river suddenly made turbid with the mud created by some local inland rain, it will give us some hint as to how their preservation might take place.

The sea to-day swarms with jelly-fish, or Medusæ, especially in warm latitudes, and so it must have done in past ages; that "fossil jelly-fish" should be found only in one or two favored localities shows how rarely just the right conditions for their preservation occurred.

Insects—that is, the imprints of insects—have been found by the thousand in the soft, fine-grained shale of Florissant, Colo.; and many others, including such familiar forms as cockroaches and dragon-flies, have been taken from that great storehouse of wonderful fossils, the lithographic-stone quarries of Solenhofen, Bavaria. And if traces of such delicate and fragile creatures as these have been thus preserved, it is not surprising to find imprints of feathers and of the tough hides of reptiles, even when not armed with plates and spines of bone; and from these we may learn much as to the covering of these bygone animals.

There is still another class of impressions which furnishes assistance in reading the history of the past, and these are footprints. As children we may have delighted in tales of hunters tracking their game through the forest, or of Indians following the faint trail of fleeing enemies; while still more recently we may have read with equal interest Mr. Seton-Thompson's[2] stories, and followed the tracks of Wahb or

Molly along the margin of the page. In much the same manner the paleontologist patiently follows the trails of long-vanished animals that ages ago passed over the sands of Time and out of existence. For, as the animals of to-day leave their footmarks beside the pond in the meadow, on the sands of the seashore, or along the margin of the river, just so the creatures of the past left their imprints on the sand or in the mud, to harden into stone and bear an indelible record of the life of other days. It is not only the larger animals that left this record in the rocks, but scores of smaller, more insignificant creatures—crabs, shell-fish, and even insects. Many of these marks have been read by comparing them with the impressions left by existing animals as they crawled over mud and sand, or over wet plaster of Paris; but now and then we come upon markings quite different from those made by any animal with which we are acquainted. In such cases, knowing the kind of tracks made by living animals and the manner in which they move their legs, it is necessary to cast about for some fossil form whose feet can be made to fit the impressions, and in this way were interpreted the markings on Cambrian rocks now ascribed to trilobites.

If the tracks of trilobites were puzzling because they were different from those made by any modern animals, those made by the great reptiles called dinosaurs were long misinterpreted for precisely the opposite reason. Ordinarily the feet of different groups of animals are constructed on different plans, so that footprints may show not only whether they were made by mammals, birds, reptiles, or batrachians, but even indicate the particular division to which the individual making them belonged. But the feet of some dinosaurs were so much like those of birds that for many years the tracks made by them were ascribed to gigantic birds. Close observers, however, pointed out that some of the finest impressions showed that the texture of the skin was quite different from that covering the feet of birds, while in most cases the bones of the toes were shorter and heavier, and subsequent discoveries have made it clear that these footprints are those of dinosaurs.

Very often tracks are all we have to tell that some animals ever existed, for their bones were either destroyed or lie buried deep in the rocks in places now inaccessible. A well-known instance is that of the famous footprints in the red sandstone of the Connecticut Valley, which bear testimony of the presence of a host of animals, great and small, but two or three of which have ever come to light. When these tracks were made, a long, narrow bay or estuary ran northward from Long Island Sound, and the rocks tell that at times the shores were left dry to bake in the sun, and again that they were overflowed by water, sweeping down quantities of mud and sand, filling up all impressions, and making casts of the tracks of those creatures that had wandered by the waterside.

How fossils are laboriously gathered and patiently prepared are stories by themselves, but stories that in the present instance may be passed by; what does concern us is the method by which these characters of stone are made to tell the story of the past life of our continent. It is not so many years ago that fossils were looked upon as mere “sports of nature,” interesting from their resemblances in some cases to shells or bones, but having no meaning whatever. A little later their real nature was acknowledged, but they were regarded as “medals of creation,” marking various stages in the history of the world, but of importance mainly for the identification of strata and determining the distribution of rocks. Now, however, it is recognized that fossils do not merely mark different epochs in the history of the past, but that only by their aid can we determine the relationships that animals bear to one another, and only through them can we hope to trace the development and distribution of living things.

The student of the past has at his command the teeth and bones of vertebrates, sometimes complete skeletons, their footprints, and, more rarely, imprints of their coverings or even outlines of their forms. Of invertebrates, there are shells or casts of shells, the hard coverings of such creatures as crabs, impressions of soft animals like jelly-fishes, and the trails made by these various creatures as they crept over the shore. Fossilized logs and seeds, clean-cut impressions of leaves, rushes, and seaweeds, combine to tell the plant-life of the ancient world, while the rocks in which all these are preserved add their information to that of the fossils. And with the aid of all this material it is possible to picture plant and animal life as it was at various epochs of the world’s history, although these pictures are, of necessity, more or less incomplete and lacking in details.

The story of the past is read as a Chinese book *seems* to be, from the end backward, and it is necessary to study not only the structure of animals now living, but their appearance and habits, in order to understand the meanings of the fragments of bone from which we must derive our knowledge of the animals that have long ceased to be. Even with a good knowledge of modern animals it is often a difficult matter to tell the relationships, habits, and appearance of many extinct forms, as they were so different from any now living that we have no term of comparison. Still, careful research has done much within the last twenty-five years to increase our knowledge, not merely by discovering new animals, but by the finding of more complete specimens of those already known to us by fragments. Fortunately, too, for the student, while the majority of living animals differ more or less from those of the past, there are a few of the old-fashioned types still remaining to throw some light on those that have passed away.

From the animals and plants we are able to tell what the climate was at different periods; for when, in the rocks of Wyoming, for example, we find fossil palms resembling those now living in the tropics, or a bread-fruit tree turns up in California, we naturally infer that the climate of that part of the world was very much warmer then than now. So the former presence in Greenland of forest trees similar to those now growing in New York indicates that the climate of the entire globe was once milder. And if remains of great reptiles are found associated with plants, these inferences are strengthened, for the reptiles of to-day have their headquarters in warm countries, and large forms never cross the line of frost.

On the other hand, the bones of reindeer in southern Europe, and those of musk-oxen in Kentucky, tell of a time when these places were far colder than now, and that their tale is true we know from the testimony left by the great ice-sheets that have given their name to the Glacial period. More than this, since the bones are those of species still living, we know that this cold period could not have occurred so very long ago.

Sometimes we may even go a little further than this, and tell what the weather was at some particular time; there are prints of rain-drops, and these may even show the direction of the wind, casts of gaping cracks in the sun-dried mud, telling of long drought, and marks left by the rippling waves as the tide went out, speaking of gentle breezes and fair weather. It is always well to have corroborative evidence in doubtful cases, for if Nature does not exactly play tricks on us, her messages, like those of the Delphic oracle, are occasionally obscure, and capable of being translated in more ways than one.

Cuvier inferred from the bones of the elephant and rhinoceros that at the time they lived Europe rejoiced in a warm climate; but later discoveries showed that these animals were clothed in fur and fitted to endure the cold.

In cases such as these, plants furnish reliable testimony as to climate, for they are less adaptive than animals, or show their adaptation much more plainly. When we go north we find the trees growing smaller and smaller, until finally they disappear; but the reindeer and musk-ox are large animals, and the polar bear and Greenland whale even larger than their tropical relatives.

And if fossils tell what the climate was while the rocks in which they are contained were forming, the rocks, on the other hand, may show *why* the climate changed, and with it the plant and animal life of that portion of the globe. The upheaval of mountain ranges has cut off warm and moisture-laden winds, transforming verdure-clad plains into arid wastes; the slow rise of great masses of land has cast a chill over vast areas, transforming those species that—we know not why—can respond to changed conditions, pushing southward, or blotting out of existence those that can not. The mountain range may countless ages ago have been leveled to a plain, the continent again sunk beneath the sea and again risen, but from the rocks and fossils we may learn the story of these changes, set the former boundaries of the land, and people the earth with its long-vanished life.

If the rocks from two widely separated localities are found to contain the same or even similar species of fossil land animals, it is to be inferred that these rocks were formed at about the same period of time, and that there was a land connection between the two places. These are very general propositions, but in actual use there are several factors to be taken into consideration, and with invertebrates the case is yet more complicated.

If the fossils are very different in their nature, we may be sure that the rocks were separated either by time or space; and if the fossils are those of mammals, they will probably tell which of these two possibilities is a probability. For here it may be said that the different kinds of animals keep as it were different kinds of time, the low animals of simple structure seeming to change much more slowly than those higher in the scale. This is really what might be expected, for the more highly organized a creature the more susceptible should it be to changes of any kind, although another factor probably plays a part here, the fact that the simpler animals as a rule move about less, and live now, and did in the past, under more uniform conditions than their relatives. And among animals the mammals, after they became fairly established, changed the most rapidly of all, so that, aside from the marsupials, there is not now living a single family that dates back to the Eocene. The birds of that period were very much like those of to-day, while many families of fishes, and genera even, go back to the Cretaceous. So mammals indicate changes of time and of surrounding conditions much more exactly than other animals.

Fresh-water shells, or, better yet, fresh-water fishes, furnish the best testimony as to former land connection between countries now separated by the sea; for, owing to their mode of life, these spread but slowly, and long lapses of time were necessary in order that they might be carried from one region to another.

To apply these facts to the history of our own country, it may be said that fishes still living hint at a former union between North America, Asia, and Europe, while the testimony of fossil mammals is to the effect that Europe and this continent were united just before, or during, the Eocene period. Fossil elephants and mastodons speak of an early connection between Asia and America, while existing animals show that very recently (geologically speaking) Alaska and Siberia were connected by a land bridge in the vicinity of Bering Straits.

As for the testimony of the rocks themselves, thick beds tell of long periods of quiet, when changes in the earth's crust were few and slow, while thin beds of rock speak of frequent changes of level. Fine-grained limestones indicate the presence of lime-secreting creatures such as corals and crinoids, or perhaps of those stony-jointed plants, the so-called nullipores, once counted with the corals, and, like them, aids in reef-building. Fine shales tell of soft mud washed from the adjacent shore and deposited in quiet waters, while coarse-grained sandstones and coarser conglomerates were laid down nearer shore, where the wash of waves and sweep of tides and currents carried away all finer particles, to deposit them farther out at sea.

Such is a general outline of the data available for writing the history of the past, and such the methods by which these data have been interpreted and the scattered parts woven into a connected whole. That many mistakes have been made in doing this is undeniable, nor may we say that all have been corrected. But the same may be said of any history, even of the record of current events, and if errors are pardonable, surely the historian may be forgiven who is writing of events that took place not hundreds, but thousands and millions, of years ago. It must be borne in mind, too, that the student of the past is sadly hampered by what Darwin called the imperfection of the record, the utter lack of anything like a continuous transcript of past life. Very many animals were by their very structure prevented from leaving any vestige of their former presence, and the vast majority of those that could, perished under such conditions that they failed to do so. The greater part of all fossils are inaccessible, for we can only reach those whose ancient burial-places have been laid bare by the wearing away of overlying rock, or where the edges of strata have been cut through by rivers, or exposed by the mighty thrust of forces that have converted plains into mountains. And even after events like these had laid bare the rocky pages wherein the story of the past is written, the hand of Nature, with the selfsame means, has ruthlessly erased all traces of the record before they had been seen by the eye of man.

There is perhaps no group of animals that illustrates this imperfection of the record so well as birds. There are living to-day not less than 12,000 species, and half of these belong to one group, the Passeres, or perching birds. The ancestors of some of these were living at the time camels, horses, and elephants were among the common animals of North America; but if we go back to the Eocene we find the group represented in our continent by just three specimens, and two of these seem to have been much like modern birds. The Cretaceous has yielded more specimens and more species, but the birds of that day were totally unlike those of the Eocene, for they were birds with teeth, and we can not trace the connection between them. And here the record ceases, so far as North America is concerned, for back of that we have absolutely nothing. And yet birds there were, because our toothed water-fowl represent two groups, one of which had become so specialized for aquatic life that it had lost the power of flight, and almost lost every vestige of wings. The older rocks (Jurassic) of Europe have yielded two birds, besides a single feather, and these differ as widely from our toothed species as do those from the birds of to-day. The wonder is, not that we know so little of the life of the past, but that we know so much.

CHAPTER II

DIVISIONS OF LIFE AND TIME

The history of modern times can not be taught without mentioning dates, or giving the names of nations or of men; nor can the history of the past be discussed without frequent reference to periods of time, groups of rocks, or animals, or even particular individuals among them.

So, at the outset, it will be necessary to say something of the principal divisions of animals, rocks, and time, and of the methods by which they are arranged or classified; for classification is merely setting things in order, placing together related objects, be they animals, plants, or rocks, just as we might arrange books in a library. We would hardly put books on the shelves just as they came to hand, nor would we place books of various kinds side by side, merely because they were bound alike. We would naturally group them according to their subjects—histories in one place, novels in another, books of travel in still another. And just as books are arranged by their subjects or contents, and not by their bindings, so animals are classified according to their contents or structure, and not by their coverings, form, or external appearance. If in the present brief review of the animal kingdom more attention seems to be paid to mere appearance than to those plans of structure by which animals are grouped, it is because to the great majority of people appearance is not only the more interesting but very much the more familiar. Very few care to trouble themselves with the plan on which a creature is built any more than they would care for the plans of a pretty cottage; the completed structure is the thing of interest. But the paleontologist, the delver into the ruins of the past, rarely has more than the framework to deal with, and counts himself as extremely fortunate if the greater part even of this be not missing. So the reader will please take it for granted that the various assemblages of animals mentioned are each characterized by some common peculiarity of the plan on which they are built; and if he doubts this he has only to refer to some good work on zoology. And if the name of a division of animals can be associated in the mind with the form of some one of its more familiar members, we can understand very well what is meant when the group is referred to.

Animals are, according to their degree of relationship, placed in larger or smaller assemblages, the principal of which, in the order of their size being known, beginning with the largest, as Classes, Orders, Families, and Genera. Letting books as a whole stand for the subkingdom Vertebrata, the classes may be said to roughly correspond to books of a given kind—histories for example—and the orders to those relating to the history of one country, while the families would be represented by histories of a given section of that country. As for genera, we will look upon them as books telling, as they often do, the story of a single town, or some particular event, and the species as those written by the various authors. And just as the events pertaining to the history of one small portion of a country might require many volumes for their proper record, while a single book might contain all that was to be said of another and much larger section, so one family of animals, or an order even, may comprise many genera and species, while another may contain but a single species. And one of the first things to be remembered is, that the rank or importance of any division does not depend on the number of species it contains, but on the extent to which these agree with or differ from the members of other groups.

Right here it may be well to forestall the complaint that is so often made, that animals are overburdened with long scientific names, and reply to the frequently asked question, Why is it that they have no popular names? The reply is simple; a common name can be used only where an object is common, and many living and most fossil animals are so little known as to have received no popular appellations. The scientific names given them appear strange and seem difficult only because they are unfamiliar, and are often much simpler than many of the so-called “common” names. How many readers know what a potto is, a colugo, mulligong, scheltopusic, cacomistle, or wobblygong? And yet these are popular (?) names. Then, too, these so-called “common” names may have different meanings in different places, so that woodcock may be a woodpecker or a species of snipe, and partridge may refer to a quail or a ruffed grouse, while the term pheasant applied to the latter in some portions of the United States is an utter misnomer, for no true pheasant is a native of America. The popular name, like the cowrie money of Africa, is good only for local use; the scientific name, like a gold coin, passes current in all civilized countries.

Scientific names, like those of persons, originated in the attempt to define an animal in a few words containing some allusion to its appearance or character. The names Smith, White, or Strong once described the individuals to whom they were applied, and this kind of name is in use among savages to-day. And as names have become changed by use, ceased to be descriptive, and used merely to designate the individuals to whom they are given, so scientific names have been cut down to two parts. The first of these is the generic name, and includes all closely related species; the second, or specific name, is restricted to one species or special kind of animal. And as scientific books were formerly written in Latin because that was the common language of scientific men, so Latin is still used for the names. It must be understood that a scientific name does not *necessarily* mean anything; it is simply a handle by which to lay hold of some particular kind of animal, and had such a method been agreed upon, the species might have been lettered and numbered, much as astronomers have done with the stars.

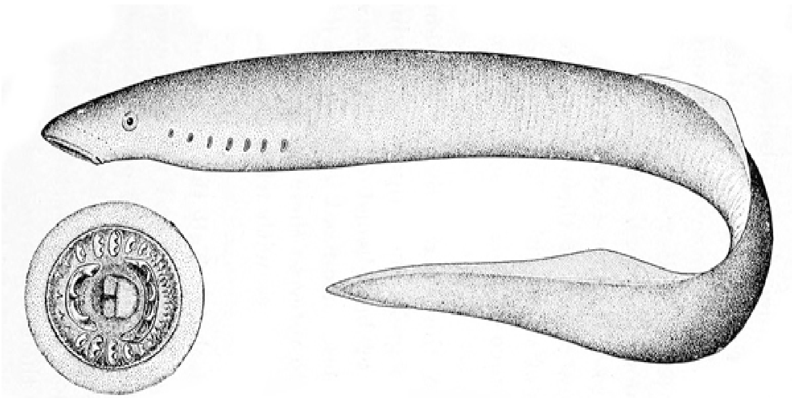
Representatives of the larger divisions, or classes, of back-boned animals are familiar to most of us, but there is an unfortunate tendency to confine the name animal to mammals, instead of allowing it to include, as it properly does, all forms of animate things, or animals, from the microscopic, single-celled being which finds a bucket of water an ample world, up to man.

The warm-blooded, air-breathing mammals, whose young are born alive[3] and helpless, and are nursed by their mothers until old enough to care for themselves, we all know. Some of them, it is true, are more or less disguised by adaptation to some particular mode of life, but if we strip off these disguises their identity is revealed, for we find them all built on the same plan. There is little outside resemblance between the hand of a monkey, the hoof of a horse, the wing of a bat, and the paddle of a whale, and yet the same parts are present in all. The whale wears mittens, and the more aristocratic monkey gloves, but they have the same bones as ourselves. Note, too, that habits and place of residence are not characters; the whale is just as much at home in the water as the fish, and the bat is more expert on the wing than many birds, but the one is not a fish nor is the other a bird; both are equally mammals. Dress, however, does count for something in the rest of the animal kingdom, if not so much as it does with us, but it may not be used as the basis of classification, only as a help to distinguish species from one another. Most mammals are clothed in hair or fur, but many go naked, especially in warm climates, and so do the whales, in order that they may slip through the water readily.[4] The armadillos are protected by an armor of bone, and their cousins, the pangolins of Asia and Africa, by an even more effective armor of sharp-edged, overlapping horny scales.

Birds are familiar to all, and even the kiwis and penguins, which depart most in appearance from their fellows, are easily recognized as birds, so the class may be passed by with little further notice other than to say that its members are almost as uniform in the matter of internal structure as they are in external appearance, and that both are modified according as they fly, run, or swim. The divisions of this class are not so sharply defined as are those of other groups of vertebrates, but the crow and ostrich may be taken as representatives of the two principal subdivisions. This is not merely because the one can fly and the other can not—for there are birds related to the ostrich which possess the power of flight, while certain relatives of the crow are flightless—but on account of peculiarities found in the skull and hip bones of these birds.

Reptiles, too, are fairly well defined in the minds of most of us, although some uncertainty may now and then exist as to whether or not the Amphibia should be included with them. Crocodiles, lizards, snakes, and turtles are familiar and typical examples of this class, but, as we shall see later on, the largest and most striking members of the group, comprising hundreds of species and constituting several entire orders, died out long ago, and are known only from fossils. The Amphibia include not only such creeping and crawling things as newts, salamanders, and mud-puppies, but frogs and toads, a small number of curious little snake-like creatures, and a large number of extinct species, including very many of almost gigantic size. These last form an order by themselves, which was of no little importance in the ancient world. So far as size, number, and distribution are concerned, the reptiles and amphibians of to-day are a degenerate lot, and it is difficult to imagine that they were successively the dominant forms of life, as common and as widely spread over the world as mammals are to-day.

Under the comprehensive term Fishes are really included three divisions or classes of equal rank in classification, though very unequal in the number of species. One of these is represented by the lowly little lancelet, which has no skull even, and can barely be considered a vertebrate; another contains the lampreys and their relatives, more or less distant; while the third comprises the sharks, chimeras, sturgeons, and the hosts of true or bony fishes which form the vast majority of the class. The lampreys, which deserve more than passing notice, because they will often be referred to, have no jaws or limbs, and a soft backbone without even a hint of divisions into joints or vertebræ. Still, low as they are in the scale of vertebrate life, they date back almost to its commencement; though while they may be respected for their ancient lineage, they may also serve as a warning that fortunately the importance of a family does not depend upon the length of its pedigree.



The Alaskan lamprey.
The figure at the left shows the mouth and teeth.

At the very lowest end of the back-boned animals, occupying a somewhat intermediate place between what may be termed true vertebrates and true invertebrates, are the curious sea squirts, forming the class Tunicata, and the equally strange, but even less known animals of the class Enteropneusta; so little known, indeed, are they as to have no common name. These are the animals referred to as vertebrates in disguise, or degenerate vertebrates, because their form is believed to have changed with their mode of life, and they have not merely failed to progress, but have actually gone backward, and lost the position occupied by their remote ancestors.

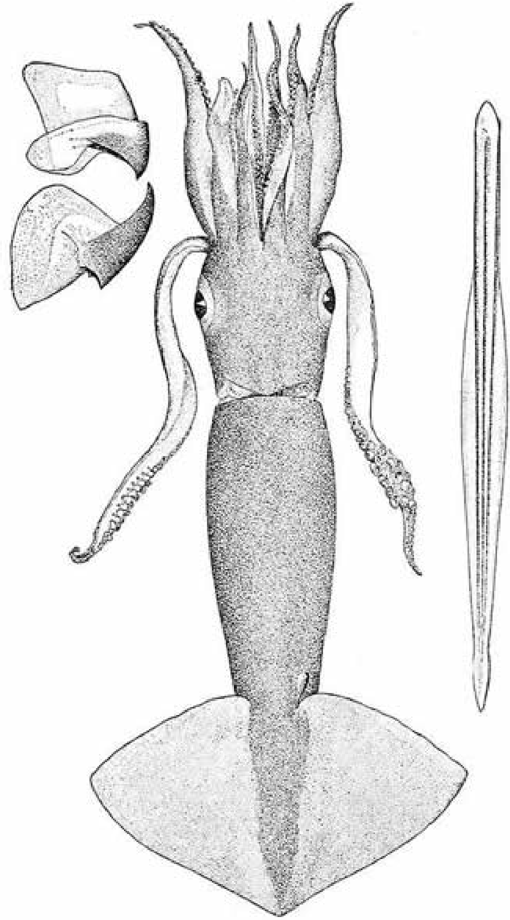
Owing to their soft texture these animals have left few traces of their existence at former periods of the earth’s history, although we do find evidence of their presence in some Miocene rocks.

Such are the great, primary divisions or classes of the great and important phylum or subkingdom of back-boned animals, or vertebrates, and these once fixed in the mind it is an easy matter to refer to their proper places the unfamiliar creatures with which we may have to deal.

Representatives of all the classes of vertebrates are found fossil, and not only examples of all existing orders, but of a number that have become extinct. Fishes are perhaps the most common of fossil vertebrates, partly on account of their numbers and partly because they had a commendable habit of dying where their remains would be preserved and subsequently found. Birds, on the other hand, are extremely rare, particularly the earlier species, which are the ones we are most anxious to know. It is commonly stated that this is on account of their power of flight, as well as the lightness of their bodies, the first preserving them from many accidents to which other animals are subject, while the last caused their bodies to float and rendered them particularly liable to destruction after death. Still this explanation is not quite satisfactory, for birds sometimes perish in great numbers in spite of their power of flight, and in some favored localities many of their bones are found.

As charity covers a multitude of sins, so the term invertebrates includes a vast number of animals which agree with one another in the negative character of lacking a backbone. Formerly the invertebrates were regarded as forming a group of equal rank with the vertebrates, the two divisions including all animal life; but it is now known that this assemblage comprised several distinct classes of animals, equal in importance if not in size, just as Rhode Island and Texas, though very different in area, are both States of the same rank so far as independence and form of government are concerned. But while “invertebrates” is no longer used to denote one of the primary divisions of the animal kingdom, it is still a most useful and comprehensive term for all the creatures which have no backbone.

Owing to the vast numbers of invertebrates and their numerous divisions, it will be possible to mention only a few of our great primary groups or phyla, bearing in mind that each of these phyla corresponds in the degree of its importance to that including all vertebrates.



A common species of squid, *Gonatus amœnus*. Natural size of a small specimen. On the left is shown the beak of a larger individual, and on the right the pen.

The highly specialized structure of the squids and cuttlefishes comprising the class Cephalopoda is generally considered as placing the mollusks next to the vertebrates; and while we usually associate the term mollusk with animals covered with a shell, forgetting the fact that the name means soft, yet among the highest living members of the group only the nautilus and argonaut are thus protected. On the other hand, the familiar slugs are apparently without a shell, as this is so rudimentary as to be concealed within the mantle, while the marine forms known as Nudibranchs are quite naked—another of the many cautions not to judge animals by their clothes, or lack of them.

The members of the class Lamellibranchiata, or leaf-gilled, may be readily distinguished by having a hinged shell of two parts or valves, whence the common name of bivalves. To this class belong the common oyster, mussel, clam, and other commercially important species.

The Gastropoda include the so-called univalve shells, such as limpets, ear-shells, snails, and top-shells, many of which are spirally twisted; but some of the members of this class have no shell, and the curious chitons, often placed here, are protected by a covering of several overlapping parts, on the principle of a piece of scale armor.

The little wing-shells, forming the class Pteropoda, which stands well up in the group, may or may not be protected by a shell. These animals, in spite of their small size, play quite an important part in the economy of nature owing to the vast numbers in which they exist. They are so numerous in arctic seas as to color large tracts of water a pale green and to provide an important article of food for the great Greenland whale, while their shells settle in countless myriads on the sea-floor to form the deposit known as pteropod ooze.

The Arthropoda, the joint-footed animals, contain besides other less familiar forms such well-known groups as crabs, insects, spiders, and centipeds, and comprise several hundred thousand species, forming a prominent and important portion of the living world. Doubtless all these flying, creeping, and crawling things were equally abundant in the past, although this is not indicated by their fossil remains, since, as has been said before, many were so delicate in texture as to be preserved only under very favorable circumstances. To this great group belongs the extinct order of Trilobites, of which we shall learn more later, and the great and equally extinct Eurypterids.

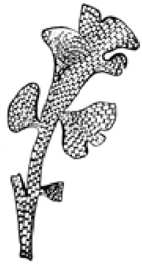
Going down the line, the next phylum, the Echinodermata, contains the echinoderms or sea-urchins, the starfishes and brittle stars, the crinoids or sea-lilies and the sea-cucumbers, the first two familiar to all, the last two much less widely known.

The crinoids, so abundant in Carboniferous seas, now nearly extinct and represented by a few species found in deep water, may be roughly compared to a starfish growing upside down on a stalk attached to the middle of its back. As the rays of the star turn gracefully upward and outward, while the stem bears little arms that may pass for leaves, the suggestion of a lily is very strong. The sea-cucumbers, or holothurians, do not at all resemble their radiate brethren, being soft-bodied animals, that look to the untrained eye far more like some strange overgrown worm than any relative of a starfish, although a study of their internal structures has led to the recognition of their proper place.

Then come the Vermes, or worms, a group containing several orders and many members, though in general little known, partly owing to their retiring habits, partly to the unattractive appearance of many, even though it has been thought that the ancestors of vertebrates are to be sought for in this group. Here, again, while every one knows the class as represented by such typical members as the useful earthworms, there are several groups whose relationship with creeping things is so obscure that it long went unsuspected. One of these contains the Rotifera, or wheel animalcules, minute creatures which comparatively few have seen, although they abound in fresh water. They show their relationship only in their early stages, when they exhibit resemblances to the very young of worms.

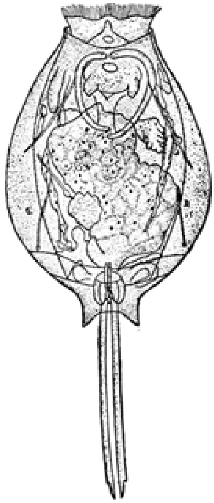
Placed sometimes with the worms, sometimes accorded the importance of divisions of their own, are Polyzoa, or moss animals, and Brachiopoda, or lamp-shells. The former are of small size, and are associated in colonies, which often bear a strong superficial likeness to a piece of seaweed, although on closer examination this resolves itself into an assemblage of little animals each occupying a sort of pocket or cell.

The brachiopods bear shells, and were long and not unnaturally considered as belonging with bivalve mollusks, which they closely resemble in outside appearance. It may be said, however, that while the two halves of such a shell as that of a clam represent the two sides of the occupant, in a brachiopod the valves cover the upper and lower portions of the

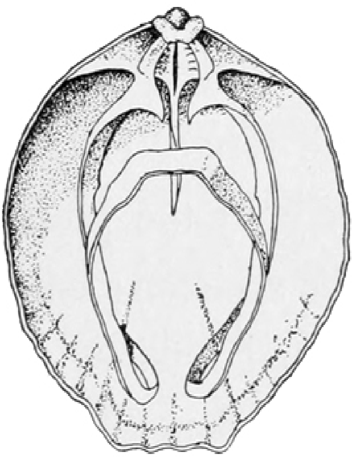


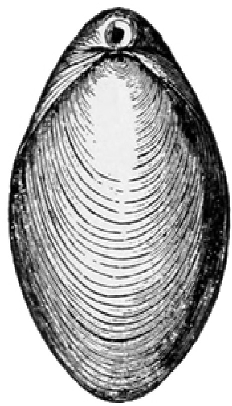
A polyzoan, *Flustra truncata*.

animal. The inside of these shells often has curious loops or spirals for the attachment of the muscles that move them, and in some species there is a sort of stalk running through the point of the shell, by which the animal is attached to the sea-bottom. This group of shell-bearing creatures is most ancient, and held a high place during the early history of the world, so that it is frequently necessary to refer to them.



A rotifer, a minute relative of the worms. Very much enlarged. (From Bulletin of U.S. Fish Commission.)





Shells of brachiopods, one showing the loop, the other the opening for the passage of the stalk.

Below the worms are the Cœlenterata, including a large number of lowly but beautiful animals, such as the jelly-fish, Portuguese man-of-war, sea-anemones, and the coral-forming polyps so persistently and wrongly called *insects*. As may be inferred from the names, the vast majority of these are marine; most of them have a long pedigree, dating back to the beginning of the recorded history of life, and the corals have played an important part in building up the land, and are still industriously at work constructing barrier reefs and coral islets.

Then come the Porifera, or sponges, for so long a time bandied about between the animal and vegetable kingdoms, but now definitely located in the former. This division contains several orders, which, with one exception, have an interior framework of glassy or horny fibers, and it is this framework that forms the sponge of commerce, all the living matter having been removed. Sometimes the former existence of sponges is revealed merely by the presence of spicules, or portions of the skeleton; sometimes these have held together and retained the general outline of the entire sponge. A living sponge is really an assemblage of numerous individuals disposed about a common cavity, provided with one or more openings through which the water passes, and, small as are the individuals, yet their combined action causes such a current that on a calm day the presence of a large sponge may be revealed by the motion of the water. Huxley has compared a sponge to a "kind of subaqueous city, where the people are arranged about the streets and roads in such a manner that each can easily appropriate his food from the water as it passes along."

Last and least are the single-celled organisms grouped under the name of Protozoa, making up in number of individuals what they lack in size. Some, like the Infusoria, are soft, and when dead leave behind no trace of their existence, but others, belonging to the class Rhizopoda, form beautiful shells of carbonate of lime, or still more beautiful geometrical skeletons of flint. The Foraminifera of to-day dwell in the depths of the ocean, and in some localities their minute shells accumulate to form the most important constituent of the soft ooze. In other places the flinty skeletons of the Radiolarians predominate, and in the past they have existed in such numbers as to form considerable deposits of radiolarian limestone. It gives one a vivid idea of time and number to try and imagine how long it must have taken and how many individuals it must have required for their microscopic shells to form a bed of rock a foot thick and even a mile square.

As with vertebrates, all orders of invertebrates now living are represented by fossils, except where they have been too soft and small for preservation, while several important orders occur only as fossils, and several more are even now verging on extinction.

Owing to their hard coverings, the shell-bearing mollusks are naturally the most abundant of fossils, and many thousand species are known. They play a most important part in defining the limits of groups of rocks and in identifying the individual beds, some species being found through a number of strata, while again others are confined to and characteristic of a single layer of rock. And this furnishes a hint of the intimate connection there is between the divisions of life and time and of the manner in which the latter are defined.

There is a ceaseless warfare waged by water against the land; the sea hurls its waves against the coast, rivers cut their channels through earth and rocks, and every rain washes something of the earth into the sea, directly or indirectly as the case may be. This warfare began when the first ridge of rock peered above the level of the primeval ocean, and has been carried on without a moment’s intermission ever since, the results of the conflict being the formation of beds of mud or sand that later hardened into rock. Into the mud and sand sank not only the remains of animals that dwelt in the lake or ocean where the beds were being deposited, but those of creatures that lived upon the adjacent land and perished along the shore or were swept down by rivers. Hence the layers of rock contain the vestiges of the plants and animals that lived at the time they were being formed, and these fossils serve to identify the strata in which they are found. So rocks above those which show no traces of living things are arranged or classified according to the fossils they contain, each layer or stratum being termed a formation or stage. Now the life of the globe has been ever varying with the movements of its crust, some plants and animals dying out and others arising to take their places, so that at no two periods of time were the living beings just the same. Certain kinds of animals will be found in a number of layers of rock and then disappear, or be present in greatly reduced numbers, while from time to time new plants and animals make their appearance. And while these changes have in the main been slow, at some periods they took place much more rapidly than at others, causing very marked differences between the animals found in various beds of rock, and these differences are used as boundary marks to distinguish the divisions of geological time.

Any well-defined stratum, or bed of rock, which is shown by its structure and the fossils it contains to have been the result of the uninterrupted deposit of sediment, is termed a Formation, or Stage, and it is easy to see that this may vary greatly in thickness. According to the extent of the resemblances between the animals they contain, Formations are combined in Series, the Series in Systems, while these in turn are united in Groups; such, at least, is the classification and such the names adopted by the International Geological Congress. And as these assemblages of rocks necessarily represent the time that elapsed while they were being formed, the various divisions just named are made to correspond to divisions of time known, counting from the smallest to the largest, as Age, Epoch, Period, and Era. This may be shown as follows:

Divisions of rocks.		Divisions of time.
Group	Paleozoic	Era.
System	Upper Silurian	Period.
Series	Niagara	Epoch.
Stage or Formation	Medina	Age.

For example, the Medina sandstone, well known as a building stone in western New York, is the Medina stage of the Niagara series of the Upper Silurian system of the Paleozoic group; and while all this may seem very technical and uninteresting, it is merely an aid to the proper locating of specimens, and it is just as necessary to exactly locate animals as it is to locate cities. For example: To say that Rochester is in the United States would mean very little, but to say that Rochester is in Monroe County, New York, would show just where it is situated. Similarly, to say that remains of the great dinosaur Triceratops occur in the Laramie sandstone is to convey the information that Triceratops is one of a group of extinct reptiles and tell at just what period it lived.

One thing must be borne in mind, and that is that periods of geological time have no exact equivalent in years. Our own standard for the measurement of time is the period required for the earth to make a complete revolution about the sun; but divisions of geological time have no such fixed standard, being records of the changes that have taken place among plants and animals rather than actual measurement of the lapse of years; hence these divisions may be, and are, of very unequal length.

The number of years represented by any given group of rocks is computed by estimating the time that would be required to wear away and deposit in the shape of mud or sand sufficient of the earth’s surface to form the beds under consideration. But as the rate of wear varies greatly, not to say enormously, according to the material, rainfall, and elevation of the surface acted on, there can be no fixed rate of wear, and it is not surprising to find that estimates vary immensely. For this reason it is quite impossible to give a very accurate or satisfactory answer to the oft-asked question, How many years ago did this creature live?

CHAPTER III

THE ERA OF INVERTEBRATES

How, and when, and where life first appeared in this world of ours we do not know[5]—in all probability we shall never know—but we may be sure that it began with extremely small and simple forms, and it is fairly certain that these originated in the sea at a time long before any of the animals whose remains have actually been preserved had made their appearance. Theoretically, the further back we go in time the simpler should we find the life of that period, and the earliest animals of all should be the simplest in structure. Up to a certain point facts accord with theory, and as we go down in the rocks the higher animals drop out one by one, mammals and birds disappearing entirely before we are half-way toward the lower fossil-bearing rocks, while reptiles and amphibians are found wanting farther down. But at the very beginning of things the animals that have actually come to light are somewhat higher than many living to-day, and hence it is inferred that these must have been preceded by other and still lower creatures. These supposititious, minute, single-celled plants and animals that marked the very commencement of life would, from their very nature, have left no traces of their presence, and many of the rocky pages in which the history of the past is contained are blank, not because there were no living things, but because these have left no record of their existence. The existence of life at an early date is also inferred by some from the presence, in those ancient rocks called Laurentian, of strata of limestone, beds of graphite, layers of shale and slate containing carbonaceous material, all of which may be organic products, that is, the results of the action of plant and animal life, as well as the result of chemical action.

Certain green and white masses of limestone and serpentine which occur in very ancient rocks in Canada, Germany, and Finland were regarded by a few paleontologists as representing great colonies of foraminifers, and termed Eozoon, or early life. But after much discussion and long and careful study, the balance of opinion is decidedly against the animal nature of

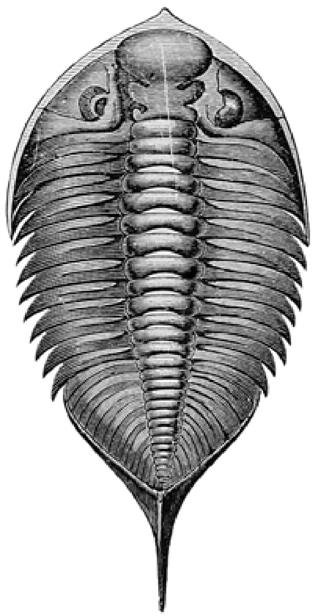
Eozoon, and in favor of its being a mineral; so the dawn of life is still to be sought for, and the occurrence of living things at an early date rests upon indirect evidence.

***Eozoon canadensis*. A polished fragment showing the structure. Natural Size (After Dawson.)**

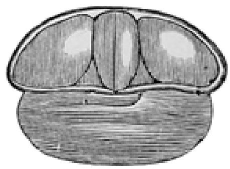
Apparent indications of animal life are found in the pre-Cambrian rocks of England in the shape of long, narrow, dark streaks running through the stone. These are believed to be the burrows of worms that were filled with soft mud, and subsequently squeezed out into long ribbons of extreme thinness by the enormous pressure of the rocks that in course of time were formed above the strata containing the worm burrows.

The earliest incontestable record of life in this country, if not anywhere, is in some rocks called Algonkian, found in the Belt Mountains, Montana, and Grand Cañon region, in which have been found a few shells. Like the earliest remains of fishes, these are in an imperfect state of preservation, although unmistakably the remains of animals, and animals related to those found in the rocks above. In these overlying rocks, constituting the Cambrian system, so called because it was first studied extensively in Wales, the Cambria of the Romans, evidences of life are met with in comparative abundance. It is not so very many years ago that a few species of shells represented the entire known life of this great series of rocks, but careful search has led to the discovery of numerous species of brachiopods and trilobites, as well as a few mollusks, and now over one hundred and seventy species of animals are known, from the very lowest portion of the Cambrian, and over five hundred species from the entire system.

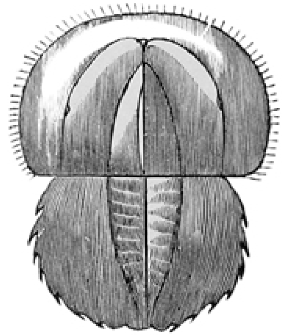
One of the extraordinary things about this early life is the apparent suddenness with which it sprang into being, for it embraces representatives of no less than seven of the great divisions[6] of animal life. Neither are these creatures so simple in structure as we might expect them to be from their great antiquity. On the contrary, many are highly specialized in structure, and not so very different from their relatives living to-day and separated from their ancestors by an interval of millions of years. Nor do we find that they intergrade, or show evidences of a common ancestry, so that the line of descent of the crustaceans, for example, can be traced through them to single-celled protozoans, but the groups are marked off from one another as sharply as now. In the Cambrian sea were sponges and corals, sea-lilies of simple forms (Cystids), brachiopods, shells, and crustaceans; insects are not as yet known from the Cambrian, but their absence may be only apparent, not real, due to the difficulty of their preservation. For there is much reason to suppose that insects had their origin in the water; many of the more generalized forms among living species deposit their eggs in the water, and there pass the early part of their lives, preparatory to the final transformation, while the wings are believed to have been developed from breathing and swimming organs.



***Dalmania limulurus*.**

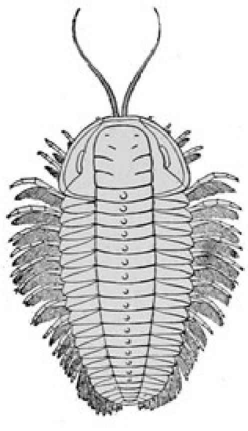


Larva of a trilobite.



Larva of a king crab.

We know even that there were such soft and perishable creatures as jelly-fishes floating in the waters that then covered the face of the earth, for indications of their presence have been preserved in the shape of certain star-like markings in the rocks, which represent casts of the interior of the bodies of these animals formed by the fine infiltering mud. The highest forms of life of this period were trilobites, a group of animals belonging with the crabs, whose nearest living relative is the king crab, *Limulus polyphemus*, so common at some places on our Eastern coast. The resemblance between the two is best seen by comparing very young king crabs with trilobites, for it is a general rule that in their very young or embryonic stages animals show their affinity with those of simpler structure and lower in the scale of life. The three lobes which suggested the name trilobite are marked by two more or less pronounced grooves running lengthwise of the body, dividing it into three portions, while the head, body, and tail also divide trilobites into three sections crosswise. Some trilobites, and especially the later forms, could roll themselves into a ball, just as can be done by some of the smaller armadillos, or on a much reduced scale by the so-called pill-bugs, or sow-bugs; in fact, the pill-bug bears a general resemblance to a diminutive trilobite, to which, indeed, it is believed to be related.

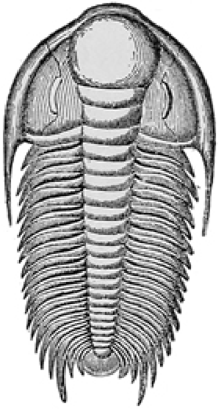


A trilobite, *Triarthrus becki*, showing the antennæ and

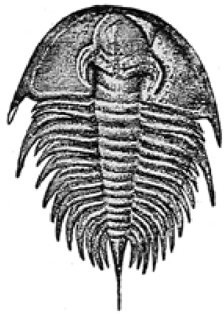
For a long time after the discovery of trilobites it was a moot question whether or not they had legs; thousands were found lying out flat or rolled up into compact little balls, but never one with any sign of legs. Finally a specimen was found in Canada with a few legs preserved, and some bearing a single leg. Then Mr. Walcott attacked the problem by making scores upon scores of sections through rolled-up specimens of a species of *Calymene*, found at Trenton Falls, in which legs, if present, should have been protected and preserved. These sections, by showing portions of the legs where they were cut across, made it very

limbs. About natural size. (After Beecher.)

evident that numerous legs had been present in the living animals, while by carefully combining the results obtained from very many sections it was possible to build up these appendages and reconstruct their form. And, after all this had been done, two good-sized specimens came to light with all of the legs in place; and finally a locality was found near Rome, N.Y., where many specimens of a small species of trilobite occurred in such an exceptional state of preservation that not only legs, but delicate antennæ were clearly to be seen. The long-sought-for appendages served, according to their location, as jaws, legs, and breathing organs, being fine examples of the modification of similar parts for very different purposes. Thus, trilobites are good illustrations of what is termed generalized structure—the absence of special organs, each, or each series, of which is specially devoted to the performance of some one function of life. Besides being the highest types of early life, trilobites are the most important of the early fossils in another way, and that is, for the identification of strata and the marking of some periods of geological time. Certain genera endured for quite definite periods, so that they are characteristic of the strata that were then being deposited, and their names have been applied to the assemblage of animals, termed a fauna, found in these beds. Thus the Upper Cambrian of Europe contains the *Olenus* fauna, this genus of trilobites being characteristic of the strata forming that series of rocks, while in North America the corresponding series has the other genus, *Dikellocephalus*. Our Middle Cambrian (Acadian epoch) has the *Paradoxides* fauna, and the Lower Cambrian (Georgian epoch) the *Olenellus* fauna.



***Paradoxides harlani*, a typical trilobite of the Cambrian. (After Meek.)**



***Olenellus thompsoni*, a typical trilobite of the Cambrian. About half natural size. (After Walcott.)**

The primitive character of the life of the Cambrian period is shown not only by those animals which are clearly simple in their make-up, but by some of those that, at first sight, are apparently complex, such as crustaceans and the many-jointed worms. But in these there is really no complication of structure, only a multiplication of similar parts, one joint being very much like another, bearing the same appendages and having the same uses, so that this has been termed multiplicate structure. We know from fossils that the same animals were found in northern seas and in those of southern latitudes; hence it is inferred that the climate of the Cambrian era was mild. The uniformity of distribution of the animal life of the northern hemisphere may, however, be due to the fact that the sea was comparatively shallow, and that there were no large masses of land running north and south to limit the range of animals. The testimony of land plants as to temperature is lacking, for only the faintest traces even of supposed seaweeds have been found, but the abundance and variety of animal life suggests a mild climate.

The Cambrian rocks of Newfoundland contain many important fossils; and these rocks are of great importance, because they were deposited in an uninterrupted series, one layer after another, so that their record is unbroken. Eastern New Brunswick, too, has furnished much information to the paleontologist, and the fossils in the rocks of northern and eastern New York have been studied long and carefully.

Coming upward, the rocks above the Cambrian represent the Lower Silurian or Ordovician era, the first name being derived from the *Silures*, or ancient inhabitants of Shropshire, while the latter comes from another Welsh tribe, the *Ordovici*. The early faunas of the earth were first extensively studied by English geologists (Sedgwick and Murchison) from the abundant outcrop of the rocks of Wales; hence the names given to the divisions of paleozoic rocks.

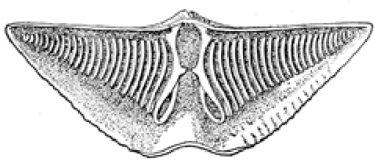
Here, in the Ordovician, life is multiplying in numbers, increasing in diversity of form, moving onward in quality. The progress of life may indeed be compared to the growth of one of those great snowballs boys take such delight in forming, which begins with a ball shaped in the hands, and then as it is rolled along increases more and more rapidly with every turn. So after life was once fairly started every revolution of time added more and more to its varied forms; first one group of animals, then another sprang into being, until the world was peopled as we see it at present. And just as accidents may happen to the snowball as it is pushed along, here and there a portion crumbling away and falling by the path, so some animals dropped from among their fellows and have no place in the life of to-day.

The history of the curious and puzzling graptolites illustrates these points very well; this subclass of small animals related to the jelly-fishes began its career in the Cambrian, reached its highest point of development in the Ordovician, and disappeared entirely during the Devonian period, having run its entire cycle in this comparatively short space of time.

Sea-lilies, or crinoids, have increased, for the simpler forms of the group are at their maximum and the more highly developed and beautiful species have made their appearance, although their day of supremacy is still to come. Corals, too, have increased in numbers and species, but they have not as yet begun to play their part in the scheme of life by the building of reefs to deflect tides and currents and form harbors of refuge for many aquatic animals. More than this, in the Water Lime group of rocks a scorpion has been found, showing very clearly the existence of life on land. The mollusk-like brachiopods not only multiplied in numbers during the Ordovician, but increased in complexity by developing curious loops and spiral structures inside their shells as well as a better form of hinge-joint.

Graptolites, *Dendrograptus hallianus*.

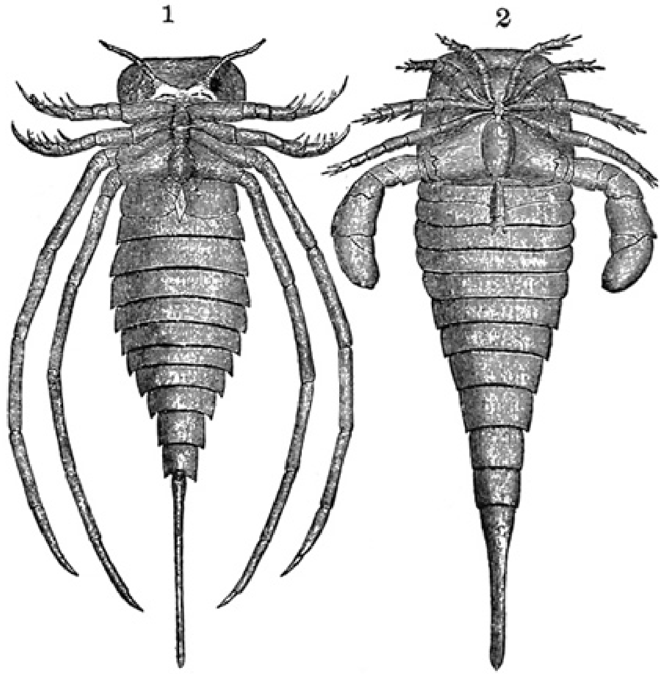
Trilobites have increased in numbers, kinds, and size, reaching at this time the highest point in their history. Perhaps the most notable advance is that made by true mollusks of the class Cephalopoda[7] in the development of forms related to the pearly nautilus, a shell that unfortunately does *not* sail the unruffled main, but creeps humbly along the bottom of the sea. The nautilus is a relative of the naked squids and cuttlefishes, but, unlike them, dwells in a closely coiled shell of many divisions, or chambers, the outermost of which contains the animal. As growth proceeds chamber after chamber is added, the occupant moving forward and always residing in the last. The few species of nautilus are the only living representatives of a host of chambered shells that started into existence toward the close of the Cambrian period and soon acquired a prominent position among the residents of the sea. But the early cephalopods were by no means all tightly coiled; the shells of some formed an open spiral, as if the shell of a nautilus were uncoiled, while most were quite straight, like the members of the genus *Endoceras*, which comprises a few huge species six to twelve feet in length.



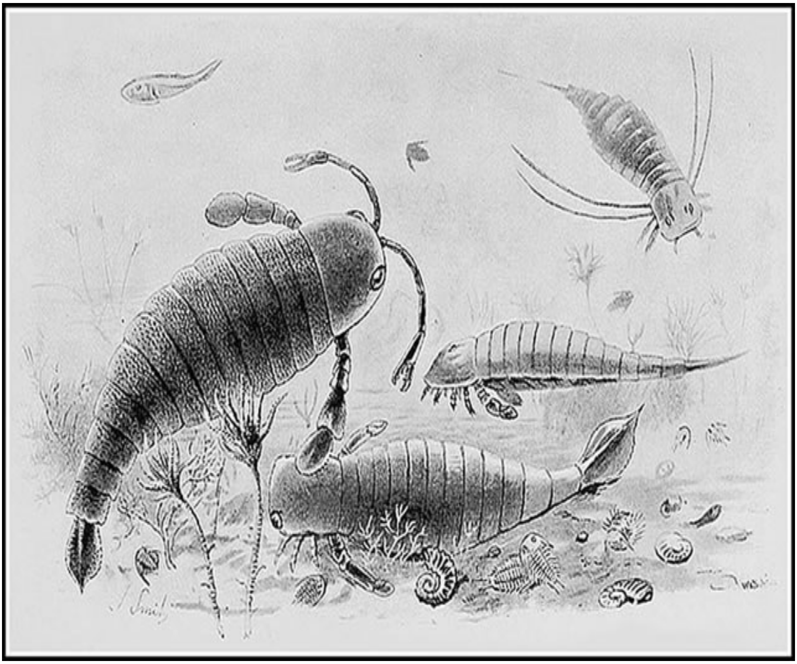
A brachiopod, showing the curious spiral loop.

And now, most important of all, vertebrates appear upon the scene, the first hint of the far-off coming of man, but the story of this important event and of the rise of the fishes may well be reserved for another chapter, the more that life does not progress from start to finish by one continuous and even ascent, but has its ups and downs. The highest species in any given group of animals may stand considerably above the level of the lowest species in the next, and on the whole more specialized group, while this in turn has some species above the grade of its immediate successor, so that there is a continuous overlapping of species. We have a good example of this in the mollusks, where the squids and cuttlefishes are far more specialized and higher in structure than such simple vertebrates as hagfishes and lampreys, although these claim a place in, or next, man's own class. And just as animals overlap in classification, so that they can not be arranged in a straight line from lowest to highest, just so they overlap in point of time; and while certain species may be, and often are, confined within very definite limits of time, as indicated by the rocks in which their remains occur, the group of which they form a part is apt to overstep these narrow limits. So, for the sake of smoothness of narrative, we may well let some chapters overlap a little in order to treat the history of various groups of animals in a more connected manner. So, too, we may pass over the record of the Silurian period, long though it may be in actual years and rich though the rocks are in species, with the remark that it seems in the main to have been a time of rest, when life developed along lines already laid down without branching out into any new forms.

With the advent of the Devonian we find the trilobites running riot in curious shapes, bedecked with spines, a decoration perhaps foreshadowing their coming extinction. For Dr. Beecher considers it a dangerous symptom for animals to suddenly develop spines, and brings forward many instances to show that there is reason to regard this as indicating degeneration, and that it seems to occur among animals when their race is almost run and they are about to disappear from the scene.[8]



Stylonurus and eurypterus, showing the structure of the under side.

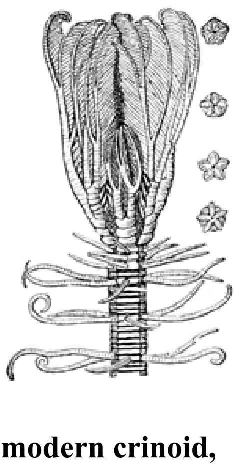


Pterygotus. **Eurypterus.** **Stylonurus.**

GIANT CRUSTACEANS.

Crinoids are still increasing in numbers and beauty, but the nautiloid branch of cephalopods has already begun to decline, although the most beautiful members of the group, the Ammonites, are just starting in the shape of rather small and plain shells called *Goniatites*, whose successors were to become among the largest, handsomest, and most noteworthy of shell-bearing animals. Crustaceans, however, are still among the rulers of the sea, for the strange eurypterids at this time reached the maximum of size, Stylonurus and Pterygotus (see plate I) attaining a length of five or six feet, although in spite of this bulk it is quite possible that neither would have been a match for the giant crab of Japanese waters, or even for one of the big overgrown lobsters that now and then is taken by our New England lobstermen. Like the trilobites, the nearest existing relatives of these eurypterids are the king crabs, although they have some points of resemblance to scorpions, and the Rev. Mr. Hutchinson has dubbed them sea scorpions. One of the peculiarities of these animals consists in having what are really the mouth parts modified for locomotion, so that the same jointed appendages served for walking or swimming, capturing the animals on which they fed, and devouring their prey after it had been taken.

In the Carboniferous period the eurypterids came to an end, and the trilobites and brachiopods fell off greatly in species, as did other groups of invertebrates. But this disappearance of animals once so prominent among living things must not be looked upon as a real loss, but as a part of the general progress of life, the replacement of some animals by others better fitted to the changed and changing conditions. And as mere size is no indication of rank—for if it were, man would not stand where he considers he does, at the head of all living creatures—so many of the smaller animals are an advance on the larger species that dropped out of the race. And here it may be remarked that, while the early history of insects is but imperfectly known, in the Carboniferous not only were they present in numbers, but that some were by far the largest of the class. Nowadays bats and birds are the only flying animals with a spread of wing of two feet or more, but some of the Carboniferous insects measure two feet across their wings, or nearly twice as much as any living insect.



A modern crinoid, *Pentacrinus caput-medusæ*. Much reduced.

And though by the time the Devonian period was reached vertebrates had developed to such an extent that this is known as the age of fishes, yet throughout that and the succeeding period invertebrates played a most important rôle. The Carboniferous may perhaps be styled the golden age of crinoids, or sea-lilies, for then these beautiful forms flourished, and were the most important agents in the formation of the great beds of limestone in which their fossil remains are preserved. There are few species of crinoids now living, and these are mostly confined to limited areas of very deep water and to be obtained only by means of special appliances for dredging in the deep sea. So for a long time even the most common of them (*Pentacrinus caput-medusæ*) was very rare and regarded as one of the great treasures of such museums as chanced to possess a specimen. The researches of the United States Fish Commission steamer Albatross, however, brought to light a locality in the Gulf of Mexico whence many examples of this beautiful radiate have been obtained, and other species have been discovered by the Albatross and by the English Challenger. Still, the group of crinoids is but poorly represented nowadays compared with what it was in the past, when it was not only far richer in species but individuals were vastly more abundant; also they seem to have flourished in far shallower waters than at present. So numerous were they, and so thickly did they grow, that some extensive beds of limestone seem to have been mainly formed by crinoids, and are so full of their fragmentary stems and arms as to have received the name of crinoidal limestone. The abundance of crinoids may be inferred from the fact that over one thousand species have been described from the Carboniferous rocks of North America,[9] and we can picture to ourselves the quiet depths of the sea as thickly covered with graceful sea-lilies as the rocks of the waters along our New England coast are clad with seaweeds. How such profusion of life would now rejoice the heart of the collector! How, in fact, it does rejoice his heart, for though the bed of the Carboniferous ocean be worked with hammer and pick instead of rope and dredge, none the less has it yielded up its treasures in abundance. The rocks in the city of Cincinnati and the hills round about have furnished many specimens of crinoids, but most celebrated of all localities is Burlington, Iowa, from whose quarries have come more species than from any other place. At Crawfordsville, Ind., is a bed of bluish sandy clay two or three feet in thickness, from which many thousand specimens have been taken and distributed among the principal museums of the world. In excavating a cellar at Kansas City the workmen came upon a colony of crinoids which yielded many hundred specimens of one species and in a better state of preservation than at any other locality.

But it must not be imagined that one may go out at any time and obtain fine specimens. Far from it! These animals seem to have grown in colonies and to occur as fossils in very restricted localities, while round about there may be few or none. And happy is the collector who chances upon a "pocket" containing one of these colonies, for the chances are that it may contain some hitherto unknown species.

And here we may bid farewell to the invertebrates that peopled the waters of the ancient world, for although one more system of rocks, the Permian, is included in the great Paleozoic group, yet historically it may best be considered in another place, for its life marks an advance over that contained in the rocks below by the introduction of creatures higher in the scale.

It was said in a previous chapter that no satisfactory answer could be given to the question, "How long ago did that animal live?" but still we may be permitted to make a guess at this as well as at the length of any given portion of the world's history. Now, the part we have just been considering, beginning with the life of the Cambrian and ending with the Carboniferous, has been estimated to represent a duration of something like 12,000,000 years. This estimate may be said to have a very solid foundation, for it is based on the thickness of rocks included in the Paleozoic group, and this amounts to many thousands of feet. Owing to favorable circumstances in the way these rocks are exposed to view it has been possible to measure them much better abroad than in this country; and in Europe, according to W. J. Sollas, the thickness is not far from 94,000 feet—in other words, about 18 miles. The problem is, How long did it take to wash away enough of the earth's surface to form, with the aid of the limestone deposited in the sea, this enormous amount of rock? Naturally the problem is very complicated, so that estimates vary from 5,000,000 to 30,000,000 years, and 12,000,000 may be taken as a conservative estimate. Certainly this seems long enough for many changes to have taken place among plants and animals, but when we think of those that actually did occur it appears none too long. It may give some idea of the abundant life of this era to say that a few years ago the number of species of fossil invertebrates recorded from the paleozoic rocks of North America alone was 13,500, while the progress made in our knowledge of the past is shown by the fact that in 1820 the entire number of known fossil animals, vertebrates, and invertebrates was only 2,100.

The paleozoic era dawned on a world scantily peopled by invertebrates; it closed on oceans swarming with fishes, and continents where hordes of slimy creatures disported themselves amid steamy swamps and tangled jungles of gigantic mosses. The higher life was not yet born; the landscape was totally different from that now to be seen in any part of the world, utterly unlike any ever seen by man, while not one of the air-breathing vertebrates of that day would be familiar to us.

But vertebrates were firmly established, and from then onward the development of vertebrate life was so much more important and interesting than that of the lower animals that these may well be neglected from now onward.

CHAPTER IV

THE COMING OF VERTEBRATES AND THE RISE OF FISHES

It was a long time after life began before any back-boned animals made their appearance—time enough for the formation of vast beds of sand and mud that subsequently hardened into layers of rock from 3 to 5 miles in thickness. And when vertebrate animals did appear they were small, and for the most part very unlike any now living—sham vertebrates as we might call them, or forerunners of vertebrates as they have been styled by some cautious naturalists. The very earliest indications of these animals that have yet been discovered were found in the Lower Silurian rocks of Colorado, and consist of bony plates and traces of a backbone of some fishlike creature believed to be related to our lamprey. These fossils are certainly insignificant enough to look at and of small value if judged by their looks alone; but if we stop to reflect that so far as our present knowledge goes these were the first vertebrates that swam about the shores of our continent, they acquire more importance. For in their day they were the highest forms of life in a world of invertebrates, marking the beginning of a new order of things, and containing the possibilities of future reptiles, birds, and mammals. More than this, they were the founders of the family to which man himself belongs. Some future discovery may clear up the mystery surrounding these animals and make their place in nature clear, just as a fortunate find of trilobites settled once for all any questions concerning their legs and antennæ, but now we can say very little about them.

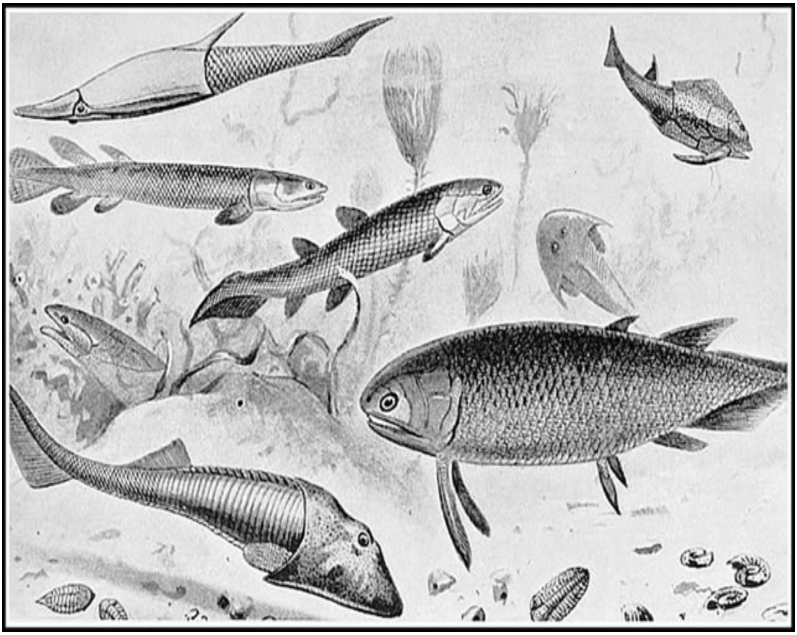
Simple in design as these fishlike creatures were, it is inferred, from the very fact that they possessed an armor of bony plates and had a backbone of sufficient consistency to be preserved, that they were preceded in time by other and simpler animals. This is inferred not only because all forms of life start in an humble way, but because there are living several curious little creatures whose true relations were for a long time unsuspected, though they are now known to be vertebrates in disguise. For while the great current of life flows ever onward, passing from lowly forms to those of more complex pattern, yet this current has its eddies where part of the stream may pause, or even for a space flow backward. So while animals as a whole move forward, some of them drop out of the stream here and there and stand still or even go backward or degenerate. This may be brought about by adaptation to some particular and easier mode of life, as when creatures become mere parasites upon others; or it may be due to quite the reverse—to conditions of life so severe that no progress is possible and a mere simple existence is all that can be achieved. We see this in mankind, both in individuals and races. Man in general is better housed, better clad, and better fed than he was 500 years ago, but some men to-day are not so well off in these respects as were their ancestors five centuries past. Just so with the race. In the north the struggle for existence is so severe that the Eskimo can make little or no progress; all he can do is to hold his own. Within the tropics much the same state of affairs is found for the very opposite reason; life is so easy that man takes little thought for the morrow as to how he may be housed or clothed, and very little thought as to how he may be fed. Only in the broad expanse of the so-called temperate zone are the conditions such as to stimulate man to do his best, and there has mankind made its greatest progress.

That relatives of man—many times removed, to be sure—are even now in existence so small and soft that they would leave no trace in a fossil state, is one reason the more for believing that similar forms preceded the advent of those sufficiently advanced to have left their fossil forms in the ancient rocks.

The Colorado specimens are so very fragmentary that we can say little more about them than that they show conclusively the existence of back-boned animals even so early as the Lower Silurian epoch, but a little higher up in the rocks remains of fishlike creatures are met with in abundance; at least they are abundant in some favored localities, and occasionally so complete and well-preserved that we can get a pretty good idea of their appearance when in the flesh.

The best known of these fishes have been described over and over again, but while we are not quite so restricted here as with birds—where we have but two individuals to form the starting-point for the entire race—yet if we are to obtain an idea of what the early vertebrates looked like, it will be necessary to describe them once more. They were small, they had no true backbone—only a rod of gristle—no skull and no jaws even, for jaws and mouths do not, as might readily be supposed, necessarily go together. But most of them were well protected above and below by bony armor, and as armor implies attack and defense, it is to be inferred that the more powerful creatures preyed upon the weaker then even as they do now, and those that could not defend themselves or were not swift enough to run away were eaten.

Living about the coral reefs of tropical waters are a number of odd-looking little fishes popularly and aptly named box-fishes, because they are shut up in a box of bone through which their fins and tails protrude just enough to let them swim. These strongly suggest in their appearance some of the early fishes, but the similarity is in appearance only, for there is not the slightest relationship between them—nature has merely repeated in some measure an old design. And in the rivers of South America are many strange little catfishes as completely clad in plate armor as were any fishes of the past, and for the same reason—to escape being eaten by other, swifter, better armed fishes, and not because they are in the least related to the mail-clad fishes of the past.[10]



Pteraspis. **Osteolepis.** **Holoptychius.** **Pterichthys.**
Glyptolæmus.
Coccosteus. DEVONIAN FISHES.
Cephalaspis.

One of the oldest North American species of these armored fishes is that known as Palæaspis, in which the front part of the body is covered by plates much as if it had been shut in between clam-shells, with an extra, narrow plate along either side and a small one over the nose. The back portion seems to have been naked—at least no scales or plates have so far come to light, and it does not seem to have borne a spine like its near English relative Pteraspis.

Just above this comes the curious Cephalaspis, with a broad, rounded head, something like a saddler's knife in shape, and the balance of the body clad in a few series of rather long and narrow interwoven plates. On either side of the head is a little flap that suggests some kind of a fin, but is supposed to have really covered the outlet of the gills.

The wing-fish, Pterichthys, and its North American relative, Bothriolepis, are, however, the best known of these early species, because the bony armor was more complete in these than in the others, and while usually so broken and distorted that its shape is unrecognizable, now and then a well-preserved example is found. In the Potsdam (Devonian) sandstone of Tioga County, Pa., is a layer containing thousands of plates of Bothriolepis, but so broken and so mixed together by their kneading at the hands of the waves that as specimens they are useless; they merely tell of the former abundance of these animals, and of their wholesale destruction.

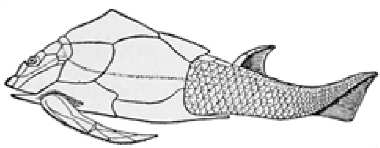
In the Corniferous Limestone a few miles north of Columbus, Ohio, is a bone bed perhaps even more remarkable than this. Though only from 2 to 4 inches thick, it covers an area of many square miles, and is composed almost entirely of broken spines, fragmentary plates, and teeth of fishes, representing, says Dr. Newberry, millions upon millions of individuals. And near North Vernon, Ind., is another similar deposit, formed, too, of the ruins of millions of ancient fishes. For it must be remembered that this thickness of 2 to 4 inches means a much greater thickness before the stratum was placed under the pressure of miles of overlying rock.

It is often thought that the sudden death of so many individuals must have been brought about by some violent catastrophe, but the more we study the ways of Nature the more apparent is it that it is not necessary to call in the aid of an earthquake or a volcanic eruption to destroy animals on a large scale, and that it may be brought about quite as effectually with the expenditure of much less violence. A good illustration of this was the destruction of animal life on the California coast, near San Pedro, in the summer of 1901, when many fishes, mollusks, and sea-cucumbers were killed by the sudden increase in number of a minute organism belonging to the infusoria. Why this little infusorian should have suddenly become abundant we do not know, but as it died in vast numbers it seems to have poisoned the water, and to have caused great loss of life among animals much higher than itself.[11]

The deposits of Ohio and Indiana are thought to have had a different origin. Dr. Dall has noted the habit of certain fishes which exist in vast numbers of frequenting certain areas, where they eject the broken shells of mollusks, corals, barnacles, and other creatures which they have cracked, swallowed, and cleansed of their soft tissues by digestion. Some areas of the sea-bottom consist almost wholly of this material, nearly every piece of which bears the tooth-marks of a fish.[12]

And this process went on in the past, even as we know it to be going on now, with the result that very considerable beds have been formed by the work of hungry fishes.

From Scaumenac Bay, Canada, have come some very beautiful specimens of the armor of Bothriolepis, flattened down, to be sure, but with every plate in position, and from these it is possible to identify and locate the more abundant and wave-worn fragments. This fish was so like its better-known English cousin, Pterichthys, that the picture of the latter may do duty for both.

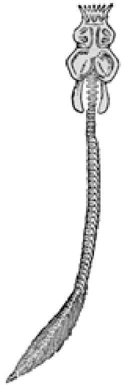


Pterichthys, the wing-fish. Very much reduced.

The figures give a better idea of the animal than it is possible to convey by words, but it may be noted that the jointed arms occupying the place of the side fins of a fish are really something like the legs of a crab, for they have the hard parts on the outside and the muscles on the inside. This is such a departure from the structure of ordinary back-boned animals, in which the muscles surround the bones, that some naturalists have thought it more than a mere resemblance, and that it hinted at some real relationship between crab and wing-fish; while some have even gone so far as to consider this strong evidence in support of the theory that vertebrates are the descendants of crustaceans.

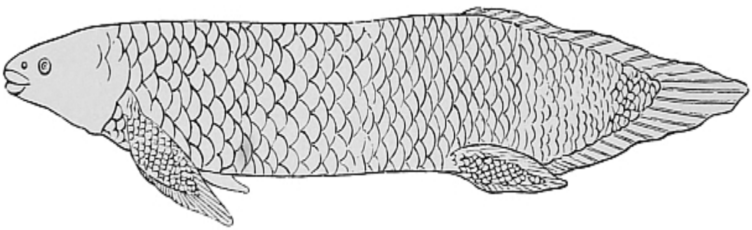
Another and probably more correct view is that these resemblances to crabs are not due to any kinship between the two groups, but are the result of living under similar conditions and pursuing a similar mode of life. Still, it is hardly to be wondered at that when, many years ago, Hugh Miller gazed upon the first Pterichthys, just brought to light by a stroke of his hammer, he should have thought that he had discovered a creature combining the characters of a crab and a turtle, or that a naturalist with only imperfect specimens at his command imagined them to represent some new and strange beetle.

These quaint little creatures stand quite by themselves in the shadow of the distant past; they left no successors, and we do not know their ancestors nor their next of kin, although it is surmised that, in spite of the seeming differences between them, they are closely related to the lampreys. A little lamprey-like creature found in the Lower Devonian rocks of Scotland is regarded as having an important bearing on the possible origin of the strange fishes just described. This animal, known as *Palæospondylus gunni*, while only from an inch to an inch and a half in length, had a better-defined skeleton than the lampreys of to-day, and so is rather highly specialized. But it must have descended from much simpler species, and some of these may have varied in other directions, and have been the ancestors of the strange little armored "fishes."



***Palæospondylus gunni*, a very ancient ancestor of the lampreys. (After Traquair.)**

The coast of ancient North America seems to have been poorer in fishes than were the waters about early Europe, for many more of these quaint armored creatures have been discovered in England and on the Continent than here. It may be that we have not yet discovered the burial-places of the little fellows, and that some day they will be brought to light, but at present we miss many of the forms found on the other side of the water.

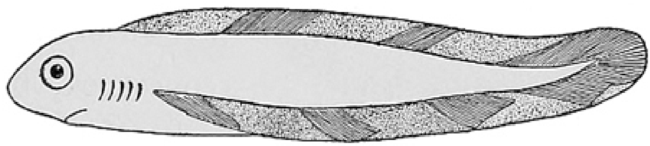


Ceratodus forsteri, a modern lung-fish from Australia.

Associated with the "fishes" just described, during the latter part of their career, were others more like those of to-day; in fact, one or two of them are represented by living species. Such are the so-called lung-fishes,[13] the Australian Ceratodus, the African Protopterus, and his South American cousin, Lepidosiren, the last two also known as mudfishes, from their habit of passing the dry season ensconced in a mass of dried mud. These form the subclass Dipnoi, whose members present some resemblances to the amphibians—another instance of the interrelation of living beings. Owing to this, as well as to their great antiquity, these fishes are of special interest, and their structure, habits, and development have been carefully studied with the hope that they might throw light on the history of the past, and particularly on the origin and development of the amphibians.

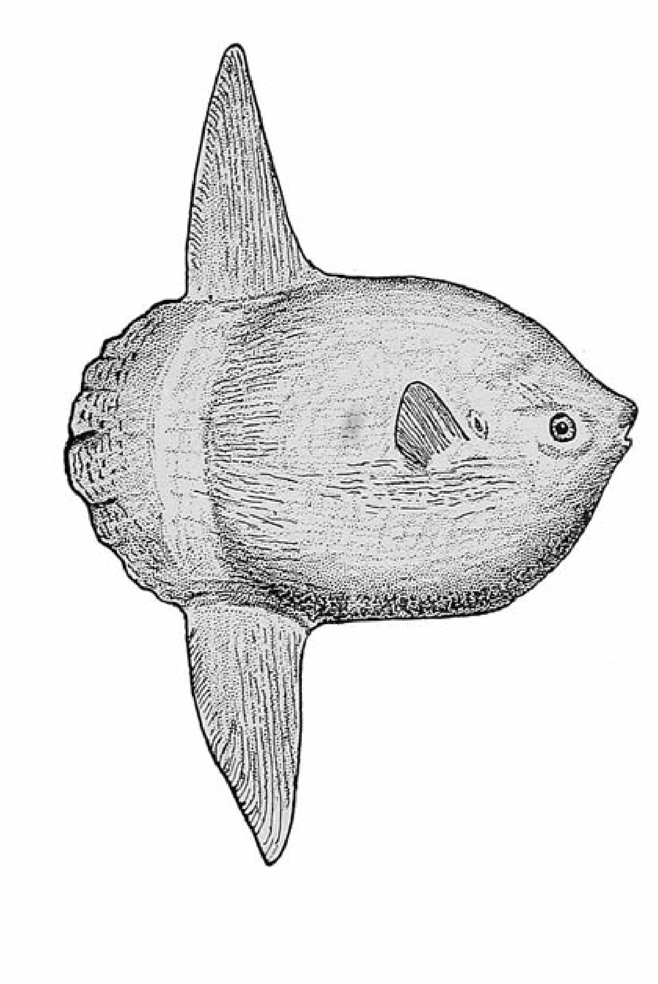
The lung-fishes of to-day are but the scattered remnants of a group once abundant and widely distributed, which comprised such huge forms as Dinichthys and Titanichthys, whose remains occur in the Upper Devonian[14] of Ohio. Some fine specimens have been found in the vicinity of Cleveland, some near Berea, Ohio, but probably the greatest number have been obtained from Lorain County. These fishes were from ten to twenty-five feet long, with the head and front protected by thick, bony plates, although the back portion seems to have been quite naked, as no traces even of scales have been found; and so far as outside appearance goes, these fishes must have looked something like enormous catfishes, minus the spines. The powerful jaws were armed with teeth for tearing and cutting, so that their owners were probably the actual rulers of the sea as well as the highest types of life during the Devonian period, which has been termed the Age of Fishes from the abundance and variety of the members of this class.

And yet here, as elsewhere in reading the history of the past, it is necessary to curb our imagination,[15] and to consider that possibly these fishes were not so bad as they have been painted. Dr. Bashford Dean thinks that they dwelt at the bottom; and if this were so, their diet may have consisted mainly of crabs and shell-fish. The big sea-lion of our Pacific coast is the largest and most powerful of the eared seals, and yet this animal subsists largely on crabs, and preys upon such poor and bony fishes as sculpins, while the still bigger walrus uses his formidable-looking tusks for digging clams. And so we may give Dinichthys and his kin the benefit of a doubt.

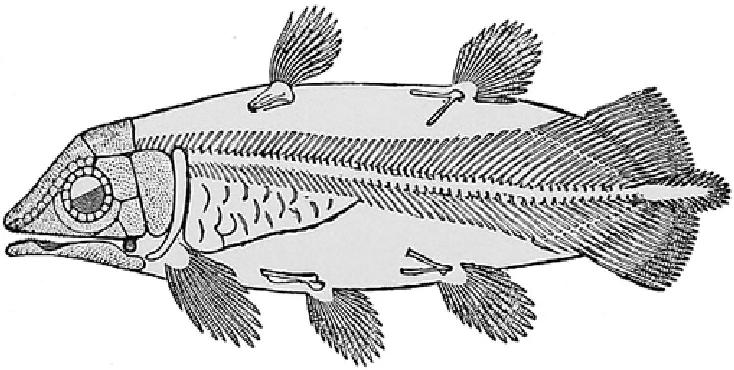


The development of fins. The light shading indicates the hypothetical original fold, the dark shading shows the present fins.

Another group of fishes which arose during the Devonian period is that termed Crossopterygii, or fringe-finned, because the members of the group have their side fins formed by a fringe of rays arranged about a central portion. These fishes, according to Dr. Dean, combine the characters of a shark, lung-fish, and ganoid, and among their curious features is what may be called their attempts to construct a tail-fin. The most commonly accepted theory of the origin of fins is that they have been derived from a fold of membrane running along either side and uniting beneath the body to form a single fold, which continued around the tail and along the back to the head. It is easy to see that if pieces were cut from such a fold the various fins of fishes would be left, and some of the fishes under consideration look as if in doing this they had trimmed the tail part of the membrane too close, so that the upper and lower fins (dorsal and caudal) were obliged to play the part of a tail. Such a thing really happens in at least one modern fish, the extraordinary salt-water sunfish or mola, in which the tail has completely vanished, its place, so far as swimming is concerned, being taken by the fins. None of the early fishes had tails of the symmetrical shape and complex structure we see among the bony or true fishes of to-day, and in these ancient forms it is easily seen that the tail probably once formed part of a continuous fin. Some of them, however, mimicked the general form of recent fishes very closely, and among these one in particular (*Cœlacanthus*) might at first sight pass for a modern dace. But closer inspection shows that it has no real tail-fin, that the other fins are wholly unlike those of any bony fish, and that, in spite of its up-to-date appearance, it is really built on the same ancient plan as the one (*Undina*) shown in the figure.

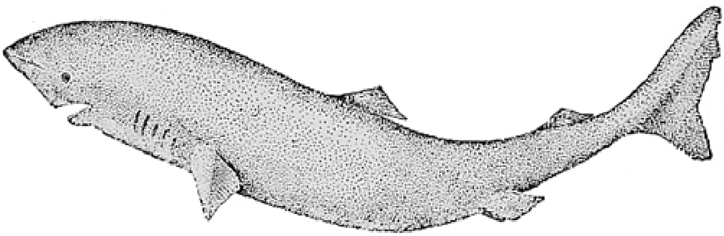


The ocean sunfish, *Mola mola*, a fish which has lost its tail.

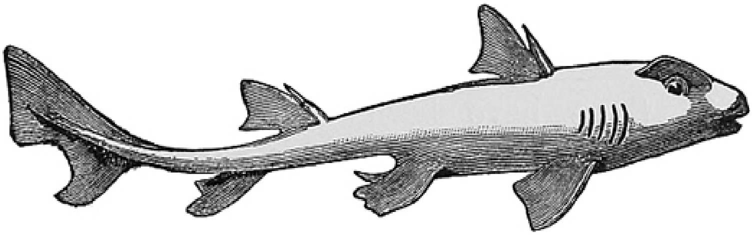


Undina, a crossopterygian fish. (After A. S. Woodward.)

In the Devonian rocks, too, are found the ancestors many times removed of the sturgeons and the mail-clad gar-pikes. Mail, in fact, was as popular in those days as it was in Europe during the middle ages. The era of intelligence had not yet dawned, the higher instincts even were perhaps not developed, and protective mimicry probably played but small part[16] in the struggle for existence; the law of the world was might, and the weaker went to the wall.

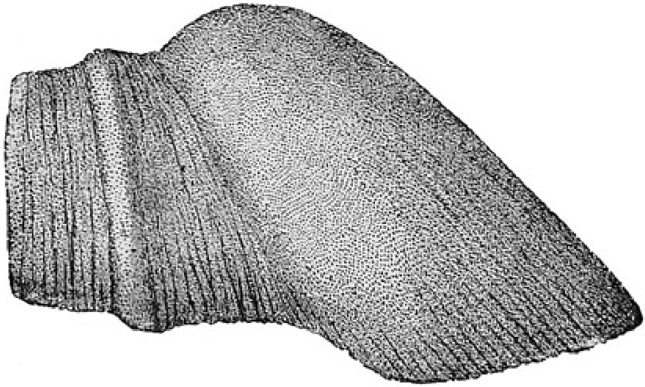


The sleeper shark, *Somniosus microcephalus*, a large but harmless species.



Port Jackson shark, *Cestracion philippi*.

As the smaller fishes of the Devonian period died out, sharks and their relatives, which first appeared in Silurian times, came upon the scene in numbers; not sharks as we now know them, but smaller and simpler forms, which were later on replaced by others more like those of to-day. We are very apt to think of sharks as great and formidable monsters ready to tear anything or anybody to pieces with their many rows of sharp and wicked-looking teeth, when a large proportion of the sharks are under 6 feet in length, and some of the very largest have small, feeble teeth, and are quite harmless so far as man is concerned. And only one of the many rows of teeth is in use at one time, the others forming a reserve supply, to be drawn upon in case of accident, and, like reserves of soldiers, these are kept at the rear and lie down out of the way. The sharks of the Carboniferous seas were mostly of small size, from 3 to 6 feet in length, and their teeth were fitted for holding or crushing rather than for cutting purposes. In some the teeth were arranged like so many little cobblestones, and these species have received the appropriate name of pavement-toothed. But one genus of them has endured to modern times, the most common representative being the Port Jackson shark, *Cestracion philippi*, a small and inoffensive species found in Australian waters.

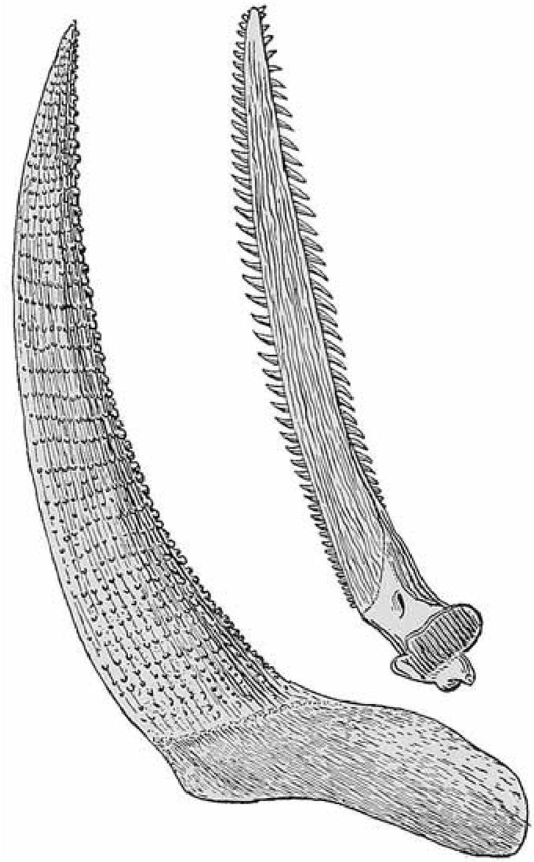


Lower tooth-plate of a cochliodont shark. Somewhat reduced. (After Worthen.)

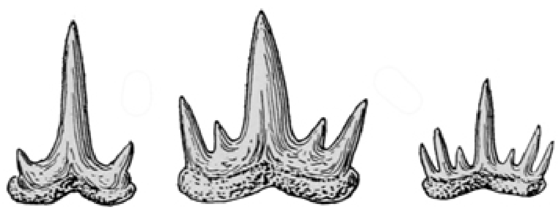
In other ancient sharks teeth were represented by a single, more or less spirally twisted and ridged plate, and as this suggests a snail-shell, these have been termed cochliodont. Teeth like these were evidently fitted only for crushing, and for crushing comparatively fragile things at that, so that these cochliodonts probably lived on crabs or thin-shelled mollusks, possibly on the abundant brachiopods. The structure of this tooth-piate is very much like that of shark skin, and it is the teeth of these and other sharks that best illustrate the fact that teeth are really modifications of the skin and do not belong in the same category as bones, intimately as the two are connected in mammals.

Many of the early sharks had the fins armed with a sharp, strong spine, and although fin spines have gone out of fashion among sharks, there are still a few species that preserve the family traditions, such as the Port Jackson shark, just referred to, or the more familiar spiny dogfish, which has a spine in front of each of the two back fins. The fossil species not only had spines on their back fins, but on their side fins as well, after the fashion we find so effective in the catfishes, and in some species the side fins are even represented by a series of spines. These are usually ornamented with ridges, but sometimes quite elaborately decorated with raised ornamental figures.

The skeletons of these sharks were mostly cartilaginous and consequently not preserved, so that most of them are known only from their teeth and the spines with which their fins were armed—a circumstance that has caused much trouble, for as these are rarely found together, one name has often been given to the teeth and another to the spines of the same individual, thus making two species out of one. Worse than this, teeth from different parts of the jaw are often quite unlike, so that teeth from a single shark may receive several names. And there is no way of finding out these mistakes



Spine from the back fin of a Carboniferous shark, and one from the side fin of an Amazonian catfish.



Teeth of Cladodus, a Carboniferous shark, showing the different kinds of teeth in one shark. Somewhat enlarged. (After Dean.)

save by the rare and fortunate discovery of some unusually well-preserved specimen having the teeth and spines in place. These sharks were none of them large as sharks now go, but what was lacking in size was more than made up in numbers, for in a short time—short geologically—after they were fairly established they became the leaders among living things. During the Lower Carboniferous period sharks were more numerous both as regards species and individuals than before or since; nearly 300 species have been described from the rocks of that period, although but 167 are from North America, while teeth and spines are abundant.

The history of the sharks is peculiar, and their fall as rapid as their rise; by the time the Permian, which overlies the Carboniferous, was reached they had dropped to 10 species abroad and 9 in this country; and while they recovered in a measure from this abrupt descent never again did they reach their former importance. This curious fluctuation in numbers during the early part of their career is somewhat difficult to account for, but it may be that at first, being for the time the leaders in life's race and having no enemies, the sharks multiplied until they actually became a check on one another. Then the over-specialized forms, and those that, on the other hand, failed to respond to changing conditions, dropped out, leaving those best fitted to survive. These in turn gradually increased until Miocene times, when they again suffered a reverse, this time very likely through change of climate and a general cooling of the oceans to the north and south of the tropics. Be this as it may, while sharks at the present day are found in the cold depths of the Arctic Ocean as well as in tropical seas, their headquarters are in the warmer portions of the world. The empire of the sharks was not one of long duration, for the day of their supremacy saw the rise of air-breathing amphibians that were ere long to stand first among living things, only to be deposed in their turn and give place to still higher types of animals.

These changes in life which took place toward, or just after, the close of the Paleozoic era have a direct relation to the changes that occurred in the continent itself. Early North America consisted mainly of land now represented by its northeastern and eastern portions, with a few narrow strips following the general trend of the mountain ranges of the West, while, save for one or two islands in the Central States, the sea rolled over the greater part of what is now the United States. Here were vast stretches of water sufficiently shallow for fishes and invertebrates to thrive, with great gulfs and sheltered areas furnishing the best of conditions for their increase and prosperity. And here they flourished while the slowly rising land underwent the changes that fitted it for the abode of plants and for the animal life that could not exist without them. Paleozoic time closed with the great upheaval that formed the greater part of the United States east of the Mississippi and created the great Appalachian mountain system, then containing ranges higher than the Alps, while changes almost equally great took place in other portions of the world. And this geological revolution, as it has been termed, brought in its train an equally great change in plant and animal life. Through the action of forces at work for millions of years and finally culminating in this mighty uplift the dry land had arisen, in due time to be populated by new races while the older perished. But we must not imagine that these transformations took place as do those we see upon the stage—that in one vast convulsion the earth arose from the sea and that the animals came walking in to take possession—we must picture to ourselves a march of events so slow in the main that had man been a spectator he would not have known they were taking place.

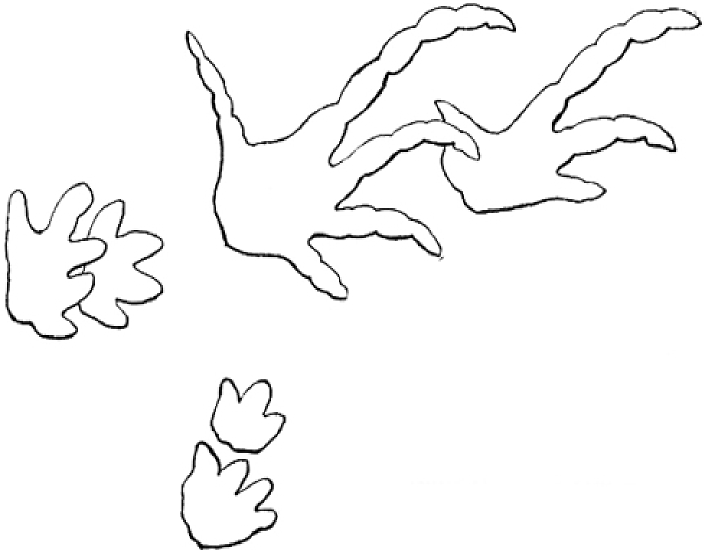
CHAPTER V

GREAT SALAMANDERS AND THEIR ASSOCIATES

While the Devonian period has long been termed the Age of Fishes, there are hints in the shape of footprints impressed in Upper Devonian rocks of Pennsylvania that even then air-breathing vertebrates had made their appearance. Other footprints, certainly amphibian, which occur in the lower coal-bearing rocks definitely announce the presence of these animals, scouts of the hosts soon to come. Over fifty years ago Isaac Lea described some of these tracks from Pottsville, Pa., and his description is so good an example of the information that may be gathered from footprints that it is repeated here.[17] “There is a succession of 6 steps, along a surface little over 5 feet long; each step is a double one, as the hind feet trod nearly in the impressions of the fore feet; the prints were hand-like, that of the fore foot five-fingered and 4 inches broad; that of the hind foot somewhat smaller and four-fingered. That the amphibian was therefore large is also evident from the length of the stride, which was 13 inches, and the breadth between the outer edges of the footprints 8 inches. There is also a distinct impression of a tail an inch or more wide. The slab is also crossed by a few distinct ripple-marks (8 or 9 inches apart), which are partially obliterated by the tread. The whole surface, including the footprints, is covered throughout with rain-drop impressions. We thus learn that in the region about Pottsville a mud-flat was left by the retreating waters, perhaps those of an ebbing tide, covered with ripple-marks; that the ripples were still fresh when a large amphibian crossed the flat; that a brief shower of rain followed, dotting with its drops the half-dried mud; that the waters again flowed over the flat, making new deposits of detritus, and so buried the records.”

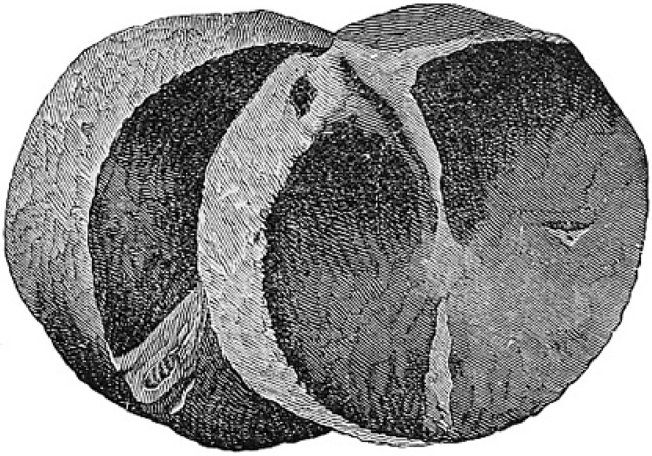
These were not the first amphibian tracks to be described from our country, for in 1845 Dr. Alfred T. King recorded quite a number from Westmoreland County, Pa., and even before this, in 1843, Mr. Logan had noted their occurrence in Nova Scotia.

Those described by Dr. Lea, however, are from a much lower level than the others, and this denotes a correspondingly greater degree of antiquity.



Tracks of a reptile and two amphibians from the coal-measures of Kansas. Reduced. (After Marsh.)

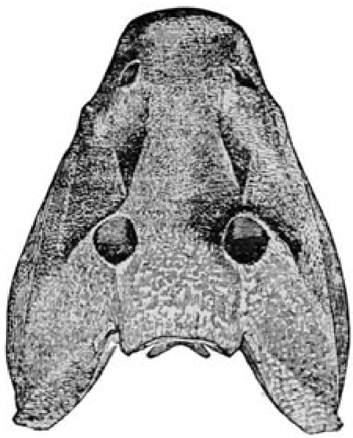
It may seem that a mere print in the mud is somewhat scant evidence of the existence of huge amphibians, but the tracks of amphibia are quite characteristic, being shorter, broader, and more hand-like than those made by reptiles, while they never show the marks of claws, these appendages not being developed in animals below the grade of reptiles. So like the print of a hand are the impressions left by the feet of some labyrinthodonts that certain tracks in the Triassic sandstone of Germany have been dubbed Cheirotherium (hand beast). In this instance it is quite correct to say that the tracks have been named, for the animal that actually made them is as yet unknown, although suspicion points at one of the great amphibians whose remains occur in the same formation.



Two vertebræ of an amphibian from the coal-measures of Nova Scotia. Reduced. (After Marsh.)

Amphibians, both small and large, occur in the Lower Carboniferous strata of western Europe, but in North America the first known specimens, aside from the footprints just mentioned, are from the Upper Carboniferous, and were found in some petrified tree trunks in a coal-mine at South Joggins, Nova Scotia; hence the name of Dendrerpeton (tree reptile) was bestowed upon them by their describer, Professor Owen. These hollow tree trunks—trees in size, mosses by nature—were the refuge of these animals, and certain abundant species of land-snails are thought to have formed a part at least of their food, for salamanders living in our streams to-day eat quantities of similar little mollusks. It was one of these old amphibians, represented by two vertebræ found at this same locality, South Joggins, that is said to have turned the attention of Professor Marsh from the study of minerals to that of the animal life of the past, and the first of his many papers on fossil vertebrates was a description of these vertebræ, to which he gave the name of *Eosaurus acadianus* (the early Acadian[18] reptile).

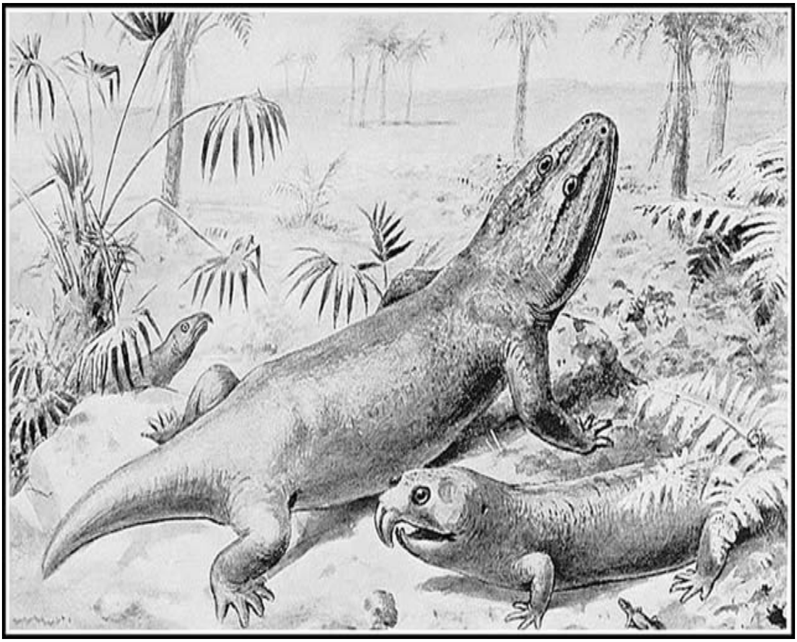
These early amphibians are without living representatives, and belong to a group which has been termed Stegocephala, roof-headed, or Labyrinthodonta, labyrinth-toothed. The first of these names refers to the manner in which the head is roofed over by bone, as in sea-turtles, while the other was given in



Skull of Eryops, a stegocephalan from the Permian of Texas. Much reduced. (After Cope.)

reference to the curious and complicated foldings of the enamel, although this can only be seen when a thin section is viewed with the microscope. The skull of a sea-turtle appears quite solidly made if looked at from above, but if viewed from the back it will be seen that its solidity is superficial, and due to wings of bone running from the brain-case down to the side, over the space in which the jaw muscles lie. Curiously enough, there is one mammal that mimics the turtle in its skull, an extremely rare African rodent called Lophiomys, one of the many instances wherein Nature repeats a character, just as she has done in the matter of wings. The limbs, so far as known, show no trace of having been modified from the fins of fishes, but resemble in their structure those of other quadrupeds. Some of the small species were legless, and these, like serpents, were slender, long-bodied animals. These Stegocephala were, as indicated by the arrangement of the nostrils, the first vertebrates to breathe by means of lungs; at least they so breathed when mature, for they are believed to have undergone a change somewhat like that a tadpole undergoes when it is transformed to a frog; and some are certainly known to have had gills when young. This transformation may not have been so marked as in the frog, but more like that which changes the salamander-like Siredon of Mexico into the air-breathing Amblystoma, the one being a gill-bearing creature with a compressed tail, the other without gills and with a round tail.

Our knowledge of these Carboniferous amphibians, and particularly of the smaller forms, is mostly derived from the abundant and well-preserved examples found in Europe; for while the ironstone nodules of Mazon Creek, Ill., have yielded up some fine little specimens, the greater portion of the fossils from our coal-measures are but poorly preserved. The Permian rocks of Texas, however, have given us a number of imperfect specimens, and a few real prizes, such as the skull of Eryops, shown on page 118, though nothing to compare with some of the material that has been found in Europe.

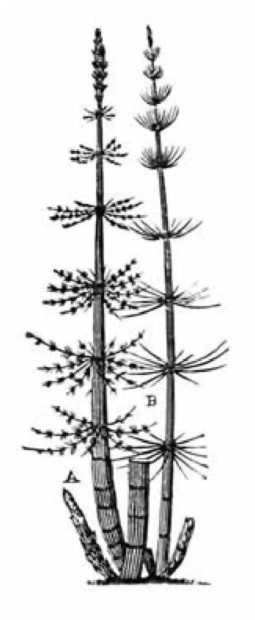


Mastodonsaurus and Hyperodapedon.

A Labyrinthodont and Anomodont of the Trias.

Many, or most, of the Stegocephala were protected to some extent by armor, but, contrary to the usual custom, this was more often found on the under side of these animals than on their backs. Still some of the smaller species were fairly well covered with scales, although these were so thin that they could have offered little real protection against the enemies by which they were surrounded, unless it were by making them more or less unpleasant eating.

Armor has practically been discarded by modern frogs, toads, and salamanders, but one or two genera of frogs (*Ephippifer* and *Ceratophrys*) having any suggestion of it, and this in the shape of bony plates imbedded in the back and serving neither for use nor ornament, merely as reminiscences of the time that armor was popular. There is one order of amphibians, the Ophiomorpha or snake-formed, whose members look very much like great earthworms, and have the same burrowing habits, in which there are rows of minute scales that may also be considered as indications of the armor of former members of the race.



A Calamite, a rush of Carboniferous times. (After Dawson.)

It was a strange world in which the Stegocephala dwelt, one quite as strange and weird in its way as that imagined by H. G. Wells in his First Man in the Moon, a world wherein ferns abounded and mosses and rushes took upon themselves the dignity of trees, reaching a height of from 50 to 75 feet, and a diameter of 2 or 3. Some of the club-mosses (Sigillaria) grew stiffly upright, without a branch, but with leaves clustered thickly around the upper part of the stem, while others (Lepidodendron),[19] after reaching a considerable height, divided into two branches, and these forked again and again with the formal regularity of trees drawn by little children. Then there were the horsetail rushes (Calamites), perhaps the most abundant of Carboniferous plants, with long, slender, jointed stems, all combining to make a tangled jungle of luxuriant vegetation. The air was heavy with carbonic acid, teeming with moisture, hot and steamy with tropical heat.

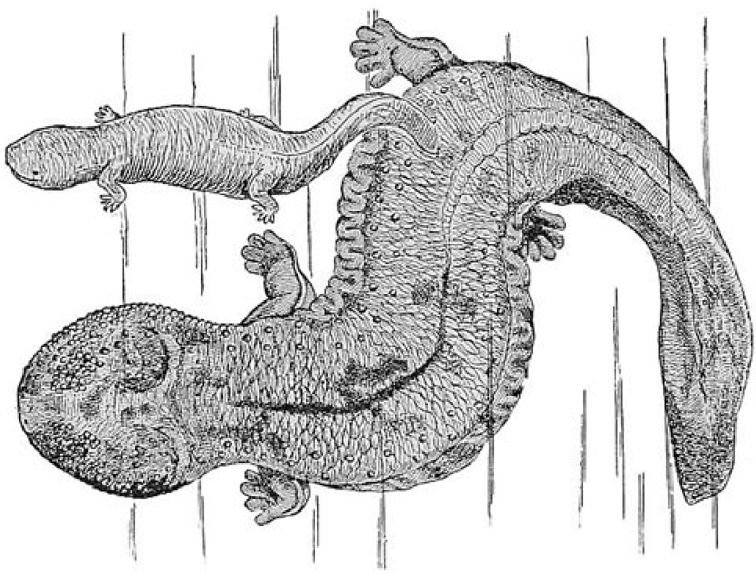
Flowering plants were few in number, their blossoms small and inconspicuous, and neither bees nor butterflies existed, for all these are dependent one upon another; nectar must exist to attract the insect, the insect in turn must be present to bear pollen from flower to flower. Birds, too, with color and song, were still in the future. Compared with the present, it was a colorless, gloomy, silent world, peopled by amphibians and reptiles, but not without its compensations in the utter absence of toil and care. Such was the realm of the Stegocephala.

While, so far as numbers go, amphibians reached their maximum during the period of coal-forming forests, their culminating point in size was in the Trias, just before their extinction. Sharks and armored fishes had declined, dinosaurs had not become paramount, and during the interregnum there was, so to speak, a silent struggle for supremacy between amphibian and reptilian types. Until very recently amphibians of the first rank in magnitude were not known from America, but the Trias of Arizona has yielded specimens indicating a creature eight or nine feet in length, larger if anything than its European contemporaries, and of additional interest from the fact that it is a member of a European genus (*Metopias*). The presence of this animal and a peculiar type of crocodile in the two countries shows that the strata are of the same age and that the two continents were very probably united at the time these rocks were forming. Only one or two bones of this great amphibian have so far been found, but fortunately the evidence of these is conclusive. A peculiar and fishlike character of the Stegocephala is that three bones, forming part of the support of the fore-limbs, show on the under side of the body, just as parts of the fin supports of a gar-pike or sturgeon are not buried in the flesh but form part of the armor. Bones like these, developed from the skin (dermal bones) and lying near the surface, are usually ornamented with pits and grooves, and those of the giant amphibians follow this general rule and bear markings characteristic of the species to which they belong.

Misled by the froglike aspect of the skull of some of these large amphibians, paleontologists were for a time led to suppose that there was a still further resemblance; and Waterhouse Hawkins restored a labyrinthodont in the likeness of a huge frog, a frog larger than an ox, of the size the frog in the fable aspired to. But later discoveries revealed the existence of a stout though stumpy tail, and showed that this restoration was more picturesque than accurate—showed, too, that the legs of a labyrinthodont were not at all like those of a frog, but much shorter and not at all suitable for leaping. Still they were probably pretty active animals at times, for while all labyrinthodonts were, as indicated by their teeth, carnivorous, the largest among them were, by their gaping jaws and long, sharp fangs, particularly well fitted for playing the rôle of beasts of prey, and their smaller brethren and the more sluggish fishes must have fallen frequent victims to their voracity.

It is a little difficult to suggest the appearance of these labyrinthodonts, for they were neither gigantic frogs nor overgrown salamanders, though more like the latter than the former. The figure on plate III gives a good idea of one of these animals, only it is necessary to remember that the creature was from 6 to possibly 10 feet long.

The largest amphibian now living is the great salamander of Japan, which sometimes attains a length of four feet; so it may be readily seen that, so far as size is concerned, amphibians have declined sadly. Moreover, this Japanese salamander is merely an enlarged reproduction of our familiar mud-puppy,[20] common in some streams west of the Alleghanies so that it is not more remarkable for looks than it is for size. Still, looks and size are not everything, and these recent salamanders are not without their importance, for they are the last of a group not uncommon in Europe during Miocene time, and they are looked upon as furnishing strong evidence of the former union of Europe, North America, and Asia.



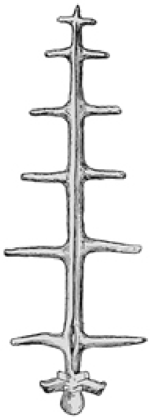
The great Japanese salamander and his relative the American mud-puppy. Drawn to the same scale.

Skull of a dicynodont, *Dicynodon lacerticeps*, from South Africa. (After Owen.)

Associated with these amphibians, probably branching off from them at an early period of their existence, or at least derived from the same source, were some curious reptiles which have become of great interest of late years as the possible original forms from which the mammals have descended. This supposition is based partly on the arrangement of the bones forming the support of the fore limb (the shoulder girdle), which is in many respects like that of those egg-laying mammals, the platypus and echidna, and partly on the character of the teeth. In most reptiles the teeth are simple in structure, with a single root, and all the teeth are made on the same pattern, although they may differ greatly from one another in the matter of size. But these strange reptiles have their teeth variously modified, whence the group as a whole is called Anomodontia (anomalous toothed); while the name of Theromorpha (beast-formed) was also given to it in allusion to the resemblances some portions of the skeleton present to the corresponding parts in the lowest living mammals. One division of these anomodonts has been named Theriodontia (beast-toothed), because their teeth, like those of mammals, are divisible into incisors, canines, and molars; and another has been styled Dicynodontia (two canine-toothed), on account of having two long teeth, one on either side of the upper jaw. These two large teeth were all that the dicynodonts possessed, the front of the jaw having a beak like that of a large turtle, so that the animals must have presented a most singular appearance. On the one hand, the anomodonts seem to resemble mammals, while the lowest members of the order have undoubted affinities with their contemporaries, the labyrinthodonts. All in all, they form a most extraordinary branch of the animal kingdom, and one of additional interest from its rapid rise, short duration—through the Permian and Trias only—and apparent abrupt termination. This last may be due to the absence of the records, and later we may come upon specimens that will extend their range in time, or show whether they did pass into mammals or simply died out.

These anomalous reptiles, to borrow a phrase from Mr. Hutchinson, have so far been found most abundantly in South Africa, where the Karoo Beds have yielded many species and a large number of individuals. In North America, Texas, Illinois, and Arizona, particularly the first-named State, have furnished a number of species; and quite recently the genus *Pariasaurus*, hitherto known only from Africa, has been found in Russia. Most of the species so far discovered are of very massive build, with short and powerful legs and large heads, the entire aspect of the skeleton—for skeletons have their own individuality—being suggestive of stupidity and brute ferocity. Stupid these animals certainly were, if size of brain is any index of amount of intelligence, for the brains of all these early animals were diminutive, and it was a long time before any animal came into the world with a brain that would compare either in quantity or quality with the brains of very ordinary animals of to-day.

The question may very naturally be asked, How is it possible to tell anything of the quality of a brain whose owner existed several million years ago? But, as we all know, the quality of a brain depends on the extent of the gray portion, and this in turn is related to the convolutions or infoldings of the outer surface. These convolutions are impressed on the inner surface of the skull, and where the cranium of an animal has been preserved in good shape, it is possible to cut away a portion, remove the stone filling the cavity once occupied by the brain, and then make a cast that will show the proportions of the brain and the shape and extent of the principal convolutions. But to return to the physical characters of the anomodonts. It may be said that while many were large others were small, and Professor Cope gives their range of size as from that of a rat up to the bulk of a lion; besides, we must always remember that the larger the animal and the more solid its bones, the greater not only were the chances of preservation, but of being eventually discovered. This loss of small animals gives an undue emphasis to the apparent average size of extinct animals, for the great majority of fossil vertebrates are bound from the nature of things to be large, or above the average, so that there is a very general tendency to think of the animals of past ages as much larger than they really were.



A vertebra of *Naosaurus*, one of the anomodonts.

Placed usually with the anomodonts is a group of reptiles from the Permian of Texas, distinguished by the great height of the individual sections of the backbone. The ridge over the shoulders of a horse and the hump of a buffalo are formed by the very long processes of the backbone. But long as these are they are greatly exceeded by the processes on the vertebræ of *Dimetrodon* and *Naosaurus*, which must have formed an enormous ridge or keel along the back; furthermore, in *Naosaurus* each process bore a series of cross-bars, like the arms on a telegraph pole, standing out at right angles to the body. It is difficult to imagine any use for these extraordinary vertebræ, and it is quite likely that they were of no use—that they were simply overdevelopments of structures that may originally have served some purpose. That they formed the supports of a sort of fin that was used as a sail, is, with all respect to the memory of Professor Cope, quite out of the question. Also associated with the great amphibians in Triassic times were crocodiles, quite different from any now living, called from their sharp teeth Belodonts, or dart-toothed. While they differ widely from modern crocodiles in many parts of the skeleton, the difference most apparent to the untechnical observer is that the nostrils open on the middle of the long snout and not on the end. Equipped equally for offense or defense, their bodies were not only protected above by an armor of bony plates, but on the under side as well. Armor on the under side of the body was quite a common feature in the early crocodiles, but it is now found only in the South American caimans. These reptiles, indeed, are even better defended than their ancient relatives, for the only part of the body left unguarded is a narrow belt along the sides, which permits a little expansion and allows a caiman to eat a hearty meal without a feeling of undue tightness. The largest of the belodonts so far found in this country come from the Trias of Utah and Arizona, and these were from 12 to 15 feet in length.[21]

Another, of almost equal size, called *Episcoposaurus* by Professor Cope, was much longer limbed than any modern crocodile, not unlike many dinosaurs in this respect, and this species was very heavily armored. The bony plates covering this animal were from ¼ to ½ an inch thick, and many of them measured 3 by 6 inches; and yet in spite of all this the creature went out of existence as quickly as did others less well defended.

So far as size and strength go none of the extinct crocodiles equals the great living Mugger or salt-water crocodile (*Crocodilus porosus*) of southeastern Asia and northern Australia, a man-eating species, which on rare occasions attains a length of 30 feet, although examples of half that size may be considered large. There is a greater range of size among large reptiles than there is among other vertebrates, for the reason that they have no fixed period of growth, but practically continue to grow as long as they live. These belodonts have been spoken of as crocodiles, but only for want of a more exact name, for while they resemble crocodiles in outward appearance there were many internal differences between them, and they also claim relationship with the race of dinosaurs. The range of these reptiles in point of time was short, for up to the present they have not been found outside of rocks belonging to the Triassic system, and the occurrence of belodont remains is looked upon as proof conclusive of the age of the strata in which they are found.

The varied relationships of the anomodonts and labyrinthodonts emphasize a feature of the animals of the ancient world, that neither the individual species nor the groups of which they formed part were so sharply distinguished from one another as are those of the present time. Life, from its beginnings, progressed along divergent lines, and as we go backward in time we find these lines approaching one another and come upon animals combining characters now found in two or more orders. It is the dying out of these intermediate forms, or their transformation into others, that enables us to divide living animals into well-marked divisions.

The great marine reptiles, the Ichthyosaurs, or fish lizards, that were so common in the seas that washed the coast of ancient Europe, seem to have been but scantily represented in this hemisphere. In the days when the earth was overrun by reptiles these creatures occupied the place now held by whales and dolphins, a place for which they were admirably adapted; for while such water-loving animals as crocodiles and turtles do occasionally seek the shore, these marine reptiles seem never to have done so, and while it was once thought that they might have crawled upon the beach to bask in the sun, this is now looked upon as very doubtful. The ichthyosaurs varied somewhat in shape, as do our dolphins, but in general shape were not unlike them. They had a pointed head, sometimes very long and slender, a rather short body, four swimming paddles, and a powerful tail.

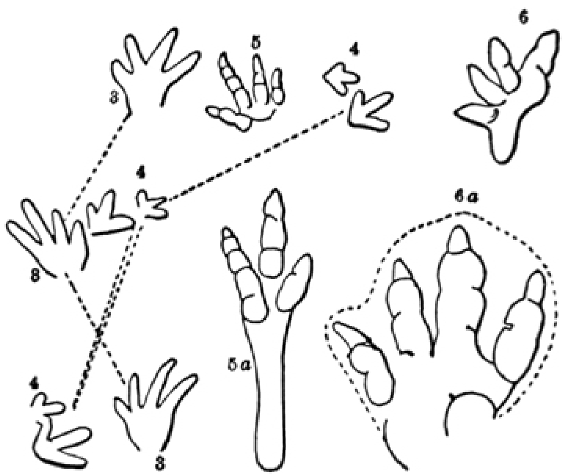
Like whales, they were clad in smooth skin and the back bore a fin, but unlike the whales, the tail was not in the form of flukes, set crosswise, but like that of a fish, up and down. This tail was long a puzzle: it was noticed that in every specimen discovered, no matter how complete it might be, there was a downward bend in the tail, just the reverse of what is found in the sharks.

It was supposed by Professor Owen that the tail of the ichthyosaurus was flat, like that of a newt or pollywog, and that this bend in the vertebral column was brought about by the dropping to one side of the flattened tail as the body decayed. But when some unusually fine specimens came to light in Germany, specimens so perfect that they showed the very texture of the skin, it was learned that the tail was just the reverse of that of a shark, and the backbone actually ran down into its lower part.

Like so many other animals, ichthyosaurs started in the Trias, but while they developed to such an extent in Europe as to form a characteristic and striking feature of the life of the Jurassic, here their career seems to have ended abruptly, for they do not pass beyond the Trias. They were apparently quite as restricted in space as they were in time, and the only ichthyosaur remains yet noted in this country came from the rocks near Mount Shasta, California, whence Professor Merriam bestowed upon them the generic name of *Shastasaurus*.

One very good reason for the seeming scarcity here of many animals that were at this time abundant elsewhere is the small extent of our fossil-bearing Permian and Triassic rocks. During these periods of the world’s history a large part of the present continent was above water and being worn away to form new beds of rocks, while much of it that lay beneath the sea remained there long enough to be completely and deeply covered by rocks that were deposited later.

Possibly another reason is that these deposits have not been worked to the same extent as others that promise better and more rapid returns for the time and labor expended.



Outlines of dinosaur footprints in the red sandstone of the Connecticut Valley. Very much reduced. (After Hitchcock.)

3, *Macropterna divaricans*.	**5, *Anomœpus scambus*.**
4, *Apatichnus bellus*.	**6, *Otozoum moodii*.**

Dinosaurs came into being during Triassic times, but the story of these animals forms a chapter by itself, the more that their record in the Trias consists mainly of footprints. However, the few bones, and teeth of carnivorous species found in Connecticut, North Carolina, Colorado, Texas, Arizona, and New Mexico, are sufficient to show that already this group of animals was widely distributed. One of these, dubbed Paleoctonus by Professor Cope, was, to judge from the bones, rather small and slender in build, though its formidable teeth, the largest of them 2½ inches long and 1 inch through, indicate a large head and rapacious habits.

A word or two may be said of the invertebrate life of the Permian and Trias, for this also took part in the general progress and transformation. The dwindling race of trilobites came to an end in the Permian, while the curious brachiopods, like the sharks, suffered a sweeping reduction in numbers from which they never recovered. And it is not at all improbable that the same causes similarly affected these two very different races of marine animals, and that the main factor which brought about the great decrease was a lowering of the temperature of the sea. The more familiar bivalve mollusks, on the other hand, increased, and the cephalopods developed new and more complicated forms. It may be remembered that the shell of a nautilus was said to be made of many chambers, divided from one another by partitions. In the nautilus these partitions, or septa, are simple, and the edges of the divisions between them plain, but in other forms the sections become more and more complicated where they join, and it is these species that developed so abundantly in the Trias. There is very much the same difference in the joining of the chambers that there would be between a set of boxes simply resting one on top of the other, and a set in which the boxes were dovetailed together like the pieces of a dissected map.

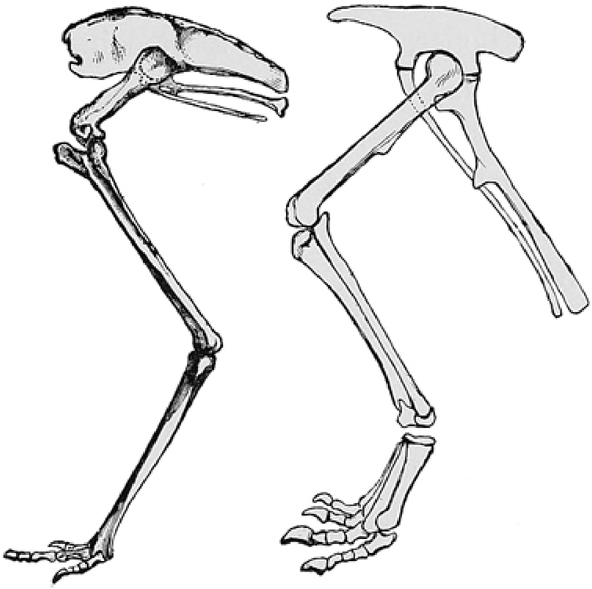
The comparatively brief period of the world’s history embraced by the Permian and Trias saw some remarkable changes among back-boned animals, not only of our continent, but elsewhere; it saw the disappearance of the great amphibians, and the coming of dinosaurs and marine reptiles. Turtles made their first appearance, abroad if not here, and the strange, mammal-like reptiles, the anomodonts, ran their course, passed across the stage, and went out of existence. Most important of all events that took place in the Triassic period was the advent of mammals, and while these were no larger than rats, and seem to have had many features in common with their anomodont associates, they marked the coming of the highest of all groups of animals. No equal period of time, before nor since, has witnessed such a complete revolution in the life of the globe, although it is possible that the mountain-making Cretaceous may have terminated the career of more species.

The vegetation, too, was changing; those giant, overgrown mosses, sigillaria and lepidodendron, which had waned with the Carboniferous, practically disappeared with the Permian,[22] while, as these declined, ferns and cycads increased, and conifers appeared in numbers. The world had changed, our continent had increased in size, and the close of the Trias looked upon a new landscape, peopled by a new race of beings.

CHAPTER VI

THE REIGN OF REPTILES

At some periods in the history of the earth life seems to have flourished with unwonted vigor, and to have developed into such strange forms that it would seem as if Nature had fairly reveled in the creation of new and wonderful shapes. The Carboniferous was the golden age of ferns and mosses, when warmth, moisture, and an atmosphere heavy with carbonic acid combined to stimulate the growth of these now lowly plants into great trees, which sprang up, flourished, and decayed, transforming the imprisoned sunlight into beds of coal for the use of future ages. And just as the labyrinthodonts flourished with the coal-forming plants so that during the Carboniferous period amphibians reached their highest level, so the Jurassic dinosaurs mark the culmination of reptilian life in point of size and numbers. It was a reptilian world; there were huge dinosaurs thrice the bulk of the largest elephant, feeding upon leaves and rushes; there were little dinosaurs no larger than a chicken, while the wolves and panthers of to-day were represented by swift, fierce carnivorous forms that preyed upon their weaker brethren.



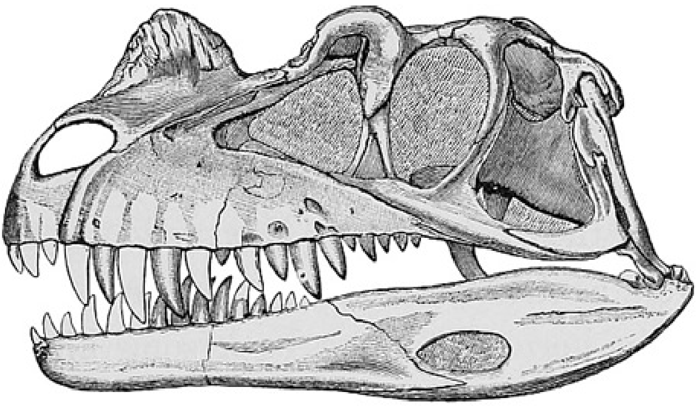
Leg of emu and dinosaur, showing the resemblances between the two.

The dinosaurs form an order of reptiles without any very near living relatives. Being reptiles, it is quite natural that they should be related, though distantly, to crocodiles and alligators, but it may seem strange that they should also claim kinship with birds. It is at first a little difficult to imagine that a tiny humming-bird could have anything in common with a huge, lumbering reptile like Brontosaurus, sixty feet long; but it is also strange that a mouse should be in anywise related to an elephant, as he is. And yet, apart from size and dress, the dinosaurs have as many points of structure in common with birds as they do with crocodiles. A very obvious feature of some dinosaurs is a three-toed foot; but while this is so very bird-like in appearance, it really is not so important a character as the structure of the shoulder- and hip-bones and that of the ankle-joint. In ourselves and other mammals, as well as in existing reptiles, the ankle-joint is between the bones of the ankle and those of the lower portion of the leg, the tibia and fibula. But in birds and in dinosaurs some of the ankle-bones are united with the leg-bones, so that the ankle-joint comes in the middle of the ankle itself, and this is a character shared by these two divisions of animals, and, aside from a few other reptiles, not possessed by other animals. And while nowadays birds have a toothless beak and a tail containing very few bones, there was a time in the past when they had teeth and long tails, and resembled reptiles more than they do now.

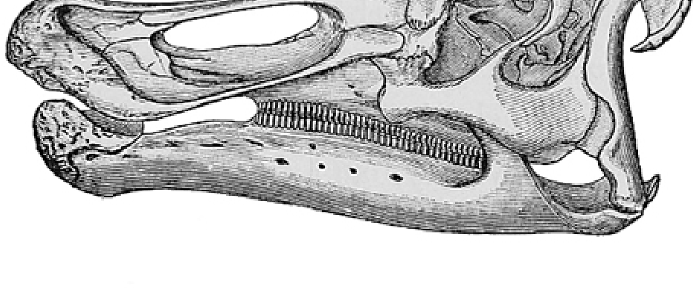
We are so apt to think of dinosaurs as great reptiles stalking about on their hind legs, that it may be well to recall that some were small, and that many went about on all-fours like the crocodiles. And both are thought to have had a common ancestor in the shape of some belodont,[23] which accounts for the similarity between belodon, crocodile, and dinosaur. Ordinarily we think of crocodiles as rather clumsy creatures when on land, crawling around in a slow, lumbering fashion; but Mr. Hornaday, who has hunted and killed various species of crocodiles in various parts of the world, states that the great Indian crocodile, the mugger of Kipling, walks away with his body and the greater part of his tail quite clear of the ground. And the same authority says that on occasion a crocodile will stand up on its hind legs and make a rush that is a reminiscence of his long-extinct cousin, the dinosaur.

A point still unsettled is whether the dinosaurs were oviparous or viviparous—did they lay eggs, or were the young born alive? If we are guided by analogy, it might be supposed that, like crocodiles and alligators, these reptiles laid eggs and left them to be hatched by the heat of the sun. But while analogy is often the only guide we have, it is by no means infallible, and rules seem to have been even more subject to exception in the past than now. Thus it is known that the young of the sea-lizards, the ichthyosaurs, were born alive; and if so, why not the young of dinosaurs? And Professor Marsh thought that he discovered traces of a young animal within a skeleton of the little, bird-like dinosaur Compsognathus from Solenhofen. So there the subject rests.

Abroad most dinosaurs have been discovered incidentally by miners or quarrymen, but in some of our Western States, notably in Montana and Wyoming, their remains are so abundant and so accessible that it is possible to obtain them in large numbers by systematic search. This does not necessarily mean that dinosaurs were any more common here than in other countries, merely that the conditions for their preservation and discovery were more favorable. And dinosaur bones have been found not only in various parts of the United States, but in other and widely separated portions of the world—in Europe, India, Madagascar, and Australia. Thus we may be pretty sure that these reptiles formed the most conspicuous life of the period. So far, however, this country has maintained its reputation for producing the biggest of its kind, and no specimens have come to light elsewhere that can quite equal our Western giants in size.



Skull of the carnivorous dinosaur *Ceratosaurus*. Original over two feet long. (After Marsh.)



Skull of Thespesius, a predentate dinosaur. Original over 3 feet long. (After Marsh.)

Dinosaurs form three well-marked groups, or sub-orders: The Sauropoda, reptile-footed, containing those with five toes on each foot, and walking on all-fours; the Theropoda, beast-footed, comprising carnivorous species, having three well-developed toes on each hind foot, besides a small inner or first toe; the hind limbs were much larger than the fore, and these animals customarily walked erect. Third and last are the Ornithopoda, bird-footed, including herbivorous reptiles, many of which habitually walked on their hind legs, having three toes on each hind foot and a variable number on the front foot. This last group is sometimes called Predentata, because the front of the lower jaw is formed by an extra bone not found in other animals, and preceding the tooth-bearing bones of the jaw proper. The predentary bone as well as the front of the upper jaw were cased in horn to form a beak something like that of a turtle.

Dinosaurs began their existence in Triassic times, but the few so far discovered are not a tithe of those that remain to be found or that never will be found. Of this we are certain, for just as the first true lizard is represented by footprints in the Carboniferous, so a goodly portion of the reptilian horde left nothing more than their tracks in the red sandstone of the Connecticut Valley, and these tracks, once thought to be those of birds, are now known to have been made by dinosaurs. These footprints indicate not only a great many individuals, but a great many species, large and small, some that crawled about on all-fours, some that walked erect, covering two yards at every stride.[24] And yet in spite of all this abundant life so far only one or two skeletons of the smaller forms have come to light, and while bones and teeth have been found in the Trias of North Carolina, Arizona, and New Mexico, these serve only to assure us of the presence of large, carnivorous forms.

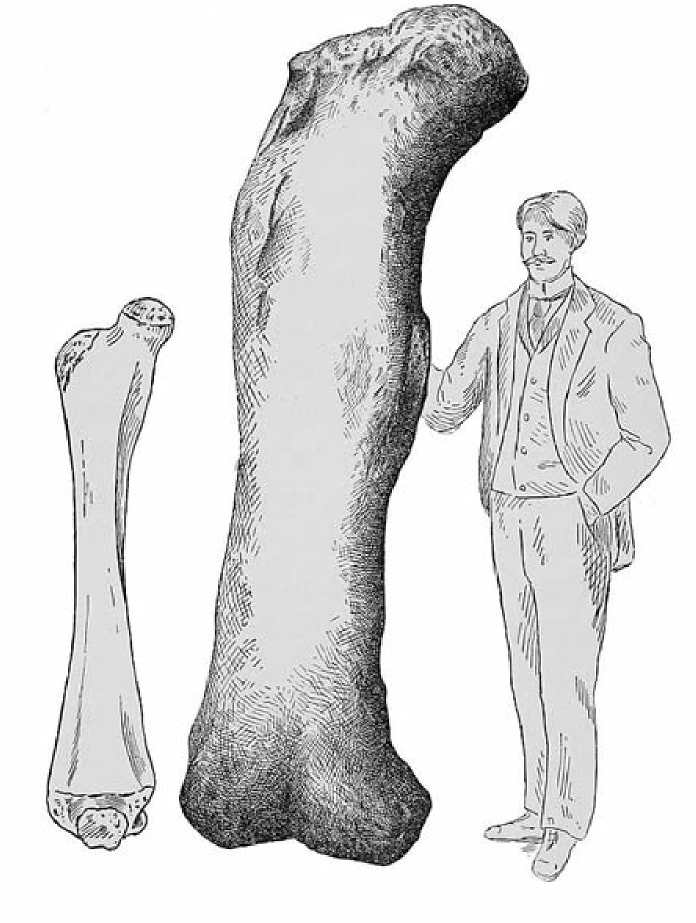
But in the Jurassic dinosaurs appear in force in various parts of the world, and from the rich deposits of our Western States, particularly of Wyoming, where the beds may be readily worked, has been obtained a large amount of material from which we have derived a very complete knowledge of these animals. And while, save in a few rare instances, nothing approaching a perfect skeleton of any one individual has been found, a great many portions of various animals have been collected, and with these it has been possible to improve upon Frankenstein, and construct not one but several monsters.

The curious mishaps that must have befallen specimens before they became entombed in rock is shown by the experience of the American Museum party at one of its collecting grounds, known as the Bone Cabin Quarry.[25] Many car-loads of valuable specimens have been obtained from this one locality, but the majority seem to have belonged to animals that had suffered the fate of Clonglocketty, and been divided close to the waist. There are tail-bones and leg-bones a-plenty, even complete hind legs, but forward of the hip-bones almost nothing has been preserved. That one or two specimens should be found in this shape would not be surprising, but it is difficult to imagine conditions that would sweep away the front half of one animal after another, and leave the rear portion of its anatomy almost intact.

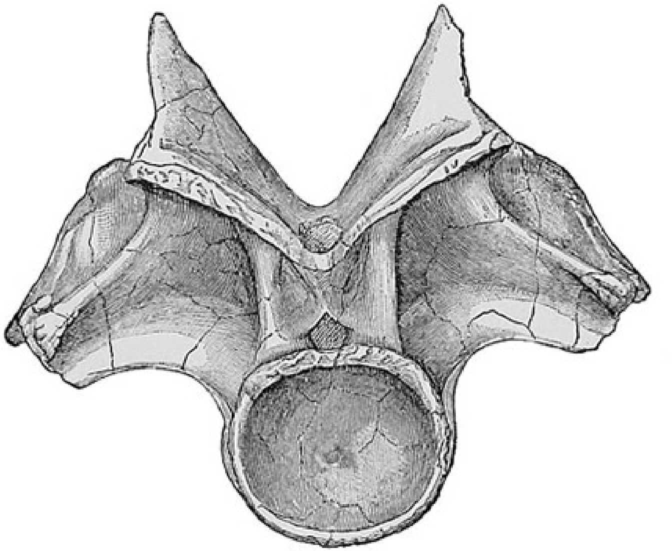
Neither is it surprising that entire skeletons are rare, for when a creature was as large as Brontosaurus, 60 feet long and 14 high, including yards of neck and tail, the chance of its being all preserved was naturally small. Even after a skeleton of such size had been buried in the mud or sand, and this had become stone, and, after long ages, finally brought to the surface of the earth, there were many opportunities for at least a part to be destroyed before man came to collect it. Thus it happens that while dinosaur remains may be common, really good specimens are rare.

The Sauropoda contain not only the largest species of dinosaurs, but by far the largest of known quadrupeds, creatures having twice or thrice the bulk of the largest elephant, and probably weighing from 15 to 20 tons. The size and weight of these animals was so enormous that it seems probable that they were largely aquatic in their habits and passed the greater part of their time in the water, where this great bulk would be buoyed up. This supposition is supported by the character of the bones and various joints, which indicate the presence of a great deal of cartilage, making them loose-jointed, while in land animals the joints are more firmly made and the bones forming them fitted closely together. Still this must not be held to mean that these big beasts passed *all* their time in the water, for they doubtless came out now and then to wander ponderously along the shore, and there must have been a deal of strength in the great muscles attached to their big bones. Besides, it is a dangerous matter to assert too positively what an animal could or could not do, for even living animals have a way of doing some very surprising things. In structure and general appearance these large dinosaurs were, so far as is known, very much alike; they had massive limbs with solid bones, rather short bodies, long necks and tails, and very small heads. The tail seems to have served as a counterpoise to the body, and if these animals did not rear up on their hind legs when on land, they surely did while in the water. As this would raise the head from 20 to 30 feet above the water, the animal could take a pretty comprehensive view of his surroundings, and possibly note whether or not one of his carnivorous brethren was after him.

The leg-bones of these sauropods are the largest bones known, and beside the thigh-bone, or femur, of one of these giants, that of an elephant appears small and slender. Still, newspaper “stories” have so magnified them that possibly the reader may feel a twinge of disappointment to learn their actual size. At present the record is held by the thigh-bone of a Camarasaurus in the Field Columbian Museum, which measures 6 feet 8 inches in length, and weighs, in its fossilized condition, 875 pounds. If this seems small, let it be remembered that this is 6 inches taller than a very tall man, nearly 1 foot taller than the average man, and that even before it was turned to stone it weighed as much as two large men together. Jumbo was a large elephant, much the largest ever seen in this country, yet Jumbo’s thigh-bone is but 4 feet 1 inch long, and slender at that, when compared with the femur of the dinosaurs.



The largest known bone. Thigh-bone of Camarasaurus, in the Field Columbian Museum. On the left the thigh-bone of Jumbo for comparison.



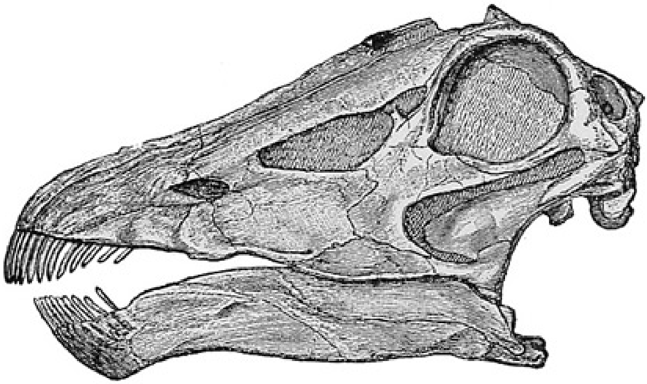
A vertebra of Brontosaurus.

The individual vertebræ of the neck and body sections of the great dinosaurs are very wonderful structures, not merely from their size, although they are the largest known, but for the manner in which they are built. The greatest amount of strength is combined with the use of the least amount of material, for they are made of many comparatively thin plates so put together as to be braced in every direction. So, instead of being massive, clumsy bones, they are, considering their bulk, light, while in many instances they were further lightened by being hollowed out at the sides. This is noted in the name of *Barosaurus*, air lizard, applied by Professor Marsh to one species in which this hollowing out was carried to a great extent. It is not easy to understand the structure of these remarkable bones even with the aid of a cut; they must be seen in order that their size and peculiarities may be properly appreciated.

The entire skeleton of Diplodocus is a trifle over 60 feet long, and stands 12 feet high just over the hips, where the animal was tallest. We are better acquainted with Diplodocus than with any of his relatives, because one very nearly complete skeleton of this monster has been found, besides large portions of various others, and concerning him we can speak very positively. The thigh-bone is about 5 feet long, but is more slender than that of other species. Brontosaurus was more massively built and a trifle larger, while Morosaurus was somewhat smaller, though still ponderous. The size of the Camarasaurus, from which came the great thigh-bone just mentioned, can only be estimated; but while the rule of three is not entirely to be relied on, this animal must have been not far from 80 feet long and 16 feet tall. And so far this is the very largest individual known, and the "monstrous reptiles one hundred feet in length" literally have not a leg to stand on.

How long was the life of a dinosaur? what would be considered a green old age for Diplodocus and Brontosaurus? did the length of their years correspond to the length of their body? Modern reptiles continue to grow practically as long as they live, and some have been known to attain an age that makes the three-score years and ten of man seem short in comparison. The Hon. Walter Rothschild has a tortoise brought from Mauritius that is known to have lived in that island for one hundred and sixty years. It had lived through two conquests and saw Mauritius pass from the Dutch to the French, and from them to the English, and each time it was specially mentioned in the treaty of surrender. And when this reptile was brought from Aldabra it was already noted for its size, and we may only guess at the years it numbered then. And if a tortoise may attain an age of several hundred years, why should not a dinosaur grow to be much older?

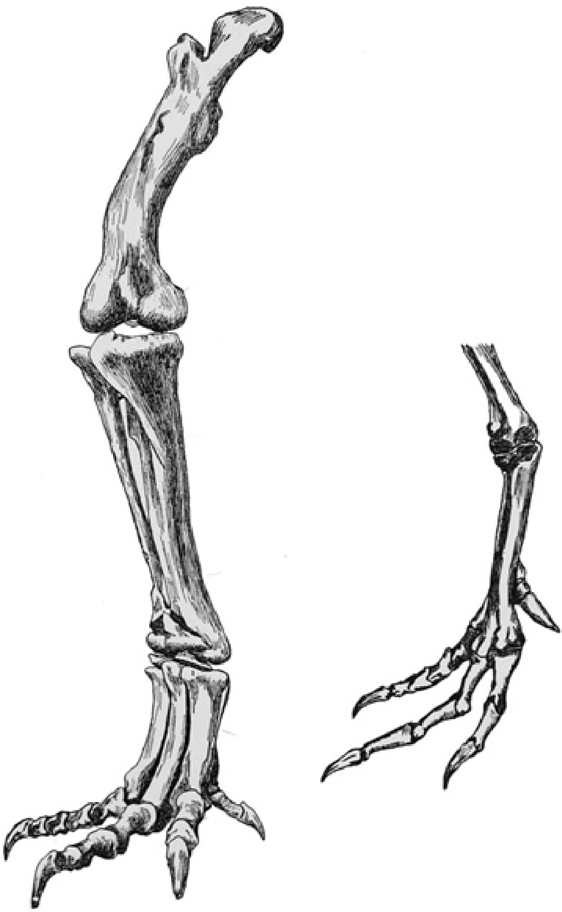
Certainly it must have taken Brontosaurus some time to have attained a length of 75 feet, or Camarasaurus to have grown a femur 6½ feet long. That dinosaurs kept on growing for many years we know, for they come in assorted sizes, and this is one of the difficulties that confronts the paleontologist, since he can place but little reliance on mere size as an aid in determining the ownership of a bone. So it is possible that these reptiles grew on and on through centuries in the days when the earth was young and time not worth a dollar a minute to the man of business. And there are those who think that the many yards of Brontosaurus, who might well have said with Kaa, "I *am* a good length," means a length of not less than five hundred of our years.



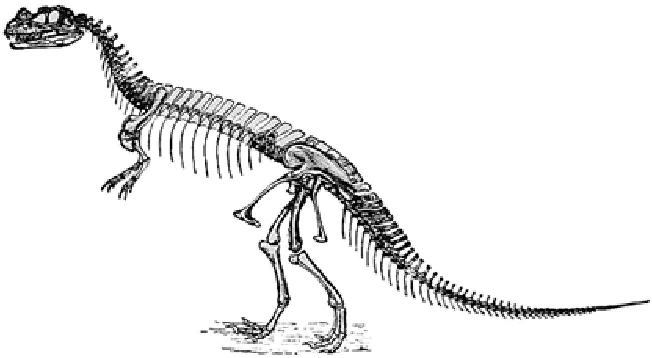
Skull of Diplodocus.

It was said that in this group of dinosaurs the head was small, and this may perhaps be suggested by trying to imagine an elephant brandishing a horse’s head at the end of his trunk. A queer combination surely, but so far as size goes no more disproportionate than Diplodocus. In none of these animals were the jaws very formidable, while in the oft-mentioned Diplodocus the teeth were so absurdly small for the apparent needs of the creature that it might be supposed he spent the greater part of the time in eating. But the vegetation of the time was luxuriant, for the climate was warm and ferns were then growing in Greenland, while lakes and marshes were scattered abundantly throughout our Western country. So taking all things into consideration—the structure of the animals and their surroundings—it is generally thought that these big reptiles haunted the streams and lakes, passing the greater part of the time in the water, alternately feeding on succulent water plants and basking luxuriously in the sun. It would have been an interesting sight to have watched Diplodocus in its native streams, its ponderous form reared amid the water like the hut of a lake dweller. Now the head would be plunged beneath the surface in search of food, now raised to the height of a small house to scan the shore for the approach of Allosaurus or one of his kin. And it is to be noted that the enormous bulk of one of these reptiles would enable him to stay in water so deep that the smaller carnivorous forms could reach him only by swimming, and thus would put the attacking party at a disadvantage. Or perhaps these huge animals slept during the day with the body submerged, and yet with the head resting comfortably on shore. There is a suggestion of nocturnal habits in the great eye-sockets, while the eyes were placed well back and at the sides, something after the fashion of a woodcock's eyes, though not in the extreme of the fashion. In one thing these animals were notably deficient, and that was in the important matter of brains. The strange anomodonts were called stupid, but the dinosaurs appear to have had no more brain than was absolutely necessary for life itself—not enough if judged by our high standards. Man has an average of about two pounds of brain to a hundred pounds of total weight, while the dinosaurs did not have one-fourth of this amount of brain to the ton. Here again Professor Marsh has embodied an idea in the name *Morosaurus*, stupid lizard, applied to one of these old giants.[26]

The giant Sauropoda culminated in the Jurassic, and their extinction during Lower Cretaceous time is believed to have been brought about by the sinking of the interior portion of our continent. This permitted the encroachments of the inland sea, the American Mediterranean, that stretched northwestward from the Gulf of Mexico. The marshy haunts of the dinosaurs became salt meadows, then shallows of the sea; the abundant aquatic vegetation disappeared, and the lumbering sauropods, accustomed to a life of ease, failed to adapt themselves to changing conditions and one by one dropped by the wayside.



Leg of Allosaurus, original 6 feet long. Foot of Apteryx, original 3 inches long.

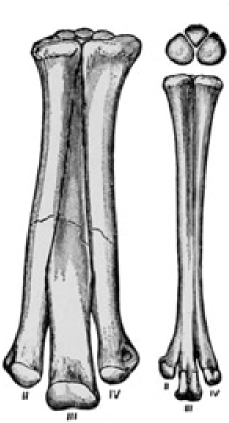


Skeleton of a carnivorous dinosaur, *Ceratosaurus nasicornis*; original 15 feet long. (After Marsh.)

The flesh-eating dinosaurs, Theropoda, as might have been expected from their habits, are of moderate size, small if compared with their great relatives, although the hind leg of Allosaurus was 7 feet long,[27] and the entire animal from 15 to 25 feet in length. Their teeth were simple in structure, but long, slightly curved, and compressed, with edges like extremely fine saws. As in other reptiles, teeth were renewed as fast as worn out, and as this happened at irregular intervals it gave the row of teeth a very jagged appearance. The limb bones were hollow, a characteristic of active creatures, though found in a few other dinosaurs, the claws sharp, in some species very much curved and very bird-like. The great claws of Ceratosaurus, the nosehorned lizard, bear such a likeness to those of a gigantic eagle that had one been found with the footprints of the Connecticut Valley it might well have been taken for that of some bird of prey, almost huge enough to have realized the fable of the roc. While the hind limbs were powerful, the fore limbs were small, often diminutive, indicating that the duty of holding prey devolved on the hind legs, while it was torn to pieces by the teeth. It is rather strange that the fore legs of these reptilian beasts of prey should have been so small, since this implies that they were neither employed for striking or holding. Certainly they were far too short and weak for walking, and indeed the larger animals of the Theropoda must have habitually walked erect. It may be that while these creatures were flesh-eaters, they were scavengers rather than active beasts of prey. It is a little suggestive that although many dinosaur bones have been found bearing the marks of fractures due to accident, in only one instance has there been any indication of tooth marks. These were on the tail-bones of a large herbivorous dinosaur,[28] and might well have been made after death.

The earliest known American dinosaur, Anchisaurus,[29] from the Trias, was a carnivorous species on a small scale, but one that must often have walked on all-fours. It is rather interesting as showing the progress of paleontology that when Anchisaurus was discovered, in 1820, the possibility of these fossils being human was seriously considered by several of the professors of the Yale Medical School.

It may also be noted here that the first dinosaur to be recognized as representing quite a distinct order of reptiles was the carnivorous Megalosaurus, great lizard, discovered near Oxford, England, in 1824.



Foot-bones of *Ornithomimus*, a dinosaur, and of a young turkey.

The Theropoda contains not only the oldest known and the smallest dinosaurs, but those whose structure most nearly resembles that of birds. While the general appearance of the feet of many species is much like that of birds, there is still one important difference. In all birds, even the early Archæopteryx, the metatarsals—the bones corresponding to those in the sole of our foot—unite to form one bone. The three bones are separate in very young birds, and they may readily be seen in the foot of a penguin. In dinosaurs these bones are always separate, but they are very much crowded together and come near uniting in a genus to which Professor Marsh gave the name *Ornithomimus*, bird-mimic. The members of this genus, too, have hollow bones and very bird-like claws, and are mostly small, so that in many ways they resemble birds.

The last group of dinosaurs to be considered, the Predentata, were, as indicated by their teeth and claws, all herbivorous, and it is easy to see that the big, horny beak would be most useful for cutting twigs and leaves. In their day grasses had not appeared, and none of the animals possessed such complicated grinding teeth as are found in the horse and cow and are especially adapted for fine vegetation. Still the adaptation of the Predentata to a diet of leaves and branches, and the general structure of their skeleton, which shows them to have been well fitted for life on land, gave them an advantage over the great, marsh-haunting sauropods, and they lived on through the Cretaceous. Besides the extra bone in the lower jaw, all had three toes on the hind foot,[30] though some of them were either too large, or not built right for walking on their hind legs alone. In the matter of size all were fairly large, while some were twice the bulk of an elephant and much the largest animals of their day.

The predentate dinosaurs appear in the Jurassic, and this period saw the development of the stegosaurs, or plated lizards, perhaps the most remarkable among them, if not the most remarkable of animals. They have often been described, but are quite too important to be omitted; besides, they are never described twice alike. The name *Stegosaurus* was applied to them on account of the presence of enormous bony plates and spines along the back and tail. There were two parallel rows of plates commencing just back of the head and continuing nearly to the end of the tail, which was armed with two pairs of huge spines. These plates were thin, from ½ to 1½ inch thick, and increased in size from the head to the hips and then suddenly decreased. While the neck plates were but a few inches broad and high, the largest were about 2½ feet in length and depth. Depth is used advisedly, for these plates stood on edge. They were placed far enough apart to permit freedom of motion, and appear to have been arranged alternately and not in pairs. The plates on the upper part of the tail were so small as not to interfere with the use of the tail spines, which were from 1 to 3 feet long, as weapons of offense and defense. And as the stegosaurs were from 15 to 25 feet long, according to age and species, the tail must have been rather formidable. The rest of the body, or at least a portion of it, was protected by small plates, or irregular rounded bits of bone about the size of marbles, embedded in the skin. These, as well as the plates, show that the skin was extremely thick, and altogether the stegosaurs were among the best defended of animals, and the most extraordinary.

Nearly all the examples of these animals come from Como, Wyo., the exceptions being two closely related species from England. This indicates that the stegosaurs were widely distributed and the continents probably united during the Jurassic period, for it is very improbable that such strange animals should have originated independently in two parts of the world.

Other species of dinosaurs there were, some like Laosaurus, small, some like Camptosaurus, of considerable bulk; but those just described are either the most striking or the best known. And here the story of the dinosaurs may rest for the present. In the chapters on Fishes and Amphibians species of two or more periods were considered together, the better to round out their history, and because they constituted the characteristic life of the various epochs. But while dinosaurs continued on through the Cretaceous, the forms were few and did not dominate the period as in the Jurassic. On the other hand, they helped swell the extraordinary variety of Cretaceous life, and their presence is necessary to complete the picture of the life of that time.

A modern cycad, *Cycas circinalis*, from the Moluccas.

A few words may be said concerning the foliage which formed a background for the dinosaurs. Old types of vegetation still lingered, horse-tail mosses and tree ferns abounded, as well as many primitive conifers, similar in some respects to those found in the Trias, while also having a suggestion of those of modern times. But the striking feature of the time was the abundance of cycads. These palm-like plants are relatives of that called by florists sago palm (*Cycas revoluta*), and at present there are but two species found in the United States. These are small, belong to the genus *Zamia*, and are confined to Florida. The Jurassic was the period of their greatest abundance, and large numbers, both of individuals and species, have been obtained from localities in the Black Hills, while others have been discovered in Maryland. The trunks only have been found, for the long fronds could be preserved only under exceptionally favorable circumstances. Owing, however, to their peculiar manner of growth the trunks include the leaf and flower buds, and by making sections of these Mr. Wieland has secured much valuable information.

Fossil trunk of a cycad, *Cycadoidea megalophylla*, from the Wealden Formation of England.

Among the more famous localities for dinosaurs are Cañon City, Colo., and Como Bluffs in Wyoming, whence came many of the specimens in the United States National Museum and the museum of Yale University. The famous Bone Cabin Quarry, from which the American Museum of Natural History has obtained literally tons of material, is partly in Albany County and partly in Carbon County, Wyo. The fossils from these localities are of the Jurassic period, and so are those from Albany County and the Freezeout Mountains, Wyo. From the Cretaceous rocks of Converse County, Wyo., have been taken all specimens of the great Triceratops so far found, and Laramie County, which adjoins it, has yielded many Cretaceous specimens. In the East dinosaurs have been found at Haddonfield, N.J., and at Muirkirk, Md., but in this last place bones are few and scattered, and the exact period they represent is still in dispute.

Compared with other periods, the time represented by the Jurassic is not of long duration. The strata in this country, as stated by Professor Osborn, are somewhat under a mile in thickness, the estimate of years not far from an even million. The principal features of the life of the time were the presence of large dinosaurs and small mammals; turtles, many related to our soft-shelled species, were common, and crocodiles numerous. The lung-fishes had become reduced to one or two genera, and armored fishes, relatives of our living gars, had increased. Thus, while the extraordinary size, remarkable appearance, and great abundance of dinosaurs make this group of animals so prominent as to overshadow all other forms of Jurassic life, yet these were by no means wanting.

Differences appear between the life of our continent and that of Europe, and for some reason North America seems to have lagged behind. These sea-lizards, ichthyosaurs and plesiosaurs, were common in Europe during the Jurassic, and so were the flying reptiles, pterodactyls. But here plesiosaurs are lacking, pterodactyls very rare, and ichthyosaurs represented by a toothless species. The absence of birds means less, for only two have been discovered elsewhere, and in course of time they may be found here.

CHAPTER VII

EARLY BIRDS AND MAMMALS

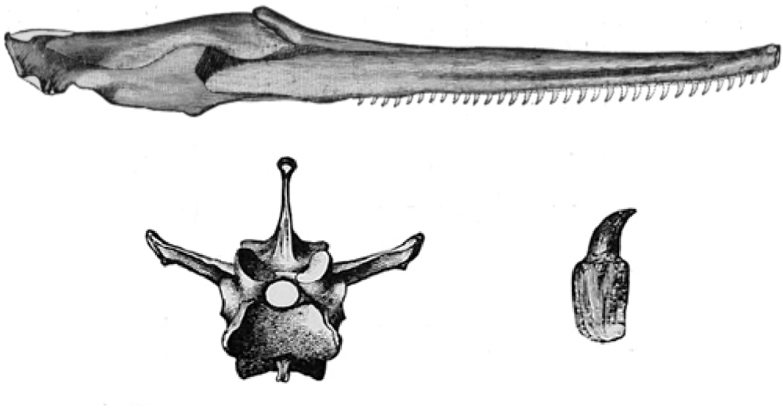
The history of early birds in this country is short, and contained wholly in rocks of the Cretaceous period. Before that time there is so far no trace of bone[31] or imprint of feather to hint at their existence. And yet birds there must have been, for a great proportion of the birds from the chalk cliffs of western Kansas are flightless species, and had been devoid of the power of flight for so long a period that only vestiges of wings were left. It may be asked what reason there is to suppose that the ancestors of these birds did fly, and the answer to this is that the character of the wing (in *Baptornis* at least) is such as to show that it must have been derived from a limb that once served a good purpose. Even the flightless birds of to-day bear about them some hints of descent from far-off ancestors that flew, while the very earliest birds known to us were birds of flight. It has indeed been suggested by some naturalists that Archæopteryx merely fluttered, and sailed from branch to branch, but the general opinion is that the creature flew fairly well.

The whole of the 15,000 living birds trace their pedigree back to the two specimens of Archæopteryx from the Jurassic rocks[32] of Solenhofen; but while this pedigree is long in point of time, it is short in material, for the reason that the links connecting the past with the present are lacking, still buried somewhere in the bosom of the earth. Moreover, as Archæopteryx had large and perfectly developed feathers and a thoroughly bird-like leg, we naturally expect to find back of him some animals of a much more reptilian type and with fore limbs less like wings. These forerunners of birds should have appeared in the Trias, and it is by no means impossible that some of the tracks in the red sandstone of the Connecticut Valley were actually made by such early birds or bird-like reptiles. Probably no paleontologist ever looks upon these tracks without an inward longing for a knowledge of the creatures that made them.

Many forms, too, are needed to bridge over the wide gap that now separates the birds of the Jurassic period from those of the Cretaceous, for the differences between them are greater than between the birds of the Cretaceous and the present. Instead of long tails with feathers arranged in pairs on either side, the Cretaceous species seem to have had the fan-shaped tails of existing birds;[33] instead of three-clawed and separate fingers, the bones of the hand were united and adapted to the support of feathers. Teeth, however, are still retained, and the freedom from one another of all the bones of the skull is a very reptilian character. One of the characteristics of modern birds is, that the various bones of the cranium unite at an early age, so that the cranium seems made of one piece, while among reptiles they remain free from one another throughout life. This has a direct bearing on the fact that birds soon reach their full size, while reptiles practically keep on growing as long as they live.

It may appear surprising that the existence of teeth in these Cretaceous birds, as well as in the Archæopteryx, was not recognized until some time after their bones had been collected, but it really is not. The presence of teeth is such an un-bird-like character that no one looked for them, while the teeth themselves are so small as not to attract notice, the more that they were so loosely implanted in the jaws that they readily fell out after death.

What does seem rather singular is that in course of time teeth should have ceased to be present in fish-eating birds, as such structures would certainly be useful in holding wriggling, slippery prey. It is all the stranger since some recent water-fowl have done their best to develop teeth, for the beak of the mergansers is furnished with a series of sharp tooth-like points, and there are sharp spines on the tongue as well. These, however, are developed on the horny covering of the beak, and thus belong in the same category as hair and feathers. A Cretaceous bird from England, *Odontopteryx*, presents still another modification, the margins of the bony jaws themselves being produced into sharp points to serve as teeth.



Jaw, vertebra, and single tooth of *Hesperornis regalis*. The vertebra and jaw are smaller than the originals, and the tooth is twice natural size.

Nearly all our known Cretaceous birds have been found in the chalk cliffs of Gove and Logan Counties, western Kansas, and belong to at least two distinct orders. One, *Odontolcæ*, contains large, flightless diving birds, having teeth implanted in a groove. The other, *Odontotormæ*, comprises species having teeth in separate sockets, and some of the vertebræ with cup-shaped ends, as in fishes; the birds of this order so far found are about the size of a small gull and were gifted with the power of flight.

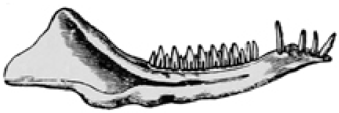
The largest of these birds was *Hesperornis regalis*, the royal Western bird, a species somewhat larger than the king penguin of the southern seas, measuring about 4½ feet from tip of bill to end of tail. Hesperornis was very differently built from any modern water-bird, being more elongate and narrower back of the hip-joints, and with a much longer and stronger tail. This would indicate that the tail served as a sort of horizontal rudder, after the fashion of those used in one of the new submarine boats, to direct the course up or down. Turning to the right or left would be readily accomplished by a slight change in the direction of the stroke of one of the powerful legs. And in respect to these same legs Hesperornis was different from any other bird with which we are acquainted, for the lower joint, or tarsus, was not directed downward, but outward, so that the legs projected on either side like a pair of oars. This is a most remarkable way for a bird to carry its legs, but it is clearly indicated by the various articulations. How the bird managed these legs when it came ashore is a puzzle; and it had no wings to help it scramble along on all-fours, as penguins sometimes do when in a hurry. The loon is said to be rather helpless on land and to pitch forward on its breast in a very awkward manner, but our Cretaceous diver must have been still more badly off. There is just a possibility, suggested by the backbone, that it may have humped itself along (there is really no other expression) after the manner of a common seal. It is probable that this bird rarely came ashore except at the breeding season, and on the water it was perfectly at home. *Hesperornis gracilis* was, as its name indicates, of more slender build than its royal relative, and much smaller, being not over one-fourth the weight of the other species. These birds were clad in rather coarse feathers, a little like those of the emu, but not so long. This is known from the impressions of feathers preserved in the chalk.

The birds of the genus *Ichthyornis* (fish bird[34]) differed decidedly from *Hesperornis* in possessing the power of flight, although this is not the reason why they are placed in another order. That is done on account of the differences between the birds in the backbone, teeth, and other parts of the skeleton. No species of Ichthyornis was larger than a small gull or a large tern, birds that they doubtless resembled in habits and very probably in appearance. The nearest living relatives are distant and uncertain, but are believed to be the cormorants.

So far no relatives of our toothed Cretaceous birds have been discovered abroad; but fossil birds are rare at the best, so this is not to be wondered at.

The majority of our Cretaceous birds have been found in Kansas, where they lived and died about the borders of the great inland sea. One or two came from Texas and the remainder from New Jersey, but whether these last were toothed or toothless we do not know, for few bones even have been found and no skulls. Besides these there is an egg, or rather the cast of an egg, from the Cretaceous of New Mexico, apparently that of some water-fowl. All these species were either swimming or wading birds, and their fossil remains all occur in rocks that were formed in the sea.

It can easily be seen that our knowledge of early birds is very limited, nor is it much greater concerning those of a later period, for deposits that have yielded abundant bones of mammals have been utterly barren of birds.



Jaw of Dromatherium, the earliest known mammal. Twice natural size. (After Emmons.)

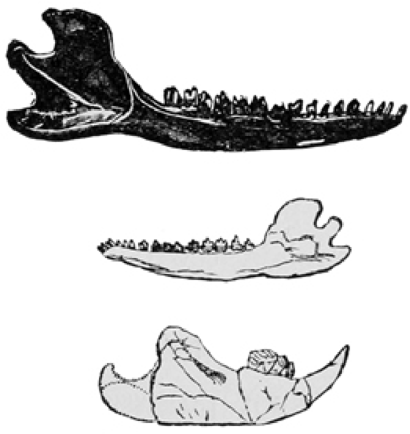
If North America can not as yet claim any examples of the most ancient birds, it at least stands foremost with mammals, for while these date back to the Trias both here and in Europe, the first of them to be discovered was in Chatham County, N.C. These Triassic mammals were described by Ebenezer Emmons so long ago as 1853 on the evidence furnished by three jaws, two of which were imperfect. These represent two species, respectively named *Dromatherium silvestre* by Professor Emmons and *Microconodon tenuirostris* (slender-nosed, minute cone-tooth) by Professor Osborn. Only one of them seems to have been preserved, and as none have been found since, the early history of mammals in this country is necessarily brief. It is still shorter abroad, for in Europe not even jaws have been found, only teeth. And recently Dr. A. S. Woodward has cast a shadow of doubt over all these Triassic mammals by suggesting that, after all, they may prove to be anomodonts, those curious mammal-like reptiles described in a previous chapter.[35] But at present these ancient species are placed with the marsupials, or pouched animals, and in the subdivision called Polyprotodontia (many front teeth), the one which contains our common opossum. The specimens indicate small quadrupeds; the jaw of Dromatherium is but nine-tenths of an inch long, and the small, sharp-pointed teeth say that they were either carnivores or insect-eaters. This is practically all that can be said of the Triassic mammals of North America.

When we come to the Jurassic, however, we find as associates of the great dinosaurs numerous small mammals, utterly insignificant, so far as size goes, in comparison with those huge beasts; and if the dinosaurs had been capable of thinking at all, they would probably not have given their diminutive contemporaries a first thought, to say nothing of a second. And yet the one type was on the decline, while the other was starting on a career that would bring it to the first place in the animal kingdom.

The early mammals are, with rare exceptions, known only from their teeth and imperfect jaws, and these are all we find until much later on. These specimens indicate small animals, ranging from the size of a mouse to that of a rat, and without exception flesh-eaters or insect-eaters. Some were related to the marsupials, while others were relatives of those egg-laying mammals, the echidna and platypus,[36] in spite of the fact that these have no teeth. But study of the very young stages of platypus has shown that teeth are then present, and while these fail to develop, their presence indicates that teeth existed and were used by the far-distant ancestors of these animals.

Owing to the numerous small points or tubercles on the grinding teeth of these Jurassic monotremes, the order in which they have been placed has been named Multituberculata.

The jaws of some of these little multituberculates show a very curious set of teeth; two in front, something like the lower teeth of a rat, and back of these three that seem made for cutting or shearing only. Without a knowledge of the skeleton it is difficult to say much as to probable food and habits of the owners of these teeth, but it is likely that they fed largely on insects. The teeth of insectivorous animals are usually provided with numerous small points for holding and crushing such hard and smooth objects as beetles, and these shearing teeth may have served a similar purpose. Special modifications have some relation to special habits or to some particular kind of food and peculiar manner of getting it.



Jaws of Jurassic mammals, enlarged. Amphitherium, Triconodon, Plagiaulax.

One of the best instances of this is to be found in that remarkable lemur, the aye-aye, in which the jaws are very powerful and the front teeth like those of a rodent, while the second finger is wonderfully long and slender. The meaning of these peculiarities is clear when we know that the aye-aye feeds largely on wood-boring grubs. The sharp front teeth cut readily through the bark and wood in which the grubs dwell, and the long finger is used to coax them out of their burrows. So, if we only knew the food of some of these old animals, the reason for the strange shape of their teeth might be evident.

A peculiar feature of some of the early marsupials, the polyprotodonts, is the number of their teeth. Nowadays no mammal save the porpoise has more than 44 teeth; but Dromatherium possesses 56, and Stylacodon no fewer than 68. This abundance of teeth is a slight suggestion of affinity with reptiles, in which, it may be remembered, teeth are numerous, but of one pattern in any given species.[37] And it may be recollected, too, that in speaking of worms and trilobites it was noted that mere repetition or multiplication of similar parts is no real increase in complexity of structure, although it may appear so at first sight.

Throughout the Jurassic period, and it may be added throughout the Cretaceous as well, the mammals, so far as we know, were all small, and belonged to those low types, the monotremes or the marsupials. Also, these were all of insectivorous or carnivorous habits, for no remains have as yet been found to indicate that any herbivorous mammal existed before the Eocene period. These conditions prevailed not only in North America, but apparently the world over.

To-day these groups of animals are almost confined to Australia and a few of the adjoining islands—almost, but not quite, for a few species of opossums are still to be found in America, and one in the United States, and the common opossum may justly claim to belong to the first family of Virginia. The mammals of Australia, with two or three trivial exceptions, are marsupials, although in variety and size they have progressed far beyond their primitive ancestors. This shows that at an early date in the history of mammals this great continental island was cut off from all other land, and has thus remained unaffected by the changes that have taken place elsewhere.

The story of Cretaceous mammals is as brief and unsatisfactory as that of the Jurassic, and, like that, is interpreted from teeth, jaws, and fragmentary bones. A few more species are known, but all from this continent are small, and the majority belong to the order Multituberculata, some representatives of which endured even into the Eocene. So far as mammals are concerned, the Cretaceous period is like the Jurassic, and until the disappearance of the dinosaurs mammals made practically no progress. Not that there was any competition between the two, but that conditions favorable to one seem to have been unfavorable to the development of the other.

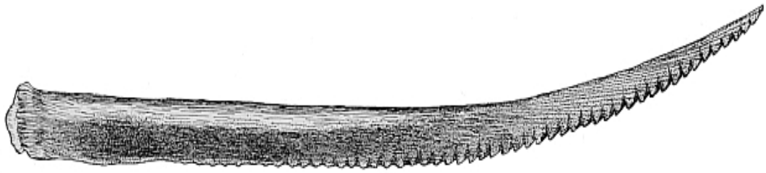
Most of the specimens come from the Laramie beds of Converse County, Wyo.—the same beds that have yielded the bones of the great dinosaur Thespesius, and his still larger associate, Triceratops.

It may be of interest to know how the small, scattered teeth from which the early mammals are mostly known are obtained. It may be readily supposed that they could not be gathered in any considerable numbers by crawling about over the ground and laboriously picking them up one by one. True, many are gathered in just that fashion, but far greater numbers are obtained by taking quantities of the sand in which teeth occur and running it through sieves of various sizes. Finally, ants have been pressed into service as collectors of small fossils. These industrious little insects, in digging their long galleries, bring to the surface the grains of sand that are heaped up to form an ant-hill, but they bring up as well the teeth of Cretaceous mammals. It was that skilled paleontologist and unrivaled collector, Mr. Hatcher, who discovered this trick of the ants, and utilized it by digging up many an ant-hill and shipping it East, there to be sifted and sorted at leisure.

CHAPTER VIII

DRAGONS OF SEA AND AIR

If the Jurassic was remarkable for the size and number of its dinosaurs, the Cretaceous period was even more noteworthy for its variety of extraordinary reptiles—Nature's final effort before settling down to the creation of every-day animals. The last of the dinosaurs flourished during this period; the seas teemed with strange reptiles, plesiosaurs and mosasaurs, while accompanying them was the largest turtle known to us, and the largest of true or bony fishes. The life of the air was quite as strange as that of the land and sea; birds had not attained their full development, but existed in curious shapes with toothed beaks,[38] while the true rulers of the air were flying reptiles (pterodactyls), which were, on the other hand, toothless.



The saber fin of Protosphyræna, original 2½ feet long.

Among the changes that took place in Cretaceous animals were the replacing of the older sharks by those belonging to modern genera, the dying out of the armored or ganoid fishes, and the multiplication of fishes similar to those that exist to-day. Fierce predatory fishes, distantly related to the modern barracouda,[39] abounded, one—aptly named *Protosphyræna*[40] *penetrans*—having its nose formed by a sharp, projecting bone, something like the sword of a swordfish, and although much shorter, apparently equally penetrating. A close relative, called from its supposed pernicious habits *Protosphyræna perniciosa*, had side fins that were a combination of saw and saber. These fins were about 2½ feet long, gently curved, notched like a saw on the under side, and attached to the shoulder by an unusually strong joint. Did this fish dash in among a school of smaller fishes, striking, maiming, and killing with strokes of its wicked-looking fins? It seems very probable; but that is really about all that can be said, for we have no similarly armed living fish to guide us. It was some time after the discovery of this fish before an entire fin was found, and the portions discovered were so different that the fish received two names, based on different parts of one fin.

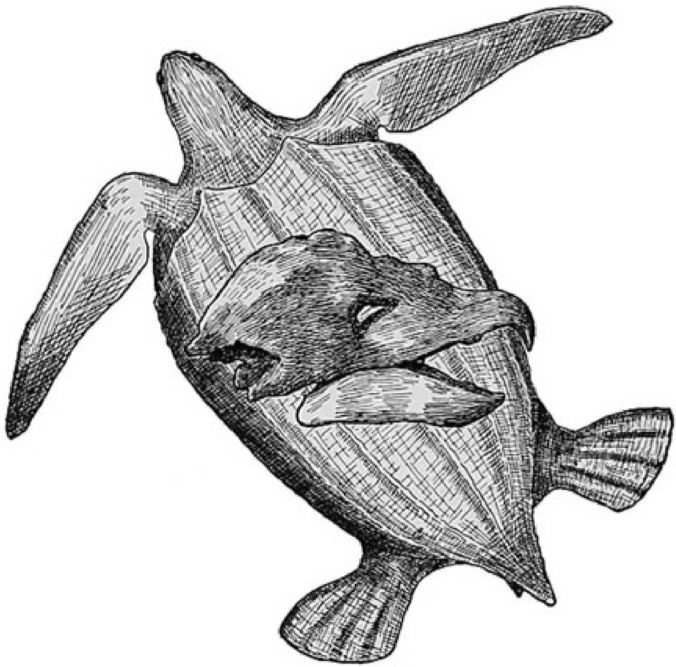
The real king among fishes—and a tyrant he must have been—was a far-off relative of that modern "silver king," the tarpon, so dear to the angler's heart. *Xiphactinus audax*,[41] as this is called, is found abundantly in the Kansas chalk, and occurs also in Texas. It reached a length of 10, 12, or even 20 feet, and the great forked tail by which he was propelled is from 3 to 4 feet across. The silver king of to-day is practically toothless, his teeth are so very small, but this Cretaceous king had the front of his massive jaws armed with a number of spike-like teeth from 1 to 2½ inches long, and back of these were a few small, sharp, cutting teeth.

This fish had at least two smaller relatives with equally well-armed jaws, but next to him in size was one of the salmon family, *Pachyrhizodus*, thick-rooted tooth, which attained a length of 8 feet.

There were many other smaller fishes, but almost without exception they carry a badge of predatory life about them in the shape of teeth fitted for cutting, tearing, or holding. In fact, while all through the previous history of the world the majority of animals were flesh-eaters, Cretaceous time seems to have witnessed an unusual development of large and powerful species.

Modern types of sharks were appearing, including the first examples of such genera as *Carcharodon*, *Carcharias* and *Lamna*. These contain the largest existing predatory sharks, those popularly known as "man-eaters," although there seems to be some doubt as to their actually attacking man. Some of the pavement-toothed species, however, still existed, those of the genus *Ptychodus* being abundant, and specially noticeable for their massive teeth, most admirably adapted for crushing crabs and shell-fish. That these formed their principal food is indicated by the wide, flattened mouth, which shows that these fishes were bottom-feeding creatures.

Crocodiles and turtles were numerous, and the latter comprised some fresh-water species, and some that were exclusively marine. Among these last was the great sea-turtle, called by Mr. Wieland *Archelon* (ruling turtle), because he was the largest of turtles, either living or fossil. The greatest turtle now in existence is the sea-roving leather-turtle, or sphargis, that never comes ashore save to deposit its eggs and perpetuate its kind. The scientific name of *Dermochelys coriacea* (leathery-skin turtle) relates to the appearance of the animal, and so does the popular appellation of leather-back turtle; for, unlike other turtles, this has no covering of plates of bone united with the backbone and ribs. Instead, the upper shell or carapace is formed of hundreds of small irregular pieces of bone embedded in thick skin, and a skilful hand can remove all the skeleton from the shell. This species, considered to be a relative of the great extinct Archelon, attains a very respectable size, a full-grown specimen measuring 7 to 8 feet in length and weighing from 700 to 1,000 pounds. But the skull of Archelon was a yard long, the total length from 12 to 14 feet. The weight can only be guessed at, but as turtles are solid animals, this could not have been far from 2 tons. To forestall the inevitable remark as to soup, it may be said that if it resembled the modern leather-turtle, the flesh was uneatable. The great fossil sea-turtle had a scanty and thin covering of bone, somewhat like that of the modern species, and, like him, was undoubtedly a sea rover. Such great weight could with difficulty have been dragged over the sandy shore. Archelon comes from the upper part of the Cretaceous beds, and is looked upon as the descendant of another turtle found in the lower portion of the same system.



The largest living turtle, Sphargis, compared with the skull of the fossil Archelon. The original skull is 3 feet long. (After Wieland.)

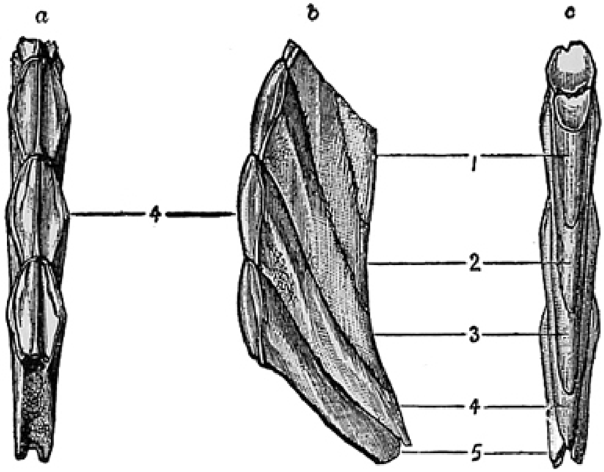
For it must not be forgotten that the interval of time between the lower and upper part of a series of rocks is very great; so that while the general character of the life in the system is the same, various portions, or strata, have their own peculiar animals.

The most characteristic feature of the life of the sea was the presence of numerous large reptiles called mosasaurs, from the name *Mosasaurus*, or lizard of the Meuse, given to the first described species. These animals had a long, pointed head, 4 short swimming paddles, and a long, powerful, compressed tail, something like that of a salamander on a very large scale. This tail was the principal agent in locomotion, although the paddles undoubtedly helped. The animal possessed no armor, for the body was covered with small horny scales, as in modern reptiles. There were several kinds, or genera, of these creatures ranging in size from 6 to 45 feet in length,[42] although examples over 25 feet long are rare, and those 15 feet long may be considered large. Mosasaurs abounded in the waters of the inland sea, for hundreds, if not thousands, have been found in the Kansas chalk, but they were also present along the coast of our Southern and Gulf States. They were indeed a widely distributed group, and will probably be found to have existed in all Cretaceous seas, for they are known to occur in the rocks of South America, Europe, and New Zealand.

The mosasaurs are related somewhat distantly to the true lizards, and the skull is in many respects like that of varanus, a group of lizards found to-day in Asia, Africa, and Australia. On account of their rather slender form, as well as on account of some features in the skeleton, Professor Cope gave to the order in which he placed these reptiles the name of Pythonomorpha, or python-formed. They seem to have taken the place that had been occupied by the ichthyosaurs and plesiosaurs in the Jurassic, and when these declined the mosasaurs became the monarchs of the sea. The teeth were sharp and strong, and fishes formed the most important portion of their diet, although there is reason to believe that they were to some extent cannibalistic and preyed upon their smaller relatives. With such fishes as Xiphactinus present and numerous, it seems as though the reign of the mosasaurs could not have been entirely peaceful.

Other dragons of the sea were the plesiosaurs, great marine reptiles that dwelt in the inland sea with the mosasaurs and swam about our eastern and southern coasts. For the most part they were not the typical species so familiar to us from books, with small heads and long necks, but large-headed, short-necked animals, although plesiosaurs in structure. Long-necked forms were not, however, entirely absent, for these were represented by species of the genus *Elasmosaurus*. There is a parallel to this among turtles, for the short-necked sea-turtle and long-necked, soft-shelled species of our Southern and Western States are both unmistakably turtles, although quite unlike in their proportions and appearance. The plesiosaurs are among the numerous examples we have of the manner in which Nature attains the same end by different means. With mosasaurs the tail was the chief means of propulsion, and the short paddles merely aids to locomotion, but in plesiosaurs the tail was short, serving mainly for a rudder, and swimming effected almost entirely by the greatly developed paddles. In this group of reptiles, as with pterodactyls, the life of our continent seems to have lagged somewhat behind that of Europe, for while they abounded there during the Lias, the lower or earlier part of the Jurassic, here we do not find them until the Cretaceous is reached.

Dinosaurs no longer completely dominated the world of living beings as they did during the Jurassic, but they still formed in North America, as elsewhere, an important portion of the fauna.



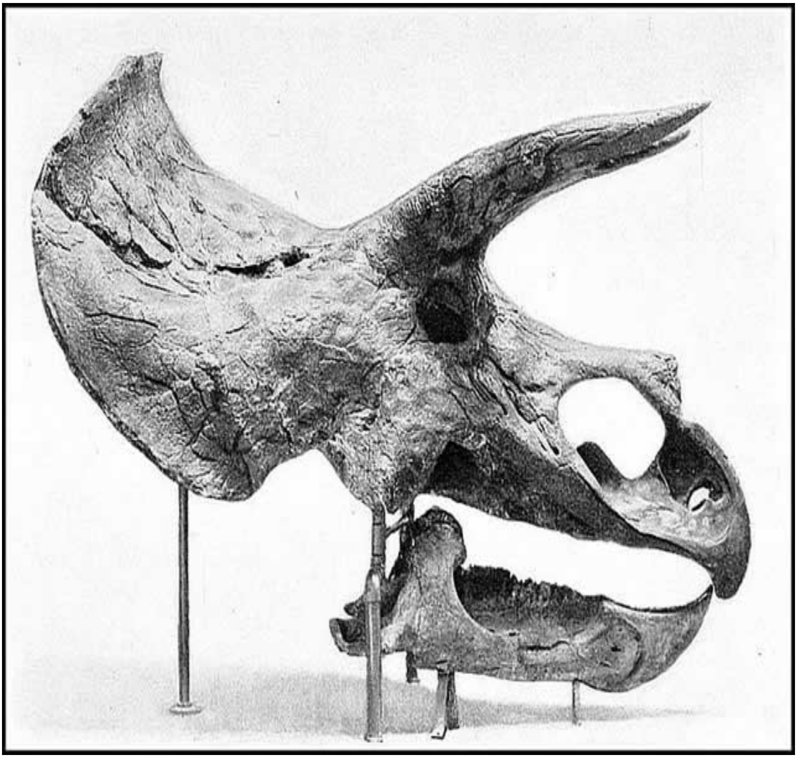
A single row of teeth of the dinosaur Thespesius, showing the manner in which they succeed one another. There are 400 of these teeth in each half of the lower jaw. About ⅔ natural size. (After Marsh.)

The best known and presumably commonest dinosaurs of the Cretaceous were the predentate iguanodons,[43] represented here by Thespesius and his relatives, which ranged over a wide extent of territory and have been found in a very complete state of preservation. In some instances this completeness is thought to be the result of animals having been engulfed in some treacherous quicksand, for not only are all the bones present, but, what is very unusual, they are all in their proper places. The thigh-bones are in the sockets, the ribs curve outward from their respective vertebræ, even the bony tendons that lay in the muscles running from the back to the tail have remained just as they were when death overtook the animal. More than this, in rare instances even the impress of the skin with its small, irregular, horny scutes is preserved in the rock, so that in this instance we are not obliged to guess at the character of the covering. They were long-headed animals, these same Thespesii, for the skull measures more than a yard in length, and as they walked erect on their huge three-toed feet the top of the head was from 10 to 12 feet from the ground. From nose to tail a full-grown animal—such as the fine example at Yale—was from 25 to 30 feet long; and this same tail was not dragged along after the slovenly manner of a modern street dress, but carried clear of the ground to counterbalance the weight of the body. The fore feet were enormous paws, with 4 long, slender fingers, one of which served as a thumb, so that the animal could grasp and pull down branches. Terrible to look at as this dinosaur must have been, it was probably inoffensive, for the great animal was strictly herbivorous and the teeth small, although to make up for this lack of size there were literally hundreds of them. For reptiles have an advantage over us, in that as fast as a tooth is worn out it is replaced by an other, tooth after tooth being pushed up from below. In Thespesius the teeth were arranged in a mosaic pattern, and either half of the lower jaw contained something like 400 teeth. It may have been an ancestor of this creature that made some of the tracks in the Connecticut Valley, for the tracks of the European iguanodons have been found showing the very wrinkles of the skin.

Imagine a score of these animals stalking along the shore at Atlantic City—and they lived near by—what a feature they would form in the landscape! And to think that puny man could lay one of these monsters low with a single shot from a 30.30 rifle—what a triumph of mind over matter!

The most complete examples of this family have come from Converse County, Wyo., but incomplete individuals have been found in New Jersey and in Mississippi. From the manner in which this last-mentioned specimen occurred—in a marine deposit in company with oyster-shells—it seems probable that it had been carried away from home by a flood, and had drifted to this locality.

Associated with Thespesius in time, but apparently restricted in territory, were the huge dinosaurs of the genus *Triceratops*, three-horned face. These, too, have been often described, and yet can not be omitted here any more than elephants could be left out of a description of the animals of Africa, simply because they were well known. With one exception specimens of this animal have come from Converse County, Wyo., and no relations have been found abroad. They were huge creatures, the largest 25 feet long and 10½ high, or about twice the bulk of an elephant. The most noticeable feature was the presence of a horn over each eye, and the extension of the skull backward into a sort of overhanging frill. Now and then a Triceratops had a short horn on the nose, in addition to the large horns over the eyes, but this was the exception rather than the rule, and we do not know yet whether the presence of this horn was found only in the males of some species, or is the mark of a distinct species.

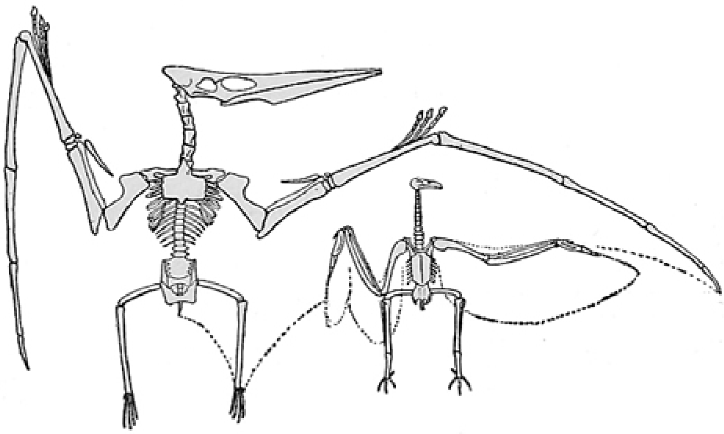


Skull of the Great Triceratops.

Original five and one half feet long.
From the specimen in the United States National Museum.

While the structure of the teeth and jaws indicates that none of the herbivorous dinosaurs ground their food after the manner of horses and cattle, the jaws of Triceratops were even more strictly confined to cutting than were those of other species. The lower teeth were flat on the outer face and the upper teeth flattened on the inner side, and they slipped by one another much like two coarse saws, shearing off anything that might be between.

These dinosaurs were among the last of their race, although their enemies, the carnivorous Theropoda, endured with and probably preyed upon them to the end. But dinosaurs ended with the Cretaceous, and after that mammals, which had been struggling along in a small way, took possession of the earth.



Skeleton of the great pterodactyl Ornithostoma compared with the skeleton of a condor.

A still higher type of reptilian life was present in the shape of pterodactyls, or flying reptiles, and in view of the apparent scarcity of birds these may well have laid claim to the empire of the air.[44] They are placed first in their class on account of their high degree of specialization, their entire skeleton being modified to adapt them to life in the air. They depart most from the general structure of the class, are more unlike the composite picture we have in mind when we say reptile. Like the plesiosaurs, they seem to have been a little slow in reaching America, for while they were abundant in Europe during the Jurassic period, here they are rare until the Upper Cretaceous is reached. In time we may be able to trace the route by which they passed from the Old World to the New, but now we can only say that around the inland sea they reached an extraordinary degree of development in numbers and size. They were not present, however, in as many curious forms as in Europe, for Professor Williston recognizes but two genera, *Nyctodactylus* and *Ornithostoma*, both of which were toothless. But if our dragons of the air, as Professor Seeley calls them, were few in species, they make up for it in the size of the individuals, for Ornithostoma was the largest of flying creatures. A large condor spreads 10½ feet from tip to tip of wings, the albatross at times does a little better, but Ornithostoma reached 10 feet when he was young; in his prime he had an expanse of wing of 20 feet. And if his beak was toothless, it was a yard or more long and as sharp as a dagger, while the entire skull measured nearly 4 feet in length—45 inches, to be quite accurate.[45] The structure of this great flying creature was a marvel of lightness not exceeded by that of a racing yacht, and the largest of the fingerbones was no thicker than a sheet of blotting paper, though it was 2 inches in diameter and something over 2 feet long. The entire skeleton, even when petrified, weighs but 5 or 6 pounds, and Professor Williston puts the weight of the living animal at not more than 25 pounds.

The shoulder-joint that supported the big wings of Ornithostoma was strongly and uniquely braced, being formed by a stout **V**-shaped bone, which represents the two bones of a bird's shoulder-joint known as coracoid and scapula. In man, and all mammals save monotremes, the shoulder-joint is formed by the shoulder-blade only, and the coracoid is reduced to a little process. The lower arm of the **V** was supported by the breastbone, while the upper rested against the backbone, three joints of which were united to give a firm point of attachment. From the structure of Ornithostoma it is entirely probable that it sailed, and did not fly, by strokes of the wings, and the long toothless beak, strong neck, and remains of fishes found with its bones suggest that it lived on fish.

Ornithostoma was at once the largest and lightest of flying creatures, exceeding in this respect even the frigate-bird, although that might almost be termed an appendage to a pair of wings.

These flying reptiles naturally suggest the question as to whether Ornithostoma, the wild swan, and the condor mark the limit of size attainable by flying animals. They vary in spread of wing from 20 feet in the pterodactyl and 10 feet in the condor to 8 feet in the swan. In weight they approach one another more closely, a large condor weighing about 20 pounds,[46] a swan 25, and a pterodactyl (estimated) 25 to 30 pounds. The swan flies by strokes of its wings, the condor soars, the pterodactyl probably sailed. Are the difficulties in the way of using wings so great that evolution has stopped at a weight of 30 pounds and a spread of 20 feet? The reader may answer this question to suit himself or herself; the above figures represent the known facts in the case.

We can imagine this reptile sailing swiftly over the sea, snapping up fishes right and left, but from our standpoint it is a little difficult to imagine just what it did with its long wings and beak when it came ashore. One can not help thinking that they must have been sadly in the way, the more that the hind legs were small and weak, and the hands represented by 3 small fingers only. The wing of a pterodactyl, it may be said, is built on a totally different plan from that of a bat, and is still less like that of a bird. Instead of a wing membrane supported by the bones of the fingers, that of the pterodactyl was spread by means of the enormously developed little finger.

Judging from other reptiles, the young were hatched from eggs, and small eggs at that, as the pelvis was narrow. But did Ornithostoma build nests, like birds, or bury the eggs in the sand, leaving them to be hatched by the heat of the sun? And what a curious sight it must have been to watch Ornithostoma bringing home fish to feed the little ones, for this is something it doubtless did do, since the young could hardly be expected to care for themselves at the outset.

Professor Seeley, our best authority on pterodactyls, thinks that resemblances between them and birds are more than superficial. He considers that they were both derived from a common ancestor, and diverged to form two quite distinct groups of animals. This, however, is an extreme view of the case, and the generally accepted theory is that those characters wherein the pterodactyls most nearly approach birds are the result of modifications connected with the power of flight. But why did the flying reptile prove inferior to the bird? what is the weak point in his structure that caused him to fail? Bird and pterodactyl started together in the Jurassic, and up to the Cretaceous the latter seems to have had a decided lead, for bones of pterodactyls are far more numerous than are those of birds. But at the close of the Cretaceous flying reptiles suddenly disappeared, and it has been suggested that in the covering of feathers, which enabled them to withstand changes of temperature, birds found their great advantage.

It has generally been taken for granted that pterodactyls were naked, like other reptiles, although Professor Seeley has barely hinted that some sort of a covering may have been present. The latest contribution to the subject is by Professor Williston, who found under the thigh-bone of a very fine specimen of Nyctodactylus "very vivid markings of the integument." There was "no direct evidence of either scales or feathers, but the numerous, regularly placed patches of darker material are such as might have been produced by the skin of a bird where there are many feathers." He is "convinced that the integument was not a simple smooth membrane over the body, though what it really was he is not prepared to say."

This brings the history of our continent down to the close of the Cretaceous period, which ends the Mesozoic era or, as it is sometimes called, the Age of Reptiles, because these animals were the marked feature of the life of the time.

The Cretaceous period is distinguished by the abundance of great marine reptiles, by the presence of pterodactyls and some groups of dinosaurs, and by the final extinction of all these groups of animals.

Bony fishes came into prominence, as well as sharks of modern types; the first known birds, so far as this continent is concerned, make their appearance; and mammals were apparently not uncommon in some localities. But these were insignificant in size, and formed an unimportant feature in the life of North America.

Vegetation had progressed with the animals, and in the upper beds are found such familiar forms as sycamores, tulip-trees, and magnolias, the general aspect of the forests being not unlike those of our Southern States. This in spite of the existence of true palms, which appear in the Upper Cretaceous, while cycads continue to lend a tropical coloring to the flora, although these plants are by no means so numerous as in the Jurassic.

Toward the close of the Cretaceous there took place the most extensive upheaval that has occurred on our continent, giving rise to the Wasatch, Uinta, and Rocky Mountain ranges. The disturbance continued along the “backbone of the continent” and affected South America as well, and it was accompanied in places by the bursting open of the earth and the outpouring of vast floods of lava. These changes had a far-reaching and almost immediate effect upon the life of the period. To some extent this was probably direct, by destroying many animals outright; but the most sweeping effects must ultimately have been due to changes in climate and subsequent changes in vegetation.

“The disappearance of species at the close of Mesozoic time was one of the most noted in all geological history. Probably not a tenth part of the animal species of the world disappeared at the time, . . . yet the change was so comprehensive that no Cretaceous species of vertebrate is yet known to occur in the rocks of the American Tertiary, and not even a *marine* invertebrate. . . . Here ended not only the living species of dinosaurs, of mosasaurs and pterosaurs, but these tribes of reptiles.”[47]

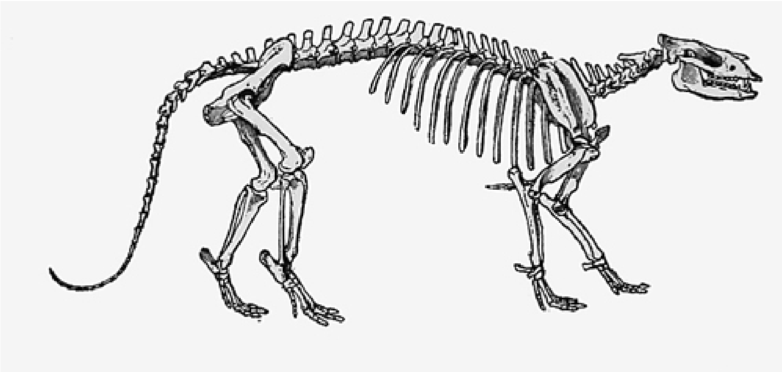
Thus the competitors of mammals were swept out of existence and they were left free to develop.

CHAPTER IX

THE RISE OF THE MAMMALS

The rule of reptiles came to an end in the Cretaceous, and with the Eocene the mammals assumed the supremacy; the name Eocene, dawn of the recent, being given to this period of time because it marks the beginning of the present order of things. Mammals, as we have seen, existed at the time of the dinosaurs, but were then both scarce and small, as they apparently still were during the Cretaceous period. That they now appear in North America in numbers, and include species of considerable size, means that this is another of the cases where links in the chain of life are missing. They must have been developing during the Cretaceous in some locality yet unknown to us, or so many diverse forms would not be found in the lower rocks of the system. Thus at the very outset we find representatives of several orders and not far from a score of families; and while not one of these families has endured to the present time, yet they were the forerunners of our existing wolves, cats, deer, and horses.

These mammals of the Lower Eocene beds were of what is termed generalized types; that is, they were built on the same general plan. This generalization of structure is shown by the fact that Professor Cope said of certain species that in the absence of the bones of the feet it could not be said whether they were lemurs or insectivores. And later Dr. Matthew decided that some at least were rodents. None of them were very greatly modified for any particular mode of life or kind of food. Such a foot as that of the deer, so clearly fashioned for speed, does not appear among them, nor is any animal to be found with the sharp, retractile claws of a cat. The feet of these creatures were more like those of a tapir, supposing a tapir to have five toes, without any particular adaptation for climbing, running, or striking down prey. Nor did any of these animals have teeth especially modified for cropping grass, though it is easy to see how, starting with such teeth as they did possess, a few changes would lead to such grinders as those of the deer.



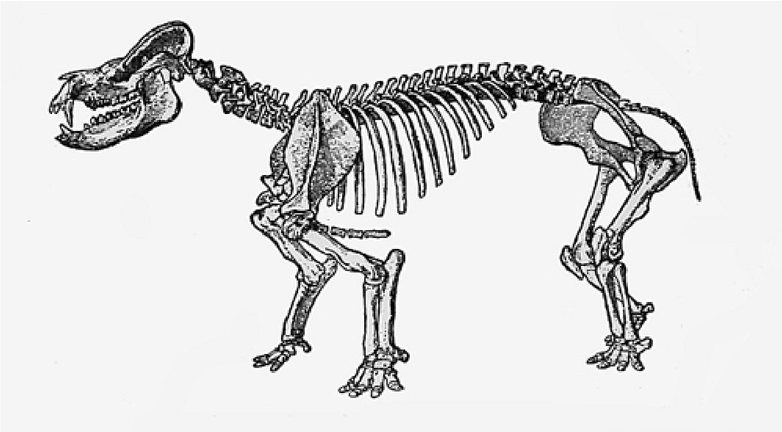
Phenacodus, a typical Eocene mammal. (After Osborn.)

The hoofed quadrupeds were represented by animals *something* like tapirs, though this gives a very vague idea of their appearance, and named, from the character of their foot-joints, Condylarthra. One of the best known and most characteristic of these animals is that named by Professor Cope *Phenacodus*, or deceptive-toothed, because while the grinding teeth suggest those of a small hog-like beast, the creature itself was quite different, presenting, as a generalized animal should, a combination of characters. Several species of this genus are known of varying size and build, but the largest, and the one with which we are best acquainted, is *P. primævus*.

The body and tail of this animal were long, the back arched, the legs stout and of moderate length, and there were five toes on each foot—all points in which Phenacodus resembled the early carnivores. The outermost toes did not reach the ground, but while the animal was not quite plantigrade, it did not walk on the tips of its toes, as do modern ungulates like the sheep and deer. The animal was evidently omnivorous, and as it possessed neither claws nor sharp teeth, it must have sought safety in flight. Phenacodus is a typical member of the group of primitive hoofed quadrupeds from which all modern ungulates are believed to be descended. It is of additional interest from the relationships it shows to other groups, and notably to the clawed animals, from which those with hoofs are thought to have branched off at an early date. This interest is enhanced by the fact that its discovery fulfilled a generalization, one might say prophecy, of Professor Cope, to the effect that the primitive types of hoofed mammals would be found to be characterized by having five-toed, plantigrade feet, and tubercular teeth. No such animal was known at the time (1874), but in 1880 Dr. Wortman obtained a practically complete skeleton of Phenacodus, nearly at the close of a collecting season that up to that time had yielded almost nothing. And this well illustrates the uncertainties attending the collection of fossils.

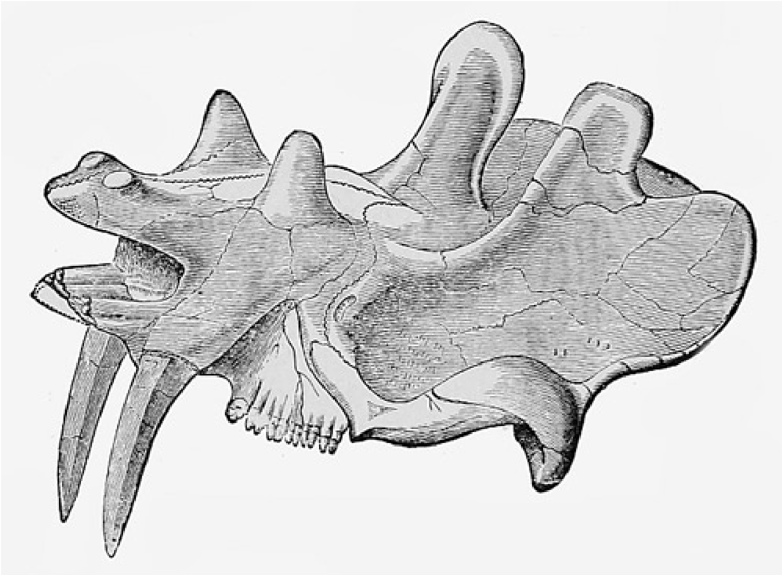
In the fore foot of Phenacodus we get the first suggestion of a hand, though it be a suggestion merely. The articulations of the innermost finger are such that it looks inward, and while it had no such power of grasping as exists in the hand of man, or even a monkey, yet it seems to have been Nature's first attempt at a hand. So Professor Cope argues that we must look to the early members of the group to which Phenacodus belongs for the ancestors of the lemurs, while from these have come the higher monkeys.

The place of the carnivores was at this time held by animals similar in habits, though different in the details of their teeth and skeletons, and these animals have been called Creodonta, flesh-toothed. They were mainly heavily built, short-legged animals, something after the pattern of a civet cat, but none of the Eocene species attained the size of those of later date. Neither do they possess the large cutting teeth that were developed in subsequent species and attained their maximum in the back part of the jaws of true carnivores. This location of these large teeth is a matter of mechanics; for as the jaw is a lever of the third order, with the pull of the muscles in front of the support, the farther back the teeth the greater is their crushing power. There are a number of species of these creodonts, but they are known mostly from their teeth, and it would be a dry matter to merely give a list of the scientific names by which they are known.



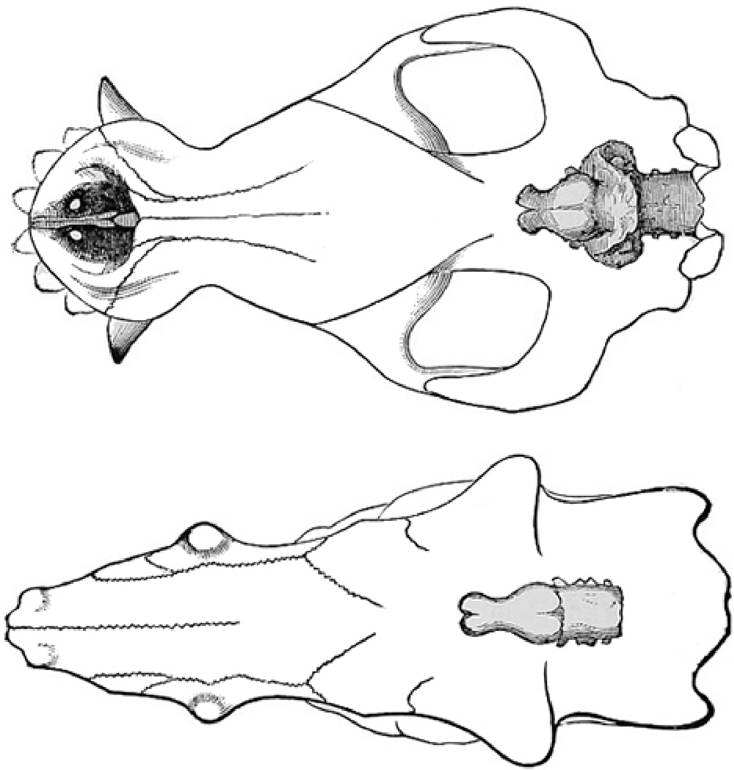
The clumsy Coryphodon. (After Osborn.)

Coryphodon was one of the larger mammals that appeared on the scene during the Wasatch epoch—a clumsily built, stumpy-footed creature, adapted for an easy life in a mild climate. In general appearance the coryphodons more nearly resembled bears, plus a well-developed tail, than any other living animals, and they probably had a similar shuffling gait. But the resemblance was only in appearance, for in spite of their large canine teeth, the coryphodons were not related to the carnivores. The coryphodons may have come from Europe, since the genus was present there at the same time; and with them, or at this date, there came into North America a host of animals. These included the ancestors of the horse[48] and rhinoceros, the earliest members of the pig family, and the first undeniable rodents, or gnawing animals; so that this stage marks a great advance for the mammals.



Skull of Uintatherium, the largest land mammal of the Eocene.

The first trace of the horse family is found in middle Eocene deposits, and the animal rejoices in the long name, *Protorohippus venticolus*. The generic name means “before the mountain horse,” and the specific name is a joke of Professor Cope’s, which will be readily recognized as “dog-Latin” for Wind River, the locality where the specimen was found. The Eocene horse was so small and so different from the horse of to-day, that did we not have the links in the chain which connect the two the relationship might be unsuspected. The story of the horse is now so well known that it need not be dwelt on in detail.[49] It naturally impresses us, because the horse is familiar to every one; but the line of descent of the camels and rhinoceroses is almost as well known as is that of the horse. The largest of the Eocene mammals were those belonging to the genus *Uintatherium* (Uinta animal), thus named because their bones are found in the rocks of that formation. These animals averaged about the bulk of a rhinoceros, some smaller, some a little larger, but, like the other early mammals, they were more or less flat-footed. The most noticeable feature about them is the skull, which bears three pairs of knobs or prominences of various sizes, the foremost pair, on the nose, being small, and the hindmost pair, situated on the back of the head, the largest of the series. These may have supported horns, or they may merely have been covered with callosities like those on the cheeks of the wart-hog. From the smooth, rounded nature of the bone this last supposition seems the more probable, but still short horns, something after the fashion of those of a rhinoceros, may have been present. Although herbivorous, the upper jaw was armed with long, dagger-like canines, and these, when the mouth was closed, were guarded by curious projecting flanges on the lower jaw.



Comparative size of the brains of Coryphodon and Uintatherium. (After Marsh.)

Compared with the great Jurassic dinosaurs and the mosasaurs and pterodactyls of the Cretaceous, this Eocene life was tame and commonplace, but none the less was it important, for it marked the ascendency of animals with the best developed brains. Not that our Eocene friends had anything to boast of in the way of cerebral development, although they were a great improvement over Brontosaurus with his 2 pounds of brain to 20 tons of flesh. In all of them the olfactory lobes, the organ of smell, formed a much larger portion of the brain than in recent animals, while the entire brain was small when compared with the bulk of the body. At the same time the cerebrum, the thinking part of the brain, was little developed, lacking in convolutions, and not sharply marked off from the cerebellum.

The fossils of the Eocene are found in what were then the beds of a series of great lakes that during that period successively occupied portions of the West. The Puerco, Wasatch, Bridger, and Uinta series, consisting principally of hardened sands and clays, represent the deposits that formed in these bodies of water, and in them is preserved an almost continuous record of the life of the Eocene period. The great Wasatch Lake was the largest of them, and extended from New Mexico, over eastern Utah and western Colorado and Wyoming to the Wind River Mountains, a distance of 450 miles. It had a breadth of 250 miles, and was altogether a goodly body of water.

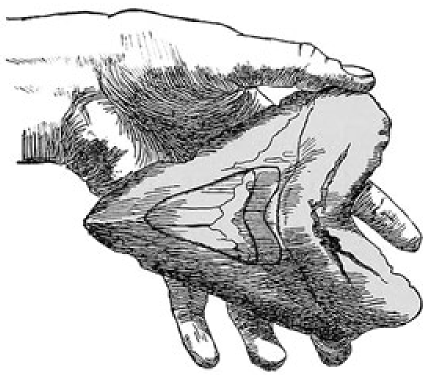
As may be imagined, our Western territory was a very different place then from what it is now; the uplift of the Rocky Mountains and central plains had not gone far enough to cut off the moist winds from the Pacific, while at the same time draining the lakes; the climate, as we gather from the plants and insects, was mild, and the now barren plains abounded in streams and lakes. The waters teemed with fish, turtles related to our long-necked “soft-shelled” species were numerous, and crocodiles common.

One deposit of fishes deserves special mention, that of the Green River shales, for it is probably better represented in public museums and private collections than any other locality in the world. These shales crop out at various points on the Union Pacific Railroad, but the most famous deposit is at the little town of Kemmerer, west of Green River Station. From this spot thousands of specimens have been taken, and while series of them may be found in any museum, the bulk of them have been sold to tourists and scattered far and wide over the world.

The fishes are in a beautiful state of preservation, and represent several species, some of which are related to the shad and herring.

Another deposit that should not go unmentioned is the shales of Florissant, Colo., which consist mainly of light volcanic ashes thrown out by one of the many volcanoes characteristic of the period. These shales contain vast numbers of insects, and have yielded many thousand specimens and many hundred species, this being one of the most famous localities in the world for fossil insects.

Very little can be said of the birds of this period, for while fragments of several waders have been found, but two birds are at all well known. One of these, *Palæospiza belli*, was described as a sparrow; the other was not at all unlike the small curassow living in Texas, known as the chachalaca.[50] A bird as heavy as an ostrich is indicated by some fragments of a leg-bone from New Mexico, but there is reason to suppose that in spite of its size it was not a relative of that bird. Its real affinities are very likely with a group of huge birds whose remains are found in Miocene strata of Patagonia. It is to be noted that birds have made rapid progress since the Cretaceous, for while the older toothed forms were unlike anything now living, the few Eocene birds that we really know are without teeth, and practically the same as those of to-day.



A tooth of the great Eocene shark *Carcharodon megalodon*. The smaller outline is a tooth of the

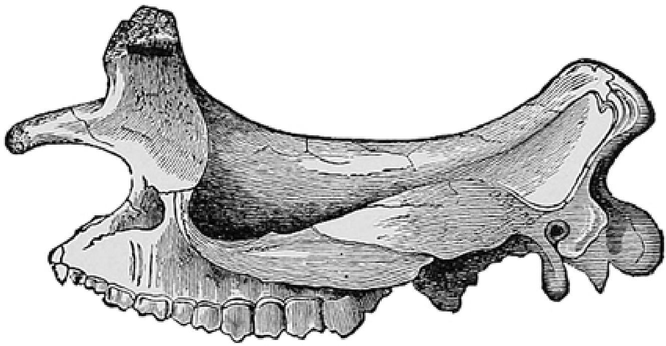
living white shark drawn to the same scale.

Such was life around the inland lakes. In the waters along the southern coast of our continent prowled the hugest of sharks, *Carcharodon megalodon*, the specific name, great-toothed, referring to the size of the teeth, which are sometimes as large as a man's hand. This monster must have reached a length of 70 feet, and not impossibly 100, while the jaws were not less than 5 or 6 feet across. Associated with this shark was a creature known from the shape of its teeth as Zeuglodon, yoke-tooth, an animal very far from being a whale, and yet more like to a whale than to any other animal with which we are familiar. The head was very small in comparison with the body, and the greater part of this corresponds to the tail of other animals, so that no less than three-quarters of the length and bulk of Zeuglodon consisted of tail. The formidable array of teeth, adapted for seizing and cutting, show that the animal was predatory in its habits; but what could have been the use of such a tail? The individual vertebræ are 18 inches long, the longest known. The heavy bones of the manatee are supposed to be for the purpose of enabling it to feed off the bottom with ease, and the long tail of Zeuglodon may have acted as a counterpoise, so that the animal could rear his body out of water, somewhat as Diplodocus is thought to have done.

In the Eocene, too, snakes make their first appearance, small species on land, large ones in the sea or rivers, for their bones are found associated with those of Zeuglodon and other aquatic animals. These sea-snakes reached a length of 15 or even 25 feet, and are the largest sea-serpents known outside the columns of the daily papers. There are plenty of sea-snakes living in the China Sea and waters about southeastern Asia, but these are mostly small, rarely exceeding 3 or 4 feet in length.

One noteworthy change in animal life is the great increase of herbivorous animals. In the past carnivores were greatly in the majority; labyrinthodonts, crocodiles, anomodonts, and a large proportion of dinosaurs were flesh-eaters. Even the early birds, as shown by their teeth, were all most literally birds of prey. But from the Eocene onward the increase was among herbivorous animals.

Above the Eocene comes the Miocene system, but the lower portion of this, together with a small slice from the Eocene, is considered as sufficiently distinct to deserve separation as a period by itself, termed the Oligocene, or little recent. The record of this time is preserved in the White River beds, which cover a large portion of South Dakota and a part of Nebraska and Colorado, where they form the well-known Bad Lands. These beds are considered to have been partly formed in lakes and broad streams, and partly by the heaping up of earth on the wind-swept lowlands. They form a great cemetery of ancient animals which has yielded scores of species and thousands of specimens, and its possibilities in the way of fossils seems to be by no means exhausted.



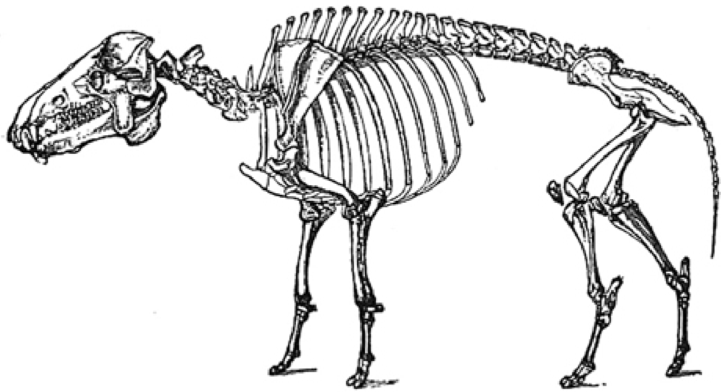
Skull of a Titanothere, *Brontotherium ingens*. (After Marsh.)

Heads of the first and last of the Titanotheres. (From statuettes by Charles R. Knight.)

The giants among these animals were the Titanotheres, the largest of which attained almost the bulk of an elephant, though proportionately less heavily built and standing somewhat higher on their legs. Their most striking peculiarity, however, lay in the saddle-shaped skull with its blunt horns, one on either side of the nose. It does not seem probable that these were covered with a pointed sheath of true horn,[51] such as is found in cattle, but that they were simply encased in tough, callous skin. The very first of the titanotheres were comparatively low of stature, and their horns were small knobs, well back over the eyes. As we come upward in the rocks and onward in time we find the horns growing larger and larger and their owners bigger and bigger, until the animals were the size of a small elephant, the skull a yard long, and the horns a foot high and on the very end of the nose. Specialization could go no farther, and then the race stopped, cut off in its prime, and the titanotheres ceased to be. While this stopping seems abrupt it was no doubt gradual, extending over long years, during which the great brutes became more and more rare until there were none. Probably this was due to over-specialization in size, while their teeth failed to change with the changing vegetation; for the teeth of these beasts were, like themselves, simple, with enamel merely spread over the surface instead of forming deep plates in the soft dentine, so that the face of the tooth was kept rough by use and was literally a grinder. Thus the teeth of the titanotheres were, from a mechanical standpoint, poor, and adapted only to coarse, succulent vegetation, for the coarse molars crushed rather than ground; and when the enamel was worn from the face of the tooth it wasted away rapidly save at the edges. At the same time there were no cutting teeth in the front of the jaw, only two or four useless little round incisors, and whatever cropping was done must have been with the lips entirely.

But if the great titanotheres had passed away an abundance of other animals remained, and as grasses spread over the land herbivores came into being, fitted to browse upon them, and active carnivores arose to prey upon the helpless chewers of the cud.

The primitive flesh-eaters, the creodonts, were still represented, and true carnivores appeared in the shape of small dogs and the forerunners of the large saber-toothed tigers. Early members of the camel family were there, together with rhinoceroses and numerous smaller beasts. The most abundant mammals of the time were the oreodonts, animals that combined some of the characters of the hog, deer, and camel. This combination does not make so strange-looking a creature as might be supposed, since these characters were found in the teeth and skeleton. The general appearance of the oreodonts must have been something like that of a small, heavily built doe, with, however, a long tail, and 4 toes to each foot. The commonest species of oreodon was about the size of a sheep; the smallest was about the stature of a collie dog, and they doubtless formed a large part of the prey of the numerous carnivores.



Skeleton of the great elothere, *Elotherium crassum*. (After Marsh.)

Starting with the titanotheres, but coming into prominence later, when they wandered over the plains of Oregon and the lake region of South Dakota, were the Elotheres, a group of great hog-like animals, represented also in Europe. Some of these were no larger than a wild boar; some, like *Elotherium imperator*, had heads nearly a yard long, the cheeks and jaws adorned with great callosities like those from which the modern wart-hog gains its name. Though so much like hogs in general appearance, these animals had great pointed canines, and some of the grinders very similar to those of flesh-eaters, the character of the teeth indicating that the elotheres were truly omnivorous. Very often there are little grooves cut around the bases of the canines, just such as might be made by sawing a string back and forth around a piece of soft wood, and for a long time the reason for the presence of these grooves remained a puzzle.

Finally it was suggested that the elotheres were root-eaters, and that in grubbing for food the slender rootlets, covered with dirt, worked around the bases of the teeth and in course of time wore the little grooves they now bear.

During the White River period, small, three-toed horses (*Mesohippus*) were not uncommon, and although they were no larger than a small sheep, yet it is not difficult to recognize in them the likeness to a horse.

The ancestors of the llamas were here, too, represented by the genus *Pœbrotherium*, as well as several species of rhinoceroses. Some of these were heavily built and apparently aquatic in habit, while others were of lighter build and evidently made for running. Most of these early rhinoceroses departed widely from our ideas of these animals, for they were quite hornless.

During the Miocene period rhinoceroses were still abundant in North America, and if some of them had no horns (*Aceratherium*), others made up for this by having two (*Diceratherium*), one on either side of the nose, something like the bygone titanotheres. The most peculiar member of the group was one of the hornless species named *Aphelops fossiger*, having the short legs of a hippopotamus, and probably aquatic in its habits. In some parts of the West these short-legged rhinoceroses abounded, and the Miocene sands of Kansas have yielded the bones of thousands. These have been found in such close association that it has been suggested they perished from the effects of an unusually severe season, which drove them together in search of some last spot where food was to be had, and where they finally died.

This period, too, witnessed the continued development of camels, or perhaps it would be better to say llamas, for while the llama is a member of the camel family, it does not fulfil the popular idea of a camel. Llama-like animals, then, abounded, some greatly larger than the Bactrian camel, some smaller than the South American guanaco. The most remarkable of them was one well termed by Dr. Matthew *Alticamelus*, the high camel, or the giraffe camel; for, while a member of the camel family, as shown by its skull and feet, this animal had the long slender neck and legs of a giraffe, and, like the giraffe, must have fed on the leaves and branches of trees. It certainly was not built for feeding off the ground.

The horse family steadily progressed, and the genus *Protohippus*, before the horse, contains species of fair size, in which the middle toe is so much larger and longer than the others that these do not reach the ground.

True ruminants appear, small species with small horns something like the antlers of a deer, but they were indications of species yet to come.

The saber-toothed cats were the highest types of carnivores among the animals of the Miocene and Pliocene. They are so named from their large, flattened, slightly curved canine teeth, which were very much longer than the corresponding teeth of such animals as the lion and tiger. Professor Cope suggested that these canines were so large as to have been in the way, and ultimately to have caused the destruction of the race by starvation. This, however, is a very dangerous inference to draw, since it would apply with greater force to the walrus and elephant, and it is doubtless incorrect. Dr. Matthew considers that they were used for piercing and tearing, and that the saber-toothed cats killed their prey in this manner instead of by biting, or by a blow of the paw. The majority of these animals were of moderate size, from that of a small leopard to that of a large puma, and the very largest were about the stature of a tiger. The length of the canine teeth varied from 2 inches in Dinictis to 7 inches in the great Smilodon.

Toward the close of the Miocene period mastodons made their first appearance in America, having probably come into this country from Asia by means of a land connection at the north.

The Pliocene, however, may be called the age of mastodons, for at this time the race attained its maximum, and there were a number of species scattered over the land. They were absent from the Central and Eastern States, save one species, *Mastodon* *obscurus*,[52] which occupied a strip of territory along the coast from Florida to Maryland. To counterbalance this, they extended into South America as far as Chile and the Argentine Republic. These early mastodons were mostly species with very long lower jaws which bore a pair of tusks besides the pair present in the skull. It is a pity that none of these four-tusked species survived, as it would be extremely interesting to see what use, if any, the animals made of these seemingly superfluous tusks. The tusks differed from those of living elephants in having a band of enamel down the front, of no use whatever, so far as can be seen, but a hint of distant relationship, by way of some ancestor many times removed to gnawing animals.

In the Pliocene, too, occur the remains of the great southern mammoth, *Elephas columbi*, a species which not only preceded the more familiar hairy or northern mammoth in point of time, but outstripped him in size. For this and a near relative, *Elephas imperator*, were the largest of land mammals, in this country at least, reaching a height of 13 feet, or possibly 6 inches more.

If this seems disappointingly small, it must be borne in mind that the great majority of elephants seen in menageries are under 8 feet in height, and very few of them over 9. And every additional foot of height adds greatly to the bulk of an elephant, so that one 13 feet tall would weigh about 10 tons; and while this is small compared with one of the ancient dinosaurs, it is a goodly amount of flesh to be carried about on four legs.

These great elephants are known mostly from teeth and the larger bones, since they were generally buried in sand or gravel. This permits the bones to be wet at times, dry at others, conditions under which bones soon go to pieces. The structure of the teeth is coarser than in the northern mammoth, and the plates of enamel less in number. The tusks were sometimes very large, but the largest pair on record measure only 13 feet in length and 22 inches in circumference. These are in a skull now on exhibition in the American Museum of Natural History, New York city.

The habitat of the southern mammoth, roughly speaking, was northern Mexico and the entire United States south of a line drawn from Washington State to Washington city. The northern part of its range overlapped that of the northern species, so that remains of both may be found in the same locality.

The camel family was still prosperous, and its members were common in Oregon and Washington, in Nebraska, Dakota, and Texas. They extended to Florida, and the probability is that they extended into South America even to Patagonia, so that the original stock of the present llamas came from North America. It is also thought that during this time the early camels emigrated from this country to Asia, and that while the race disappeared completely here, it endured there, giving rise to the modern camel and dromedary. It is interesting to recall that in 1853 the United States Government imported a number of camels for use in the desert regions of the Southwest, where, ages before, the predecessors of these animals were abundant. With the camels were true or single-toed horses, and the great sloths and glyptodons of South America, saber-toothed tigers, as well as true cats, so that the life of the period comprised a mixture of temperate and tropical animals.

Such is a glimpse of the procession of life as it passed onward through the Cenozoic era—an era remarkable for the development of the mammals and the rapid changes that took place among them. Fishes have changed little since the Eocene; many existing genera of birds date back to the Miocene; but not a single genus of mammals goes back to the Eocene, and few even to the Pliocene.

CHAPTER X

THE LIFE OF YESTERDAY

The entire period comprised between the Eocene and the present, known as the Cenozoic era, or that of the new life, is variously estimated at from 4,000,000 to 10,000,000 years, the last figures being probably nearer the mark than the first. It was marked, among other things, by a gradual change in the climate of the world, due to a general cooling off and lowering of temperature, particularly at the poles. At the commencement of Eocene time sequoias and other temperate trees grew in Greenland, and palms in Wyoming and southern Europe, while by the close of the Pliocene the elevation of the northern part of the globe had brought about an arctic climate even more severe than that now prevailing.

As a natural consequence, the entire flora and fauna of the northern hemisphere was changed, tropical animals died out, and the present forms arose to take their places.

This cooling off was not continuous, for there were great fluctuations of temperature, and between the periods of cold were intervals of warmth. One natural effect of this seems to have been a shifting back and forth of the boundaries between southern and northern animals, so that at one time there were tapirs in Tennessee, while during the greatest cold musk-oxen came as far south as Kentucky.

It is largely due to this that the lines between the Pliocene and Pleistocene, and between that and the present period, are not more sharply drawn. For these periods are not clearly distinguished from one another either by the character of the formations or by the fossils they contain.

The formations consist of sands, gravels, marls, and peat bogs, and the animals contained in them are for the most part not unlike those living, the marked differences being brought about by the dying out of some of the larger forms.

The great ground sloths which were characteristic of later Pliocene times lingered on, and in the warmer intervals occupied portions of the woodlands as far north as Ohio, and even Oregon. These were creatures short of limb and heavy of body, whose coarse teeth indicate that they fed on leaves and twigs. The sloths of to-day dwell in the tree tops, but these sloths of a geologic yesterday were far too large for tree-dwellers, so large that a Spanish naturalist objected to their being classed with the edentates, on the ground that all the other members of the group could dance in the body of a single specimen. However, as noted in various places, size is not a character, and although Megatherium (the largest member of the group) had the bulk, if not the height, of an elephant, its place is with the sloth and ant-eater.

The probable habits of these huge ground sloths have been so vividly pictured by W. K. Parker that one can not do better than copy his words: “Let us,” he says, “try to imagine a megatherium waking up after lazily dozing a month or two during the dry season, and then, hungry and wet, in the heavy downpour of the beginning rainy season, setting to work to break his fast. As far as can be judged by the tools he had to work with—paws a yard, and claws a foot, in length—the first thing to be done was to throw out a few hundredweights of earth from the roots of some large tree.

“Now he changes his tactics; he has good collar-bones, and well-developed arms for embracing; so, bear-like, he hugs the tree upon which his desires are set, and busily digging still, not now with his fore but with his hind paws, his great weight resting upon his haunches and tail, he, with many groans, sways the big tree to and fro; at last with a great crash it falls, not, however, without giving him some sense of its weight, for it was a tree worthy to grow in a forest trampled upon by this Atlantean sloth.”

This huge beast came as far north on the coast as North Carolina and its bones are among those found in the river phosphate beds, and their antiquity does not cause them to be treated with respect.

One of these ground sloths, Megalonyx, the great-clawed, was found in Virginia and described by Thomas Jefferson; but the more common animal, that ranged from the Gulf to Ohio and Missouri, was named Mylodon. These animals belong to a group that is thought to have originated in North America during the Eocene period, and to have spread slowly southward while the climate of the world was mild and equable. Finding in South America a favorable environment, plenty of food and few enemies, the edentates increased in size and multiplied in numbers, culminating in the Pleistocene in such forms as megatherium and the armadillo-like glyptodonts. A return wave of migration brought these big beasts into North America, where they may have been contemporary with primitive man. In South America remains of one species, Grypotherium, have been discovered under such conditions as to make it probable that the animal was actually kept in a state of domestication. But the Pleistocene period witnessed the final disappearance of these monsters, as it did of so many other large animals, and only their degenerate and diminutive relatives are left.

At this time herds of peccaries were common throughout the Southern and Middle States, reaching, indeed, as far north as New York and Kansas, where their bones occur in gravel banks. They belonged to larger species than either of the two now living, though similar to them in general appearance.

Tapirs, too, were found as far north as Tennessee, and a great rodent, much larger than the beaver, and improperly classed with that animal under the name of *Castoroides*, dwelt in the swamps of Ohio and northern New York. The nearest living relative of Castoroides is not the beaver, but the large Coypu rat of South America, a species much used in the making of felt hats. But save a few small species in Texas, none of these animals survived the wave of cool climate which succeeded the warm wave on whose crest the southern species were swept northward. The armadillo, peccary, ocelot, and jaguar, together with a few birds, are the principal relics of this time, although it left a more lasting impress on southern Florida in the shape of tropical vegetation.

Skull of the great saber-toothed Smilodon.

Beasts of prey were well represented by the last of the saber-toothed cats—great animals almost the size of a lion, with wicked looking, sharp-edged canines far larger than those of any modern carnivore. If these cats preyed upon the ground sloths, as Professor Cope suggested, the use of their enormous canine teeth seems evident. The sloths are covered with coarse hair implanted in a thick hide, and some of the mylodons were even protected by numerous small bones embedded in the skin. While such a creature might not be invulnerable to the attacks of an ordinary beast of prey, it is evident that our largest cat, the jaguar, might beat and bite his huge carcass in vain. But the powerful teeth of smilodon, like two daggers, would reach through hair and hide to the deep-seated arteries of the neck, and before such a foe the big, sluggish mylodon would go down.

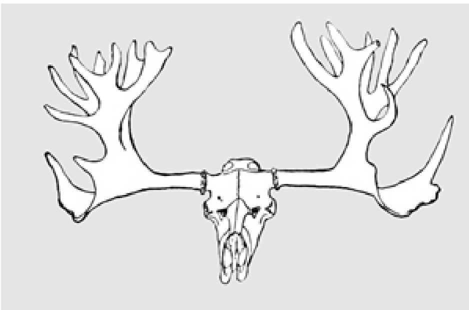
Horses, which through long centuries had been steadily advancing, increasing in speed and stature until they matured in the Pliocene, now reached their highest point. They were represented by many species of true or single-toed horses spread over the greater part of North America south of Canada, and throughout South America as well. With the possible exception of the little-known *Equus giganteus*, they were rather smaller than the average modern horse and had proportionately larger heads, being built more like an ass or zebra. The most common species was that named *Equus complicatus*, from the complicated foldings of the enamel of the teeth, and this was found from our Southern States far into the North and West. Side by side with this species in our Southern States was his smaller brother, *Equus fraternus*, while Texas, Oregon, and other sections of the country had their local and characteristic species, just as to-day different parts of Africa have their different species of zebras.

The last land connection between Asia and North America, across Bering Strait, let in the mammoth, and at his heels came the ancestors of the great brown bears of Alaska, the mountain sheep and mountain goat, and of the bison; for the groups to which these animals belong had their origin in the Old World, and did not, like the llamas and great ground sloths, develop on this continent. The grizzly bear was an earlier inhabitant and lived with the horse and llama in the late Pliocene, and the black bears are probably natives of this continent, although we do not as yet know their line of descent. At the time the mammoth was coming eastward it is not improbable that the horse passed westward into Asia, for its bones are numerous in Alaska in company with those of the mammoth. The brown bears and the wide-horned bison (*Bison crassicornis*) never passed out of the northwest; the mountain sheep found the cool climate it needed by following the mountain ranges southward; the slow and lumbering mammoth made the longest journey of all—clear to the Atlantic coast.

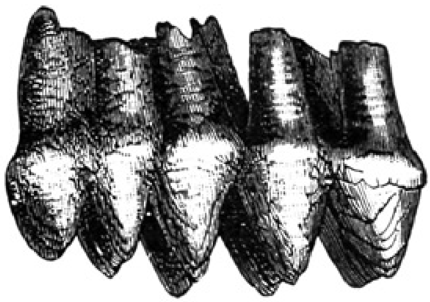
The wide-horned bison was about the size of the common species, but with longer, more flattened horns with a wider outward sweep. This species must have been abundant on the Alaskan tundras, for its bones are found there in numbers, and sometimes even the covering of the horns is preserved. Contemporary with this was another species very similar to the living bison, and very probably its immediate ancestor. Remains of this animal have been found as far east as Kansas, and an almost complete skeleton is preserved in the State University at Lawrence. At least three other species of bison flourished during the Pleistocene, the king of them all being the wide-fronted bison, *Bison latifrons*, perhaps the most superb of the ox tribe. This animal did not greatly exceed the Western bison in bulk; it seems to have been less than a foot higher at the shoulders, but its great horns had a sweep of from 6 to 8 feet from tip to tip.[53] This magnificent animal was found from Ohio southward into

Florida on the one hand, and Texas on the other; but it appears not to have been a common animal.

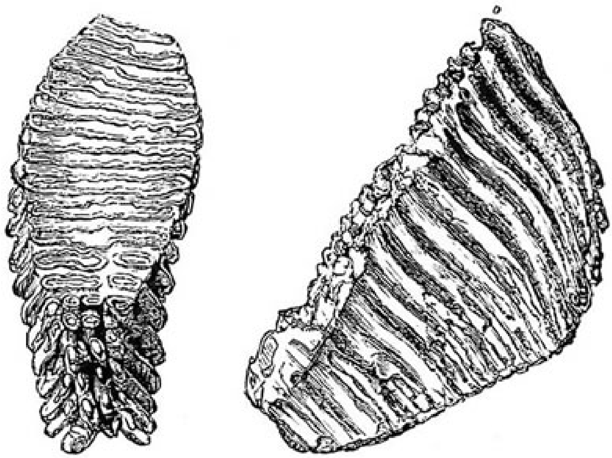
The period of warmth during which the sloths and their associates came north appears to have been succeeded by a glacial period, and this in turn was followed by a climate much the same as it is at present. This was the time of the final appearance of the Mastodon, when it was a common animal in New York and New Jersey. One other animal should be mentioned here, if only to emphasize the uncertainties of preservation, and that is a member of the deer family called *Cervalces*, because it was intermediate in appearance between the elk and moose. The antlers were neither as wide and branching as are those of the elk nor so flattened as those of the moose, but a combination of the two. This deer was as large as a moose, and is known from three specimens only. Two of these were skulls found at Big Bone Lick, Ky., a spot that must have been a great resort for the later quadrupeds such as bison, elk, and Mastodons. The third was an almost complete skeleton discovered in a marl bed at Mt. Harmon, N.J.



Skull of the elk-moose Cervalces. (After Scott.)



Tooth of Mastodon.

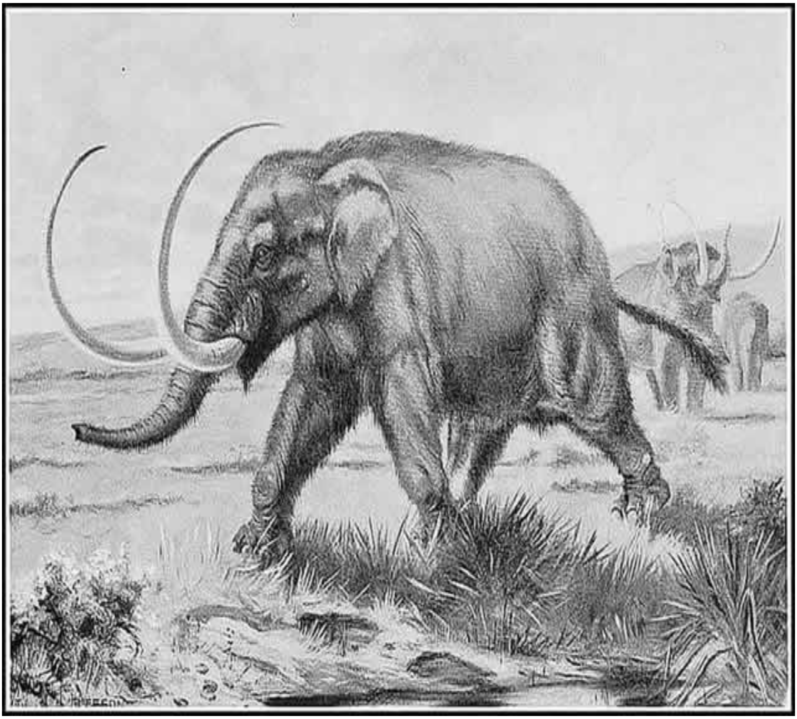


Tooth of Mammoth.

The Mammoth and Mastodon will ever be the most interesting of the Pleistocene animals, partly because they are so different from any now found in North America, partly because they have become extinct so recently that it is entirely possible that they were contemporary with early man. There is some popular confusion as to whether or not the mammoth and the mastodon are one and the same, but it may be said that they represent two distinct branches of the elephant family. They may be readily told apart by their teeth, those of the mammoth being flat grinders with plates of enamel in the body of the tooth, while mastodon teeth have Λ-shaped cross-ridges and the enamel is confined to the surface of the tooth.

The Mammoth, *Elephas primigenius*, the first elephant of all,[54] ranged from Alaska southeasterly to about the latitude of the Middle States. This corresponds roughly to a belt of territory running along the edge of the great ice sheet where the mammoth probably found the right conditions of temperature, vegetation, and fairly open country.

The Mastodon (*Mastodon americanus*) was a more southern animal, and while in the northern portion of its range it seems to have been clad in a coat of hair and capable of enduring considerable cold, yet the true habitat of the Mastodon was south of that of the Mammoth, in the forest country where water was plentiful.



The Mastodon.

From a painting by J. M. Gleeson.

We are as yet unable to trace the history of the Mastodon back to its place of origin. It may have developed from some earlier species residing in this country, but this is hardly probable, and it is more likely that the ancestors of the Mastodon were immigrants from Asia. There is a wide gap between its habitat here and that of the nearest foreign relative, but then little is known of the fossils of Alaska and Siberia.

But it may be said that specimens from California and Oregon seem to be found in beds of gravel of more ancient date than the swamps and meadows where similar remains occur in the East. It therefore seems likely that the Mastodon, like the Mammoth spread southward and eastward from some point in the Northwest. It ranged practically over the entire United States west of the Hudson, and extended its habitat north of the Great Lakes into Canada. Specimens have been found in New Brunswick, Manitoba, and on the shores of Hudson Bay, but these may be looked upon as stragglers, or as having been transported by exceptional circumstances.

In most parts of its range the Mastodon must have been abundant, though few realize this. But it is hardly an exaggeration to say that during the season when drainage and ditching work is going on not a day passes without some specimen being brought to light. The majority of these are teeth, some of the larger bones, or portions of the tusks, but often a considerable part of the skeleton is recovered, and at the present date there are 10 mounted skeletons in the United States.

If the trail of the Mastodon is obscure, that of the Mammoth is plain, and he may be traced by his widely scattered teeth and bones back to Alaska and thence to Siberia. No entire specimens of the Mammoth have been found in North America, but in Alaska, where the soil is wet and cold, the bones and tusks are common and the latter are sometimes in an excellent state of preservation, so that dishes and various implements are made from the ivory.

During recent years mining operations have brought to light many more or less complete skeletons in the gravel of old river beds, but owing to the difficulties of transportation nothing like a perfect specimen has yet been obtained, though some bones and many tusks have been brought away as curiosities.

The Mammoth was a smaller animal than is commonly supposed, much smaller than the Southern Mammoth, *Elephas columbi*, the Columbian elephant, which preceded it and attained a height of 13 feet. The Northern Mammoth appears to have rarely reached 10 feet, being about the size of the living Indian elephant. The average size of the bones found is, however, larger than the average bones of that animal; this because, as a rule, they represent full-grown specimens that had lived their allotted time, while the elephants seen in captivity are very largely immature animals.

The Mastodon seems to have outlived the Mammoth and was probably contemporary with early man in North America, while it can only be said that the Mammoth was possibly so. There is, however, as yet no definite proof that in this country man lived at the same time as either of these animals. The readers of this chapter are warned not to put implicit faith in any statements to the contrary, while they are urged to investigate *carefully*, whenever possible, the conditions under which remains of the mastodon have been found.[55]

In Europe the record of the immediate past is much more clearly written than it is in North America, and we are absolutely sure that man, the mammoth, the cave bear, and the horse were contemporaries.

The Mastodon, too, was no taller than a large Indian elephant, though a little more heavily built, with a longer, flatter head, and frequently with strongly recurved tusks, though the shape of these was very variable. Still this, the last of the mastodons, seems to have been a little larger than any of his predecessors, even if not so large as he is popularly supposed to be.

We are quite in the dark as to the reasons for the disappearance of such large mammals as the mammoth, mastodon, and horse, and the case of the latter is particularly puzzling. We know that it literally grew up with the country, and had been able not only to adapt itself to the various changes as they took place, but to progress with every change. So it could hardly be said that this animal was not adapted to its surroundings. And when horses were introduced by the Spaniards and ran wild, they increased and multiplied amazingly both in North and South America. And yet the several species of native horses which were plentiful in various portions of the country during the age of the mastodon and mammoth seem to have, unfortunately, become extinct at the very time they might have become of service to mankind.

It is interesting to speculate as to what might have been the history of North America had horses endured until the coming of man, for the possession of these animals was not only a factor in the conquest of the country, but their existence had an important influence on the progress of civilization in the Old World. Here the horse, ox, pig, and sheep were unknown; there was neither a beast of burden nor one that might be domesticated to furnish food.

The bison was too big, lumbering, and intractable for domestication by primitive man, and only the dog in the north and the llama in the south were used for beasts of burden and these were so small that they added little to the resources of mankind. In the great temperate portion of America there was no animal suitable for draught purposes, and this may have had its influence in retarding the development of man in America.

It might possibly be argued in the case of the mammoth, that he was an inhabitant of a cold region, and when the Glacial period came to an end was unable to stand prosperity in the form of a milder climate. But aside from the fact that the elephant family is quite at home in the tropics, the climate of the north was and is cool enough for any animal, and yet the woolly elephant not only vanished from this continent, but from the Old World as well.

The extinction of the mastodon is equally puzzling. It certainly was not exterminated by man, for had this been the case we should have had plenty of proof of the existence of the two at the same time. As for natural causes, the animal ranged over so wide an extent of territory, that while drought, or flood, or cold might have wrought local destruction, somewhere else it would have found peace and plenty. The old theory of sudden change of climate can scarcely be considered, for there is no evidence that any such change took place, and even had it occurred, more creatures than the mastodon would have been annihilated. When the great ice-sheet overlaid the northern and eastern part of our continent, and the climate was such that the walrus disported himself along the coast of Virginia, the mastodon could have survived in Florida, Texas, and Louisiana, where its remains abound. That he did survive somewhere is evident from the fact that after the final retreat of the ice the animal spread north even into Canada, apparently making its last stand in a belt of country running from Michigan to New York.

That this occurred *after* the Glacial period is apparent, because the bones of mastodons are found abundantly in the old bogs and meadows that were formed in the hollows scooped by the glaciers or washed out by streams flowing from the melting ice. Sometimes a careful study of the surroundings has shown that the place where the bones lay was an old beaver-pond, in which the great mastodon was mired and perished.

Had the mastodon lived here *before* the Glacial period its bones would be found under, or at least in, the glacial sand and gravel; but in the Northern States they occur in swamps and meadows in the mud and peat derived from decaying vegetation.

It can only be said that there seems to be an old age in the life of species as well as in the life of individuals, when a species, a family, or an order even, comes to an end without apparent cause, simply because its race is run. Why this occurs we do not know, and while it is an easy matter to frame theories to fit the case, these are not always satisfactory.

It was probably some time during the age of the mammoth and mastodon that man appeared in North America, very possibly coming over from Asia at the same time as did these big beasts, and, like them, spreading southward and westward. But this brings us into the domain of the anthropologist, and it is for him to deal with the vexed question of the peopling of our continent and the development of its primitive races of men. It may only be noted that here, as with animal life in past geologic ages, this continent lagged behind the Old World, and at the time Europe had attained a high degree of civilization the greater portion of North America was still in its stone age.

And here we will leave the story of the early life of our continent. Its beginnings are millions of years in the past, its record buried in the rocks, not to be read for thousands of years to come; for man, who is to decipher this record, has just come upon the scene, and it will be many centuries before he sets about the task.

CHAPTER XI

LOOKING BACKWARD

Looking back over the history of the past, it is very apparent that the animals now living are very different from those of long ago, and the farther back we go the greater do we find these differences. Not only this; the general character of the animals was different. It is not as if we merely found deer and bison, dogs and cats, unlike those of the present time, but we find animals totally unfamiliar to us, that the eye of man never gazed upon in the flesh. It has required an enormous length of time to bring about these differences, but we can see how, starting with the smallest and simplest of animals, life has progressed ever onward and upward, continually branching out into new and higher forms.

There may not be an agreement as to the reason for these changes, and it might be well to frankly admit that what are styled causes are really only carefully framed theories which seem to account for observed facts. But to sum up in a very few words, it may be said that there seems to be an inborn tendency in living things, both plants and animals, to vary and to adapt themselves to circumstances. Changes in their surroundings—and these are ever taking place—simply allow this natural tendency a chance to act. The simpler the creature and the more uniform the surroundings, the less would be the tendency to vary. The more complex the structure of an animal and the more variable the conditions to which it was subjected, the more liable would it be to undergo some change. And as more and more highly organized animals appeared on the scene the more rapidly would changes take place.

Thus, some of the simple animals that dwell in the depths of the sea, where quiet, darkness, and cold prevail, have a history that reaches back into the past for lengths of time almost inconceivable to us, amounting to millions of years. On the other hand, none of the mammals now living are at all nearly related to those that flourished during the period of time we call Eocene, while few, indeed, are to be found even in the Pliocene.

And that mammals should have changed more rapidly than any other animals is only what might have been expected from their high organization, as this should theoretically render them particularly susceptible to changes going on about them.

It may be noted that each of the groups of animals that successively made their appearance had its culminating point, its high-water mark, when it was most numerous in species and individuals. This point reached, sooner or later the tide of life receded, sometimes, indeed, carrying the race quite out of existence.

For a time after the appearance of any new group of animals it seems to make little progress, lying dormant as it were, and then suddenly branches out in various directions. It will be remembered how through two entire periods, the Jurassic and Cretaceous, the mammals remained few and insignificant, and then in the Eocene spread with great rapidity, large and varied forms springing into existence.

So rapid, indeed, was the progress of mammals in Tertiary times that each formation has its own particular species, for new animals were continually making their appearance.

With few exceptions most of the orders of vertebrates seem to have passed their culminating point, while many of them, like the labyrinthodonts, dinosaurs, and pterodactyls, have long ceased to be. To-day, so far as may be judged by fossils, those very different animals, snakes and birds, are at their maximum. Birds have spread completely over the earth, and the highly specialized poisonous snakes with movable fangs are the highest as well as the most recent of their class.

Among the very noticeable changes that have taken place, not only in the fauna of our own continent but in that of the world, is the disappearance of large animals. Aside from the great bears which are confined to particular localities, the bison, moose, and elk are the only large land animals of North America; while South America, the former headquarters of the giant sloths and home of whole families of huge mammals, is now quite devoid of large mammals, unless we are willing to bestow that term upon tapirs. Of all the continents, Africa alone presents anything like the conditions that were once common.

On the other hand this is the age of great cetaceans, and there is no evidence that at any time were there any aquatic animals, or, for that matter, *any* animals, so large as existing whales.

In view of the large numbers of predatory animals that flourished in the past the reader may naturally have wondered why these creatures did not eat one another out of existence. But the destruction of animals by one another is not exterminative and corrects itself. If beasts of prey should increase unduly and food become scarce, there would soon be a balance struck by starvation. Any increase among creatures that are not predatory—insects for example—is followed by an increase of their enemies, and again the balance is struck. It is only when man adds his intelligently[56] destructive hand that the balance of nature is disturbed and races are swept out of existence without new ones coming in to replace them. It is safe to say that the past century has witnessed greater changes in the plant and animal life of North America than did the previous five thousand years.

The dying out of large animals has left our continent as we now see it, or rather as it was at the time of its discovery, for since the advent of civilized man great changes have taken place. Some of these changes were largely unavoidable, for, while the absolute extermination of the bison was an act of wasteful and senseless slaughter, the vast herds of this animal had to be decimated to make room for herds of cattle.

One point worthy of note is the small number of animals that are natives of this continent and whose pedigree can be traced back, let us say, even to Miocene times. Race after race of animals has appeared, played its part, and then passed utterly out of existence. The prongbuck (*Antilocapra americana*) is among the indigenous mammals, so probably are the peccaries and smaller deer, the black bears, and possibly the jaguar and puma.

The largest of our mammals, the bison, moose, and elk, are immigrants from the Old World, and so are the brown bears of the extreme Northwest.

On the other hand, some animals are not, and never have been, present in this country, and among them are such important forms as the hippopotamus, hogs, goats, and true antelopes.[57]

Thus the life of our continent, and of others, is derived from two sources: that which has developed here and is the result of successive modifications among animals which came into being long ago; and that which has come in from other lands brought for a time into contact with ours by the upheaval of the earth. To understand the present distribution of animals we must study their past history, for geological and geographical distribution go hand in hand.

It is a familiar saying nowadays that steam and electricity have made the world so small that no portion of the globe may remain by itself. But it was not otherwise in the past, for Europe and Asia contributed to the animal population of North America. And if distances were great and opportunities few, time was long; the trail of the slow-moving mammoth reaches across three continents, from England to New York, though we may only guess at the number of centuries this journey required.

Finally, the one thing that stands prominently forth is that in the struggle for existence mere brute force avails nothing; not size nor strength, but adaptability to surroundings, is the prime factor of success in life’s race.

BOOKS AND SPECIMENS

There are many books for the student of paleontology, and quite a number of a popular nature intended for those who merely have a general interest in the history of the past. Among these last are Extinct Monsters and Creatures of Other Days, by the Rev. H. N. Hutchinson, and Animals of the Past, by F. A. Lucas. The Horse, by Sir W. H. Flower, tells the story of that animal at some length, and describes its various relatives, living and extinct. Winners in Life's Race, by Arabella Buckley, tells the history of the vertebrates in a very charming manner; and Frank Buckland's Curiosities of Natural History, besides telling much of the pterodactyls and marine reptiles, is full of sketches showing how much of interest lies at our very doors.

For those who wish to know more of the forces that have shaped our continent, there are The Story of Our Continent, by N. S. Shaler; An Introduction to the Study of Physical Geography, by G. K. Gilbert and A. P. Brigham; and An Introduction to Geology, by W. B. Scott. There are many other manuals of geology besides, but this is compact and well illustrated.

For the distribution of animal life there are The Geographical and Geological Distribution of Animals, by Angelo Heilprin, and a Geographical History of Animals, by R. Lydekker.

For works treating of the structure and classification of animals the student is referred to A Manual of Palæontology, by Alleyne Nicholson and R. Lydekker; A Text-Book of Palæontology, by Karl von Zittel, English edition; Outlines of Vertebrate Palæontology, by A. S. Woodward; Dragons of the Air, by H. G. Seeley; and Fishes, Living and Fossil, by Bashford Dean. The first two books are large and rather expensive; the third is a good, compact work; the last two are much more popular in their nature than the others, although, as indicated by their titles, more limited in scope.

All our large museums have on exhibition many fossils; but the American Museum of Natural History, New York, has the best display of vertebrates in this country, if not in the world. This does not mean *largest*, but most instructive, and containing the greatest number of choice specimens. The collections are so arranged as to illustrate the development of the various groups represented, and include many entire skeletons of extinct animals, limbs, and other portions of dinosaurs, and a very fine series of specimens showing the rise of the horse family. This museum has a fine series of the fossils of New York State, and so has the State Museum at Albany.

The United States National Museum contains the best example of Zeuglodon yet discovered, some fine skulls and other portions of the great Triceratops, a remarkably full series of skulls of titanotheres, illustrating their development, and a skeleton of the toothed bird Hesperornis. It also has on exhibition series of invertebrates specially arranged and labeled for students, and the specimens of jelly-fishes used by Mr. Walcott in writing his monograph on Fossil Medusæ.

Yale University Museum contains the complete skeleton of Claosaurus, the first dinosaur to be mounted in this country, and some unusually fine examples of parts of the skeletons of the gigantic sauropoda. These are of interest, moreover, as being the first good examples of these reptiles collected in this country. Of invertebrates it has an unusually fine series of brachiopods, trilobites, and sponges.

The Museum of Comparative Zoology, Cambridge, Mass., is particularly rich in examples of the early fishes, though these do not make much show.

The Carnegie Museum, Pittsburg, and the Field Columbian Museum, Chicago, each have good specimens of the large dinosaurs, and the first-named institution has a fairly complete skeleton of Diplodocus, that will be placed on exhibition as soon as possible.

Most of our colleges have collections of fossils, and some of them have very fine collections. Thus Amherst College has the large series of footprints[58] brought together by Professor Hitchcock; the State University of Kansas is very rich in mosasaurs and pterodactyls, and the University of Wyoming in dinosaurs.

This must be understood as merely pointing out a few of the particularly good things in these various institutions, and is not intended to be a full statement of their riches, or as making invidious comparisons with others.

Finally, it remains to be said that the work of preparing fossils is extremely slow and tedious, and even after specimens have been collected it requires a long time to prepare them for exhibition. So, when one reads that such and such a museum has received a carload or two of fossils, it does not mean that these may be seen in the halls in a few weeks. Also, a large number of specimens are of little interest to the visitor, and a specimen that may solve some problem of importance to the naturalist, may be to the average observer a piece of stone containing a few irregular fragments of petrified bone.

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FOOTNOTES:

[1] Lest the writer should be accused of the eighth deadly sin, that of plagiarism, he will here say that this definition and that given in Animals of the Past were written in ignorance of Lyell's very similar definition.

[2] Now Seton.

[3] Except, of course, those extraordinary creatures, the Echidna and Ornithorhynchus, included in the order Monotremata, which lay eggs.

[4] The reader will please bear in mind that in these cases the animals have no choice in the matter, that they have not shed their fur overcoats as we would take off our clothes, but that their nakedness is the slow result of adaptation to their surroundings.

[5] In this connection it would be well to read The Origin of the Oldest Fossils, and the Discovery of the Bottom of the Sea, by Prof. W. K. Brooks. Among other places it has been reprinted in the Report of the Smithsonian Institution for 1894.

[6] Porifera, sponges; Cœlenterata, corals and jelly-fishes; Echinodermata; Vermes, worms; Brachiopoda; Mollusca, shells; Arthropoda, trilobites, and other crustaceans.

[7] Head-footed, a name given on account of the tentacles arranged about the head, although, oddly enough, these are universally called *arms*.

[8] See The Origin and Significance of Spines, by Charles E. Beecher, American Journal of Science for 1898. A series of four papers commencing with July.

[9] About one-third of the known species of invertebrates in the Carboniferous rocks of North America are crinoids.

[10] The reader will please bear in mind here and elsewhere that protective and adaptive characters are not put on by any conscious act of the animals mentioned, but that they have gradually developed during a long course of years. There is a great temptation to write of protective resemblances as though they were *voluntary* acts, and many there be who succumb to this temptation. But these characters have been brought about, so it is believed, by elimination, by the weeding out of the more defenseless, so that the process is passive, not active.

[11] See the American Naturalist for March, 1902.

[12] Dall. Deep-Sea Mollusks and the Conditions under which they Exist; being the Annual Address of the President of the Biological Society of Washington, delivered November 16, 1889.

[13] So named because the air-bladder, which is present in many fishes, in this group opens into the gullet, and is so modified as to serve the purposes of a lung.

[14] This has been called Lower Carboniferous by some geologists.

[15] There is an almost irresistible tendency to picture extinct animals as much larger than they actually were, and to depict them as monsters of strength and ferocity. But large as they were, and fierce as they may have been, few among them could equal their popular reputation.

[16] It is perhaps hardly necessary to warn the reader that this is pure theory, although it has much of probability back of it, for protective resemblances could hardly have originated by any other process than that of a slow weeding out of the more conspicuous individuals.

[17] As given in Dana's Manual of Geology, page 644, edition of 1896.

[18] South Joggins is in that part of Nova Scotia known as Acadia and rendered famous by Longfellow as well as by its fossils.

[19] The Sigillarias and Lepidodendrons are included in a group called Lepidophytes, scale plants, because of the small stiff leaves arranged in spiral rows about their trunks, like so many overlapping scales.

[20] *Cryptobranchus alleghaniensis*, the generic name, hidden gills, being an allusion to the fact that while this salamander has permanent gills and is a water-breather, the gills are concealed beneath a flap of skin.

[21] The writer pleads guilty to having named this species *Heterodontosuchus ganei*, Gane's different-toothed crocodile, the generic name being an allusion to the difference in size between the front and other teeth, as well as to a peculiarity in the shape of all the teeth. The specific name is to credit Mr. Gane with the discovery of the specimen.

[22] Sigillaria possibly endured into the Trias, but lepidodendron is scantily represented even in the Permian.

[23] See the previous chapter.

[24] But the individual footprints are, of course, but 3 feet apart.

[25] So-called because cattle-herders had used the abundant dinosaur bones in the construction of a hut.

[26] Not that a scientific name must of *necessity* refer to some feature possessed by the animal to which it is given, although the best names usually do contain an allusion to some evident character or habit or to the locality where the animal was first found.

[27] This, of course, in a full-grown animal; the leg-bones range from that downward.

[28] Now preserved in the American Museum of Natural History, New York.

[29] This is not his original name; he was first called Megadactylus, but this was found to have been already used, and so *Megadactylus* was rechristened.

[30] In some cases also a small first or inner toe, as in birds.

[31] *Laopteryx*, described by Professor Marsh, from the Jurassic of Colorado, is very probably a pterodactyl.

[32] The theory has been advanced that birds have been derived from at least two sources; and while it seems improbable that such structures as feathers should have originated twice, there are some reasons why this *may* have taken place.

[33] Hesperornis very likely had a tail intermediate in pattern between these two, and he was so drawn by Mr. Gleeson in Animals of the Past.

[34] So named because, as stated above, some of the vertebræ are cup-shaped at either end, like those of fishes.

[35] In support of this theory it may be said that two animals, *Theriodesmus* and *Tritylodon*, from South Africa, once considered mammals, are now classed with the Anomodontia.

[36] Recently some doubts have been cast on the egg-laying habits of the platypus, and although eggs are found *in* these animals, it is thought that they may be retained until hatching.

[37] The anomodonts, of course, excepted; but then they furnish exceptions to a great many rules.

[38] See Early Birds and Mammals.

[39] A rather large and powerful fish of tropical waters, having strong, lancet-like teeth. It is abundant in the Gulf of Mexico and off the coast of Florida.

[40] (The fish) before sphyræna.

[41] The bold, sword-rayed (fish), in allusion to the large, powerful curved rays of the front fins.

[42] Here, as usual, the size has been vastly overestimated, and by people who should know better. Statements are current to the effect that mosasaurs attained a length of 75 feet, but Professor Williston, who has made a careful study of the group, says that there is not a specimen in existence indicating an animal over 45 feet long.

[43] Iguana-toothed, from the resemblance of their teeth, and especially the manner of their attachment, to those of a modern iguana. The iguanodons of Europe are found in the Upper Jurassic; still another instance of tardiness on our part, though very likely due to the group having originated abroad.

[44] The writer is well aware that this phrase has been employed by M. Mouillard for the title of a book, but does not on that account wish to forego all right to use the term.

[45] It is to be understood that these measurements apply to the *largest* specimens only. The majority were much smaller than this.

[46] No dependence can be placed in most statements regarding the size and weight of birds and other animals. For the most part they are no better than guesses, and very wide of the mark, as the application of rule and scales will quickly show.

[47] Dana. Manual of Geology, edition of 1896, p. 876.

[48] This is not quite certain, for the development of the horse may yet be shown to have taken place in North America, though just at present it is not traced back of Hyracotherium. The statement is made on the authority of Professor Scott.

[49] Those not familiar with it will find the ancestry of the horse given at some length in Animals of the Past.

[50] This is one of the instances where the scientific name is certainly no harder than the common name. *Ortalis vetula* is easier to pronounce than chachalaca, and conveys just as good an idea of the bird to the average person.

[51] Just here the writer is at the mercy of the English language, which calls the projections of the skull horns, applies the same term to their epidermal covering, and to the solid nasal horn of the rhinoceros and sometimes to the antlers of deer.

[52] Not that the mastodon was obscure, but the valleys between the ridges of the teeth were obscured by little projections, so as not to be so sharply marked as in the more recent species.

[53] The pair of horn-cores in the collection of the Cincinnati Society of Natural History measure 6 feet 6 inches along the curve from tip to tip, and the horns themselves that fitted over these bony cores would be quite a little longer. A pair of horn-cores, attached to the frontal bone, have just been found in Kansas which measure 7 feet between the tips and 8 feet 6 inches along the curve.

[54] As a matter of fact this name is now a misnomer, since earlier elephants are known, but a scientific name once bestowed on an animal must stay.

[55] A somewhat fuller discussion of this question may be found in Animals of the Past and the writer can only reiterate what is said there. He *believes* that man and mastodon were contemporary, but has not seen any good evidence that such was the case.

[56] Intelligent in providing the *means* of destruction.

[57] There is a possibility that these last may prove to have been represented here in the Pliocene, as a horn in the United States National Museum, and some foot-bones in Princeton, appear to belong to antelopes.

[58] Yale University Museum has perhaps a still larger collection, but owing to lack of room few examples are on exhibition.

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Transcriber's Notes:

Hyphenation has been standardised.

References to ’natural size‘ within illustration captions should be ignored.

Re: page 32, “How many readers know what a potto is, a colugo, mulligong, scheltopusic, cacomistle, or wobblygong?”

Potto: West African lemur a ’sloth‘. (OED)

Colugo: A flying lemur.

Mulligong: Platypus (New Guinea). “Old Friends Being Literary Recollections of Other Days,” William Winter, page 309, New York, 1909.

Sheltopusik: A lizard of the genus Pseudopus (*P. pallasii*). (OED)

Cacomistle: A raccoon-like animal of the south-western United States and Mexico, *Bassariscus astutus*. (OED)

Wobblygong=wobbegong: A brown carpet shark with buff markings, *Orectolobus maculatus*, found off the coast of Australia. (OED)

[The end of *Animals before man in North America* by A. Frederic Lucas]