From a photograph

MEXICAN SHEEP-HERDERS ON THE LARAMIE PLAINS NEAR THE BONE-CABIN QUARRY[1]

FOSSIL WONDERS OF THE WEST

THE DINOSAURS OF THE BONE-CABIN QUARRY

BEING THE FIRST DESCRIPTION OF THE GREATEST "FIND" OF EXTINCT ANIMALS EVER MADE

BY HENRY FAIRFIELD OSBORN

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ONE is often asked the questions: "How do you find fossils?" "How do you know where to look for them?" One of the charms of the fossil-hunter's life is the variety, the element of certainty combined with the gambling element of chance. Like the prospector for gold, the fossil-hunter may pass suddenly from the extreme of dejection to the extreme of elation. Luck comes in a great variety of ways: sometimes as the result of prolonged and deliberate scientific search in a region which is known to be fossiliferous; sometimes in such a prosaic manner as the digging of a well. Among discoveries of a highly suggestive, almost romantic kind, perhaps none is more remarkable than the one I shall now describe.

DISCOVERY OF THE GREAT DINOSAUR QUARRY

In central Wyoming, at the head of a "draw," or small valley, not far from the Medicine Bow River, lies the ruin of a small and unique building, which marks the site of the greatest "find" of extinct animals made in a single locality in any part of the world. The fortunate fossil-hunter who stumbled on this site was Mr. Walter Granger of the American Museum expedition of 1897.

In the spring of 1898, as I approached the hillock on which the ruin stands, I observed, among the beautiful flowers, the blooming cacti, and the dwarf bushes of the desert, what were apparently numbers of dark-brown boulders. On closer ex-

[1] The photographs and drawings of this article are reproduced by permission of the American Museum of Natural History.—EDITOR.

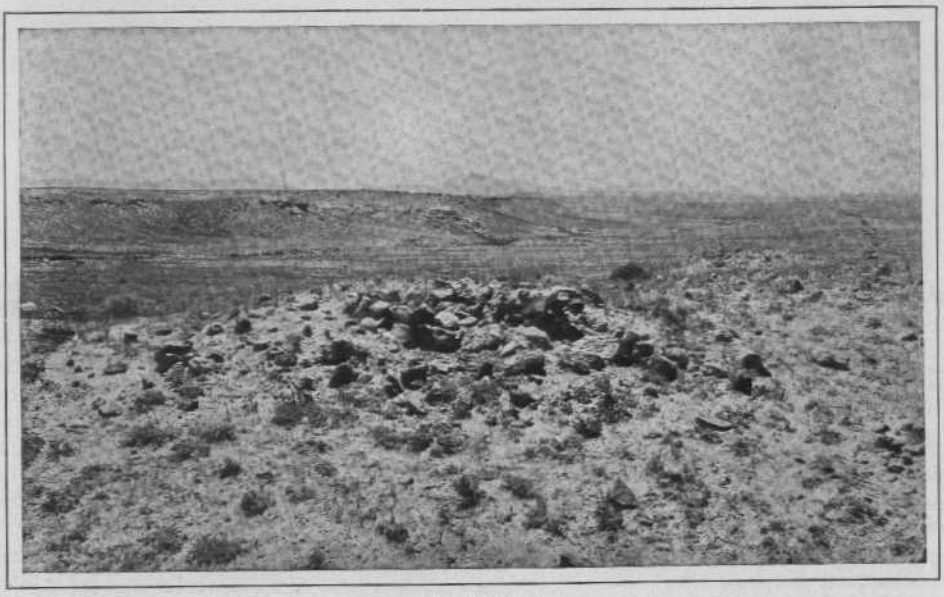
amination, it proved that there is really not a single rock, hardly even a pebble, on this hillock; all these apparent boulders are ponderous fossils which have slowly accumulated or washed out on the surface from a great dinosaur bed beneath. A Mexican sheep-herder had collected some of these petrified bones for the foundations of his cabin, the first ever built of such strange materials. The excavation of a promising outcrop was almost immediately rewarded by finding a thigh-bone nearly six feet in length which sloped downward into the earth, running into the lower leg and finally into the foot, with all the respective parts lying in the natural position as in life (see page 682). This proved to be the previously unknown hind limb of the great dinosaur *Diplodocus*.

In this manner the "Bone-Cabin Quarry" was discovered and christened. The total contents of the quarry are represented in the diagram on page 691. It has given us, by dint of six successive years of hard work, the materials for an almost complete revival of the life of the Laramie region as it was in the days of the dinosaurs. By the aid of workmen of every degree of skill, by grace of the accumulated wisdom of the nineteenth century, by the constructive imagination, by the aid of the sculptor and the artist, we can summon these living forms and the living environment from the vasty deep of the past.

THE FAMOUS COMO BLUFFS

THE circumstances leading up to our discovery serve to introduce the story. From 1890 to 1897 we had been steadily delving into the history of the Age of Mammals, in deposits dating from two hundred thousand to three million years back, as we rudely estimate geological time. In the course of seven years such substantial progress had been made that I decided to push into the history of the Age of Reptiles also, and, following the pioneers, Marsh and Cope, to begin exploration in the period which at once marks the dawn of mammalian life and the climax of the evolution of the great amphibious dinosaurs.

In the spring of 1897 we accordingly began exploration in the heart of the Laramie Plains, on the Como Bluffs, represented in the photograph on page 684. On arrival, we found numbers of massive bones strewn along the base of these bluffs, tumbled from their stratum above; too weather-worn to attract collectors, and



From a photograph

RUINS OF SHEEP-HERDER'S CABIN, THE FOUNDATIONS COMPOSED ENTIRELY OF THE REMAINS OF DINOSAURS

From a photograph

FIRST DISCOVERY OF THE LONG HIND LIMB OF THE DINOSAUR DIPLODOCUS

The discovery was made at the point where the Bone-Cabin Quarry was opened (see × in the diagram, page 691)

serving only to remind one of the time when these animals—the greatest, by far, that nature has ever produced on land—were monarchs of the world.

Aroused from sleep on a clear evening in camp by the heavy rumble of a passing Union Pacific freight-train,[1] I shall never forget my meditations on the contrast between the imaginary picture of the great Age of Dinosaurs, fertile in cycads and in a wonderful variety of reptiles, and the present age of steam, of heavy locomotives toiling through the semi-arid and partly desert Laramie Plains.

So many animals had already been removed from these bluffs that we were not very sanguine of finding more; but after a fortnight our prospecting was rewarded by finding parts of skeletons of the long-limbed dinosaur *Diplodocus* and of the heavy-limbed dinosaur *Brontosaurus*. The whole summer was occupied in taking these animals out for shipment to the East, the so-called "plaster method" of removal being applied with the greatest success. Briefly, this is a surgical device applied on a large scale for the "setting" of the much-fractured bones of a fossilized skeleton. It consists in setting great blocks of the skeleton, stone and all, in a firm capsule of plaster subsequently reinforced by great splints of wood, firmly drawn together with wet rawhide. The object is to keep all the fragments and splinters of bone together until it can reach the skilful hands of the museum preparator.

THE ROCK WAVES CONNECTING THE BLUFFS AND THE QUARRY

THE Como Bluffs are about ten miles south of the Bone-Cabin Quarry; between them is a broad stretch of the Laramie Plains. The exposed bone layer in the two localities is of the same age, and originally was a continuous level stratum which may be designated as the "dinosaur beds"; but this stratum, disturbed and crowded by the uplifting of the not far-distant Laramie range of mountains and the Freeze Out Hills, was thrown into a number of great

[1] At this time the Union Pacific Railroad directly passed the bluffs; in the recent improvement of the grade the main line has been moved to the south.—H. F. O.

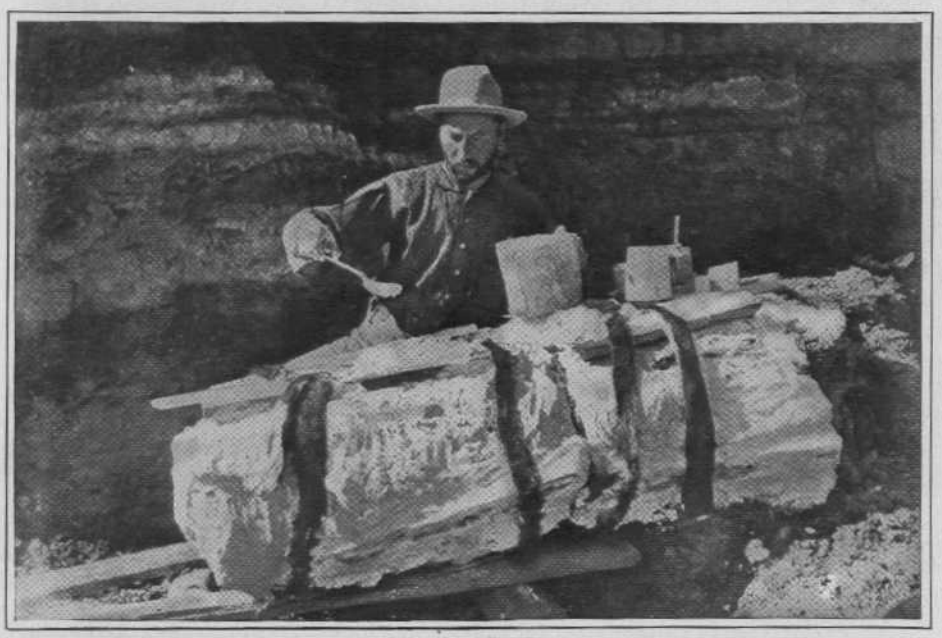
From a photograph

WORKING IN THE BONE-CABIN QUARRY DURING THE FIRST YEAR, 1898

(See * * in the diagram, page 691)

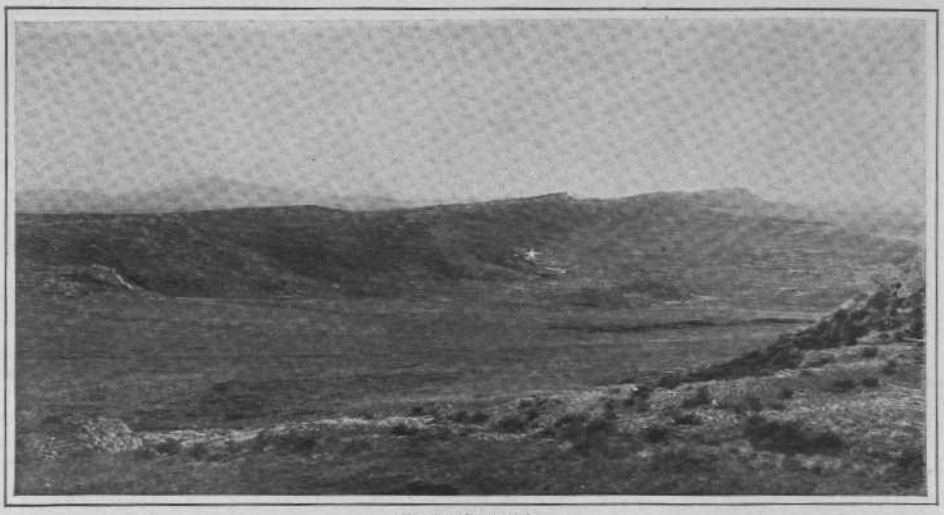
folds or rock waves, as revealed in the diagram on page 684. Large portions, especially of the upfolds, or "anticlines," of the waves, have been subsequently removed by erosion; the edges of these upfolds have been exposed, thus weathering out their fossilized contents, while downfolds are still buried beneath the earth for the explorers of coming centuries.

Therefore, as one rides across the coun-



From a photograph

SETTING FRACTURED DINOSAUR BONES IN PLASTER FOR TRANSPORTATION TO THE EAST FROM THE COMO-BLUFFS QUARRY OF 1897



From a photograph

COMO BLUFFS OF SOUTHERN WYOMING, OF THE JURASSIC AGE, WHERE MANY OF THE MOST IMPORTANT DISCOVERIES OF DINOSAURS HAVE BEEN MADE

This picture shows the Como Bluffs on the left of the valley, and the site of the Bone-Cabin Quarry on the right (see the diagram below)

try to-day from the bluffs to the quarry, startling the intensely modern fauna, the prong-horn antelopes, jack-rabbits, and sage-chickens, he is passing over a vast graveyard which has been profoundly folded and otherwise shaken up and disturbed. Sometimes one finds the bone layer removed entirely, sometimes horizontal, sometimes oblique, and again dipping directly into the heart of the earth. This layer (dinosaur beds) is not more than two hundred and seventy-four feet in thickness, and is altogether of fresh-water origin; but as a proof of the oscillations of the earth-

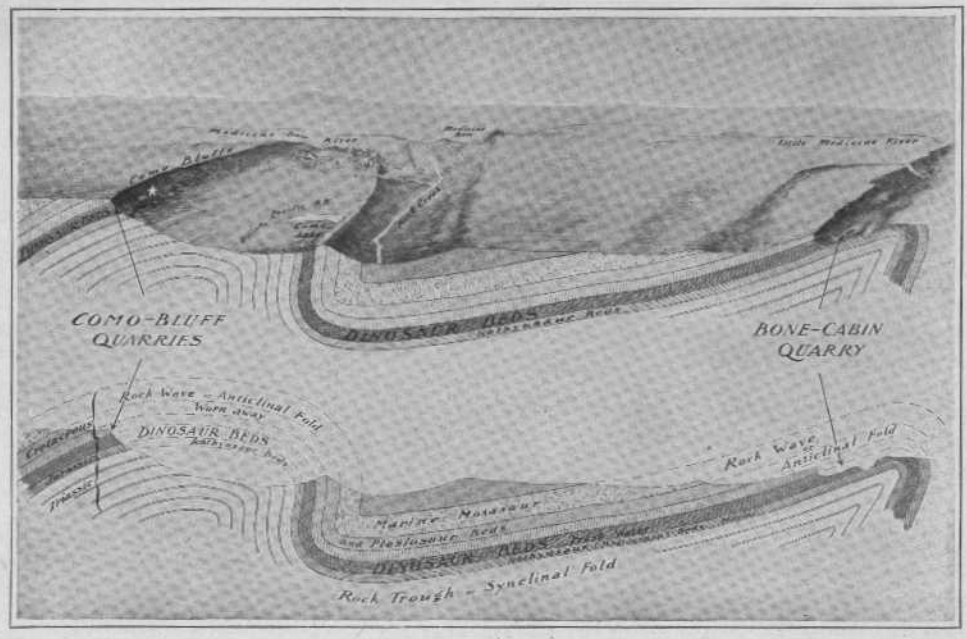
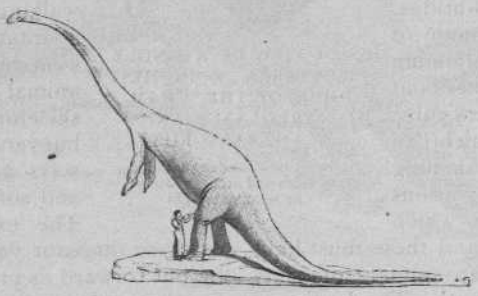


DIAGRAM KEY TO THE GEOLOGY OF THE REGION SHOWN IN THE PICTURE ABOVE

The white star, here and above, marks the location of the quarries of 1897 of the American Museum of Natural History

level both before and after this great thin sheet of fresh-water rock was so widely spread, there are evidences of the previous invasion of the sea (ichthyosaur beds) and of the subsequent invasion of the sea (mosasaur beds) in the whole Rocky Mountain region.

In traveling through the West, when once one has grasped the idea of continental oscillation, or submergence and emergence of the land, of the sequence of the marine and fresh-water deposits in laying down these pages of earth-history, he will know exactly where to look for this wonderful layer-bed of the giant dinosaurs; he will find that, owing to the uplift of various mountain-ranges, it outcrops along the entire eastern face of the Rockies, around the Black Hills, and in all parts of the Laramie Plains; it yields dinosaur bones everywhere, but by no means so profusely or so perfectly as in the two famous localities we are describing.



MODEL OF THE "LONG-LIMBED" DINOSAUR DIPLODOCUS, COMPARED WITH THE AVERAGE-SIZED MAN

HOW THE SKELETONS LIE IN THE BLUFFS AND QUARRY

At the bluffs single animals lie from twenty to one hundred feet apart; one rarely finds a whole skeleton, such as that of Marsh's *Brontosaurus excelsus*, the finest specimen ever secured here, which is now one of the treasures of the Yale museum. More frequently a half or a third of a skeleton lies together.

In the Bone-Cabin Quarry, on the other hand, as shown in the diagram on page 691, we came across a veritable Noah's-ark deposit, a perfect museum of all the animals of the period. Here are the largest of the giant dinosaurs closely mingled with the remains of the smaller but powerful carnivorous dinosaurs which preyed upon them, also those of the slow and heavy-moving armored dinosaurs of the period, as well as of the lightest and most bird-like of the dinosaurs. Finely rounded, complete limbs from eight to ten feet in length are found, especially those of the carnivorous dinosaurs, perfect even to the sharply pointed and recurved tips of their toes. Other limbs and bones are so crushed and distorted by pressure that it is not worth while removing them. Sixteen series of vertebræ were found strung together; among these were eight long strings of tail-bones. The occurrence of these tails is less surprising when we come to study the important and varied functions of the tail in these animals, and the consequent connection of the tail-bones by means of stout tendons and ligaments which held them together for a long period after death. Skulls are fragile and rare in the quarry, because in every one of these big skeletons there were no fewer than ninety distinct bones which exceeded the head in size, the excess in most cases being enormous.

The bluffs appear to represent the region of an ancient shoreline, such conditions as we have depicted in the restoration of *Brontosaurus* on page 693—the sloping banks of a muddy estuary or of a lagoon, either bare tidal flats or covered with vegetation. Evidently the dinosaurs were buried at or near the spot where they perished.

The Bone-Cabin Quarry deposit represents entirely different conditions. The theory that it is the accumulation of a flood is, in my opinion, improbable, because a flood would tend to bring entire skeletons down together, distribute them widely, and bury them rapidly. A more likely theory is that this was the area of an old river-bar, which in its shallow waters arrested the more or less decomposed and scattered carcasses which had slowly drifted downstream toward it, including a great variety of dinosaurs, crocodiles, and turtles, collected from many points up-stream. Thus were brought together the animals of a whole region, a fact which vastly enhances the interest of this deposit.

THE GIANT HERBIVOROUS DINOSAURS

By far the most imposing of these animals are those which may be popularly desig-

nated as the great or giant dinosaurs. The name, derived from *δεινός*, terrible, and *σαῦρος*, lizard, refers to the fact that they appeared externally like enormous lizards, with very long limbs, necks, and tails. They were actually remotely related to the tuatera lizard of New Zealand, and still more remotely to the true lizards.

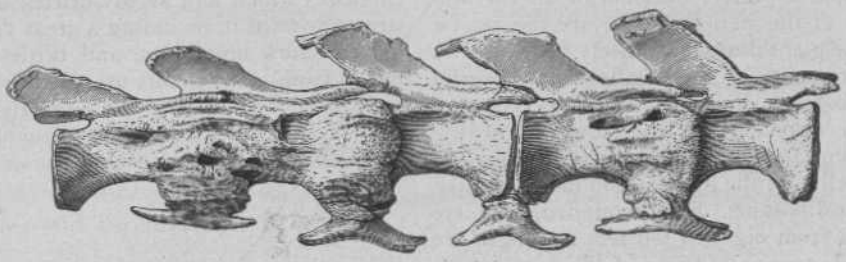
No land animals have ever approached these giant dinosaurs in size, and naturally the first point of interest is the architecture of the skeleton. The backbone is indeed a marvel. The fitness of the construction consists, like that of the American truss-bridge, in attaining the maximum of strength with the minimum of weight. It is brought about by dispensing with every cubic millimeter of bone which can be spared without weakening the vertebræ for the various stresses and strains to which they were subjected, and these must have been tremendous in an animal from sixty to seventy feet in length. The bodies of the vertebræ are of hour-glass shape, with great lateral and interior cavities; the arches are constructed on the T-iron principle of the modern bridge-builder, the back spines are tubular, the interior is spongy, these devices being employed in great variety, and constituting a mechanical triumph of size, lightness, and strength combined. Comparing a great chambered dinosaurian (*Camarasaurus*) vertebra (see above) with the weight per cubic inch of an ostrich vertebra, we reach the astonishing conclusion that it weighed only twenty-one pounds, or half the weight of a whale vertebra of the same bulk. The skeleton of a whale seventy-four feet in length has recently been found by Mr. F. A. Lucas of the Brooklyn Museum to weigh seventeen thousand nine hundred and twenty pounds. The skeleton of a dinosaur of the same length may be roughly estimated as not exceeding ten thousand pounds.

SIDE VIEW OF A SINGLE VERTEBRA, 30 INCHES HIGH, OF THE "CHAMBERED SAURIAN" CAMARASAURUS

Showing how the deep cavities in the sides and arches reduced its relative weight

PROOFS OF RAPID MOVEMENTS ON LAND

LIGHTNESS of skeleton is a walking or running or flying adaptation, and not at all a swimming one; a swimming animal needs gravity in its skeleton, because sufficient buoyancy in the water is always afforded by the lungs and soft tissues of the body. The extraordinary lightness of these dinosaur vertebræ may therefore be put forward as proof of supreme fitness for the propulsion of an enormous frame during occasional incursions upon land. There are additional facts which point to land progression, such as the point in the tail where the flexible structure suddenly becomes rigid, as shown in the diagram of vertebræ below; the component joints are so solid and flattened on the lower surface that they seem to demonstrate fitness to support partly the body in a tripodal position like that of a kangaroo. I have therefore hazarded the view that even some of these enormous dinosaurs were



FIVE CONSOLIDATED TAIL VERTEBRÆ OF THE "LONG-LIMBED" DINOSAUR DIPLODOCUS, SHOWING THE SUPPOSED RESTING POINT

capable of raising themselves on their hind limbs, lightly resting on the middle portion of the tail, as represented in the model on page 685. In such a position the animal would have been capable not only of browsing among the higher branches of trees, but of defending itself against the carnivorous dinosaurs by using its relatively short but heavy front limbs to ward off attacks.

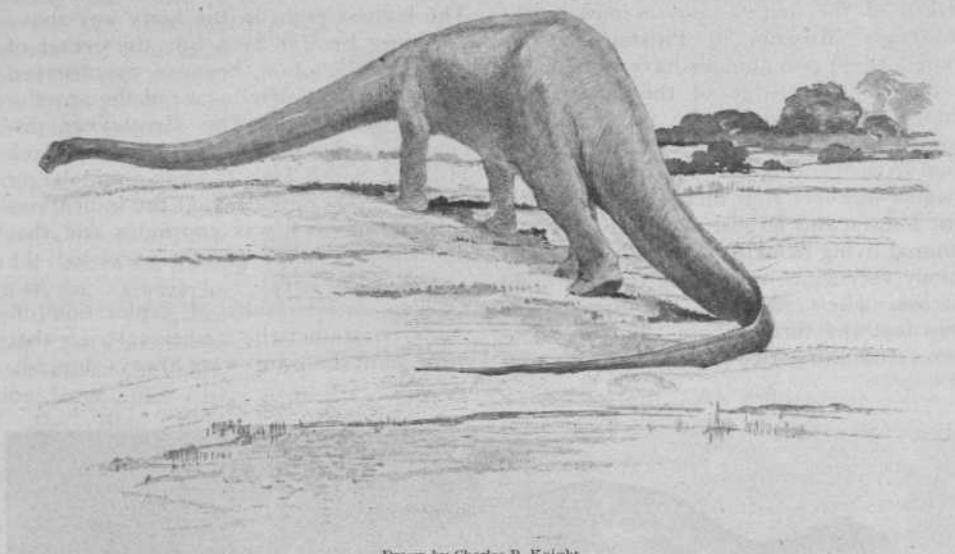
There are also indications of aquatic habits in some of the giant dinosaurs which render it probable that a considerable part of their life was led in the water. One of these indications is the backward position of the nostrils. Many, but not all, water-living mammals and reptiles have the nostrils on top of the head, in order to breathe more readily when the head is partly immersed. Another fact of note, although perhaps less conclusive, is the fitness of the tail for use while moving about in the water, if not in rapid swimming.

The great tail, measuring from twenty-eight to thirty feet, was one of the most remarkable structures in these animals, and undoubtedly served a great variety of purposes, propelling while in the water, balancing and supporting and defending while on land. In *Diplodocus* (above) it was most perfectly developed from its muscular base to its delicate and whip-like tip, perhaps for all these functions.

THE THREE KINDS OF GIANT DINOSAURS

It is very remarkable that three distinct kinds of these great dinosaurs lived at the same time in the same general region, as proved by the fact that their remains are freely commingled in the quarry.

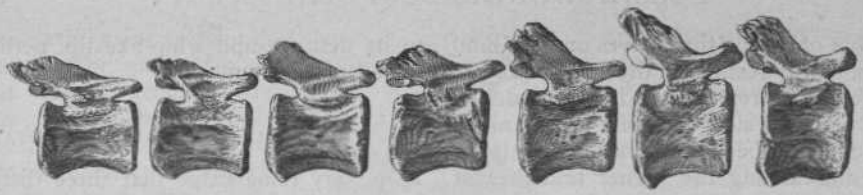
What were the differences in food and habits, in structure, and in gait, which prevented that direct and active competition between like types in the struggle for existence which in the course of nature always leads to the extermination of one or the other type? In the last three years we have discovered very considerable differences of structure which make it appear that these animals, while of the same or nearly the same linear dimensions, did not enter into direct competition either for food or for territory.



Drawn by Charles R. Knight

RESTORATION OF THE "LONG-LIMBED" DINOSAUR DIPLODOCUS

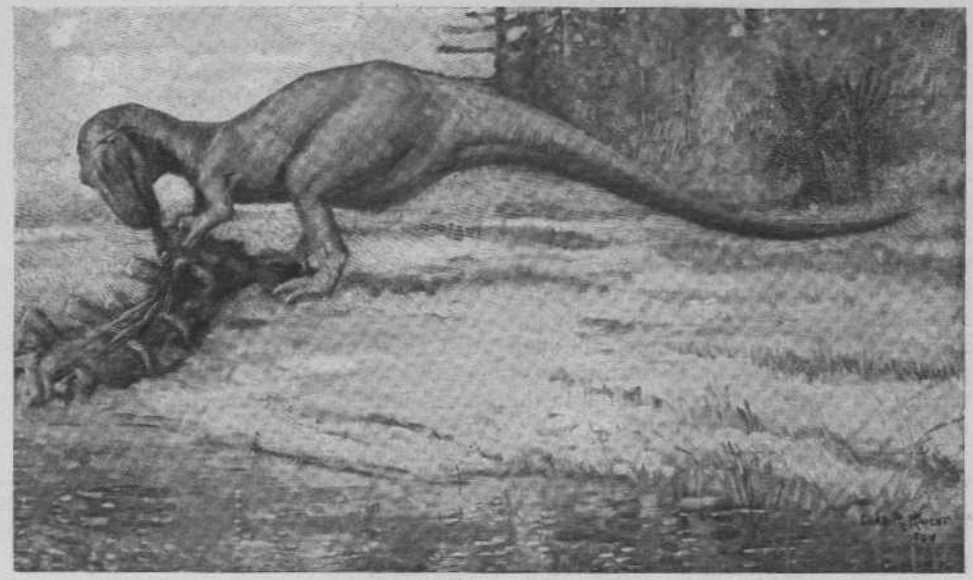
The dinosaur named *Diplodocus* by Marsh is the most completely known of the three. Our very first discovery in the Bone-Cabin Quarry gave us the hint that *Diplodocus* was distinguished by relatively long, slender limbs, and that it may be popularly known as the "long-limbed dinosaur." The great skeleton found in the Como



SEVERAL TAIL VERTEBRÆ OF A BRONTOSAURUS, SHOWING GROOVES MADE BY THE TEETH OF CARNIVOROUS DINOSAURS

Bluffs enabled me to restore for the first time the posterior half of one of these animals estimated as sixty feet in length, the hips and tail especially being in a perfect state of preservation. A larger animal, nearer seventy feet in length, including the anterior half of the body, and still more complete, was discovered about ten miles north of the quarry, and is now in the Carnegie Museum in Pittsburg. Combined, these two animals have furnished a complete knowledge of the great bony frame. The head is only two feet long, and is, therefore, small out of all proportion to the great body. The neck measures twenty-one feet four inches, and is by far the longest and largest neck known in any animal living or extinct. The back is relatively very short, measuring ten feet eight inches. The vertebræ of the hip measure two feet and three inches. The tail measures from thirty-two to forty feet. We thus obtain, as a moderate estimate of the total length of the animal, sixty-eight to seventy feet. The restored skeleton, published by Mr. J. B. Hatcher in July, 1901, and partly embodying our results, gave to science the first really accurate knowledge of the length of these animals, which hitherto had been greatly overestimated. The highest point in the body was above the hips; here, in fact, was the center of power and motion, because, as observed above, the tail fairly balanced the anterior part of the body. The *Barosaurus*, discovered by Dr. G. R. Wieland in the Black Hills of South Dakota, was a still larger animal of the same build; the indications are that its neck was enormous and that the whole animal greatly exceeded the *Diplodocus* in size.

These latest results of exploration directly contradict the traditional view that these giant dinosaurs were always sluggish.



Drawn by Charles R. Knight

RESTORATION OF THE LARGE CARNIVOROUS DINOSAUR CREOSAURUS, PREYING ON THE TAIL VERTEBRÆ (SEE DIAGRAM ABOVE) OF A BRONTOSAURUS

This slight-limbed animal was essentially tall, long-necked, and for its size remarkably agile. The restoration by Mr. Knight on page 687 is drawn from a very careful model made under my direction, in which the proportions of the animal are precisely estimated. It is, I think, accurate —for a restoration—as well as interesting and up-to-date. These restorations are the "working hypotheses" of our science; they express the present state of our knowledge, and, being subject to modification by future discoveries, are liable to constant change.

By contrast, the second type of giant dinosaur, the *Brontosaurus*, or "thunder saurian," of Marsh, as shown in the restoration on page 693, was far more massive in structure and relatively shorter in body. Five more or less complete skeletons are now to be seen in the Yale, American, Carnegie, and Field Columbian museums. In 1898 we discovered in the bluffs, about three miles west of the Bone-Cabin Quarry, the largest of these animals which has yet been found; it was worked out with great care and is now being restored and mounted complete in the American Museum. The thigh-bone is enormous, measuring five feet eight inches in length, and is relatively of greater mass than that of *Diplodocus*. The neck, chest, hips, and tail are correspondingly massive. The neck is relatively shorter, however, measuring eighteen feet, while in *Diplodocus* it measures over twenty-one feet. The total length of this massive specimen is estimated at sixty-three feet, or from six to eight feet less than the largest "long-limbed" dinosaur. The height of the skeleton at the hips is fifteen feet. There is less direct evidence that the "thunder saurian" had the power of raising its fore quarters in the air than in the case of the "light-limbed saurian," because no bend or supporting point in the tail has been distinctly observed.

Drawn by Charles R. Knight

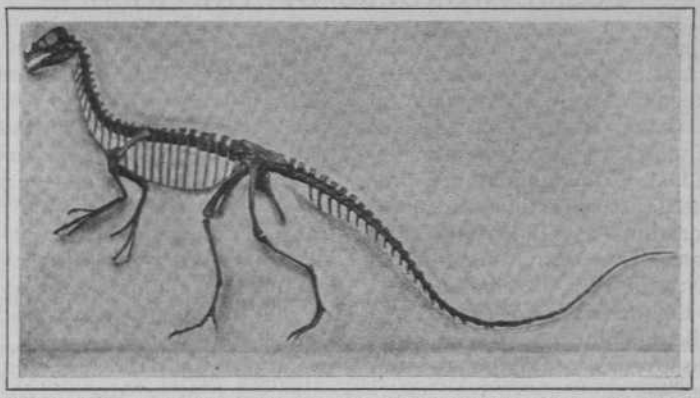
VULTURE FEEDING IN THE NEW YORK ZOÖLOGICAL PARK

To show the manner in which the carnivorous dinosaur probably tore his food

The third type of giant dinosaur is the less completely known "chambered saurian," the *Camarasaurus* of Cope or *Morosaurus* of Marsh, an animal more quadrupedal in gait or walking more habitually on all fours, like the great *Cetiosaurus*, or "whale saurian," discovered near Oxford, England. With its shorter tail and heavier fore limbs, it is still less probable that this animal had the power of raising the anterior part of its body from the ground. Of a related type, perhaps, is the largest dinosaur ever found; this is the *Brachiosaurus*, limb-bones of which were discovered in central Colorado in 1901 and are now preserved in the Field Columbian Museum of Chicago. Its thigh-bone is six feet eight inches in length, and its upper arm-bone, or humerus, is even slightly longer.

FEEDING HABITS OF THE GIANT DINOSAURS

We still have to solve one of the most perplexing problems of fossil physiology: how did the very small head, provided with light jaws, slender and spoon-shaped teeth confined to the anterior region, suffice to provide food for these monsters? I have advanced the idea that the food of *Diplodocus* consisted of some very abundant and nutritious species of water-plant; that the clawed feet were used in uprooting such plants, while the delicate anterior teeth were employed only for drawing them out of the water; that the plants were drawn down the throat in large quantities without mastication, since there were no grinding or back teeth whatever in this animal. Unfortunately for this theory, it is now found that the front feet were not provided with many claws, there being only a single claw on the inner side. Nevertheless, by some such means as this, these enormous animals could have obtained sufficient food in the water to support their



SKELETON OF SMALL CARNIVOROUS "BIRD-CATCHING" DINOSAUR
Found in the Bone-Cabin Quarry, as mounted in the American Museum of Natural History

great bulk. Possibly some of these dinosaurs fed exclusively while on land, in which case the elevation of the body on the hind limbs may have been for the purpose of enabling them to browse from the taller trees.

THE CARNIVOROUS DINOSAURS

MINGLING with the larger bones in the quarry are the more or less perfect remains of swamp turtles, of dwarf crocodiles, of the entirely different group of plated dinosaurs, or *Stegosauria*, but especially of two entirely distinct kinds of large and small flesh-eating dinosaurs. The latter rounded out and gave variety to the dinosaur society, and there is no doubt that they served the savage but useful purpose, rendered familiar by the doctrine of Malthus, of checking overpopulation. These fierce animals had the same remote ancestry as the giant dinosaurs, but had gradually acquired entirely different habits and appearance.

In a portion of the first "thunder sau-

Drawn by Charles R. Knight

RESTORATION OF THE "BIRD-CATCHING" DINOSAUR IN THE ACT OF CATCHING THE JURASSIC BIRD ARCHÆOPTERYX

BONE-CABIN QUARRY, ALBANY COUNTY, SOUTH CENTRAL WYOMING
SCENE OF THE AMERICAN MUSEUM EXPEDITIONS 1898–1904

KEY SHOWING THE MINGLING OF SOME OF THE PRINCIPAL TYPES IN THE QUARRY

Great Amphibious Dinosaurs: "long-limbed" Dinosaur *Diplodocus*, Nos. 251, 516, 655, 969; "heavy-limbed" Dinosaur, or "thunder saurian," Nos. 597, 675, 690, 860; "short-limbed" Dinosaur, or *Camarasaurus*, Nos. 467, 694, 823; undetermined, Nos. 252, 324, 339. Plated Dinosaurs, or Stegosaurs, No. 536. Large Carnivorous Dinosaurs, Nos. 290, 324, 600, 680, 684, 960. Small Carnivorous Dinosaur, No. 619. Crocodile, No. 570.

rian" skeleton found in the Como Bluffs, we discovered an interesting bit of evidence as to the probable cause of death, revealed in the picture of the tail vertebræ on page 688. As these bones were being worked out of the rock, the tips of the spines of several vertebræ of the tail were found to be incomplete, and close examination proved that they had been bitten off, not broken off, as first appeared to be the case. On the sides of the spines were large furrows at regular intervals, made by sharply pointed teeth, which intervals corresponded with the intervals between the teeth of the large carnivorous dinosaurs of the period. There is no manner of doubt that the "thunder-saurian" carcass was preyed upon somewhat as represented in the restoration on page 688, and that the bones were thus pulled apart and scattered. With less direct circumstantial evidence we may draw the inference that the big animal had been attacked, probably at the throat, as the most vulnerable point.

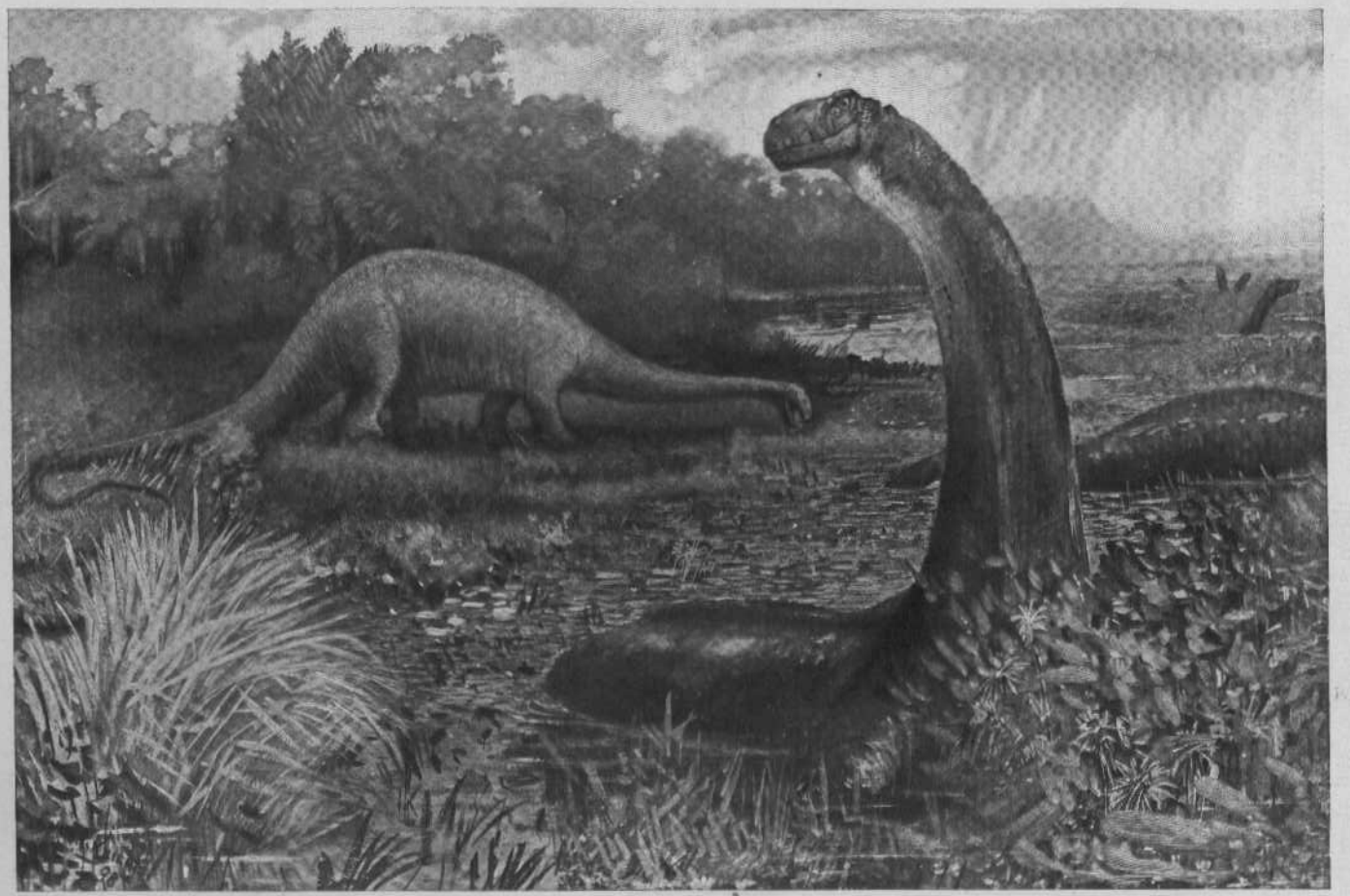
The sharpness and serration of the teeth were not the only distinction of the flesh-eating dinosaurs. Far inferior in size, they were superior in agility, exclusively bipedal, with very long, powerful hind limbs, upon which they advanced by running or springing, and with short fore limbs, the exact uses of which are difficult to ascertain. Both hands and feet were provided with powerful tearing claws. On the hind foot is the back claw, so characteristic of the birds, which during the Triassic period left its faint impression almost everywhere in the famous Connecticut valley imprints of these animals. That the fore limb and hand were of some distinct use is proved by the enormous size of the thumb-claw; while the hand may not have conveyed food to the mouth, it may have served to seize and tear the prey. As to the actual pose in feeding, there can be little doubt as to its general similarity to that of the *Raptores* among the birds, as suggested to me by Dr. Wortman, and as illustrated on page 689: one of the hind feet rested on the prey, the other upon the ground, the body being further balanced or supported by the vertebræ of the tail. The animal was thus in a position to apply its teeth and exert all the power of its very powerful arched back in tearing off its food. That the gristle of the bone or cartilage was very palatable is attested not only by the tooth-marks upon these bones, but by many similar markings found in the Bone-Cabin Quarry.

THE BIRD-CATCHING DINOSAUR

Of all the bird-like dinosaurs which have been discovered, none possesses greater similitude to the birds than the gem of the quarry, the little animal about seven feet in length which we have named *Ornitholestes*, or the "bird-catching dinosaur." It was a marvel of speed, agility, and delicacy of construction. Externally its bones are simple and solid-looking, but as a matter of fact they are mere shells, the walls being hardly thicker than paper, the entire interior of the bone having been removed by the action of the same marvelous law of adaptation which sculptured the vertebræ of its huge contemporaries. There is no evidence, however, that these hollow bones were filled with air from the lungs, as in the case of the bones of birds. The foot is bird-like; the hand is still more so; in fact, no dinosaur hand has ever before been found which so closely mimics that of a bird in the great elongation of the first or index-finger, in the abbreviation of the thumb and middle finger, and in the reduction of the ring-finger. These fingers, with sharp claws, were not strong enough for climbing, and the only special fitness we have been able to imagine is that they were used for the grasping of a light and agile prey (see page 690).

Another reason for the venture of designating this animal as the "bird-catcher" is that the Jurassic birds (not thus far discovered in America, but known from the *Archæopteryx* of Germany) were not so active or such strong fliers as existing birds; in fact, they were not unlike the little dinosaur itself. They were toothed, long-tailed, short-armed, the body was feathered instead of scaled; they rose slowly from the ground. This renders it probable that they were the prey of the smaller pneumatic-built dinosaurs such as the present animal.

This hypothetical bird-catcher seems to have been designed to spring upon a delicately built prey, the structure being the very antipode of that of the large carnivorous dinosaurs. A difficulty in the bird-catching theory, namely, that the teeth are not as sharp as one would expect to find



Drawn by Charles R. Knight

RESTORATION OF A GROUP OF BRONTOSAURS, OR "THUNDER SAURIANS," ILLUSTRATING THE HYPOTHESIS THAT THESE ANIMALS WERE AMPHIBIOUS

Remains of twenty members of this genus were found in the Bone-Cabin Quarry

them in a flesh-eater, is somewhat offset by the similarity of the teeth to those of the bird-eating monitor lizards (*Varanus*), which are not especially sharp.

THE GREAT YIELD OF THE QUARRY

OUR explorations in the quarry began in the spring of 1898, and have continued ever since during favorable weather. As shown in the diagram on page 691, the total area explored at the close of the sixth year was seven thousand two hundred and fifty square feet. Not one of the twelve-foot squares into which the quarry was plotted lacked its covering of bones, and in some cases the bones were two or three deep. Each year we have expected to come to the end of this great deposit, but it still yields a large return, although we have reason to believe that we have exhausted the richest portions.

We have taken up four hundred and eighty-three parts of animals, some of which may belong to the same individuals. These were packed in two hundred and seventy-five boxes, representing a gross weight of nearly one hundred thousand pounds. Reckoning from the number of thigh-bones, we reach, as a rough estimate of the total, seventy-three animals of the following kinds: giant herbivorous dinosaurs, 44; plated herbivorous dinosaurs, or stegosaurs, 3; iguanodonts or smaller herbivorous dinosaurs, 4; large carnivorous dinosaurs, 6; small carnivorous dinosaurs, 3; crocodiles, 4; turtles, 5. But this represents only a part of the whole deposit, which we know to be of twice the extent already explored, and these figures do not include the bones which were partly washed out and used in the construction of the Bone Cabin. The grand total would probably include parts of over one hundred giant dinosaurs.

THE STRUGGLE FOR EXISTENCE AMONG THE DINOSAURS

NEVER in the whole history of the world as we now know it have there been such remarkable land scenes as were presented when the reign of these titanic reptiles was at its climax. It was also the prevailing life-picture of England, Germany, South America, and India. We can imagine herds of these creatures from fifty to eighty feet in length, with limbs and gait analogous to those of gigantic elephants, but with bodies extending through the long, flexible, and tapering necks into the diminutive heads, and reaching back into the equally long and still more tapering tails. The four or five varieties which existed together were each fitted to some special mode of life; some living more exclusively on land, others for longer periods in the water.

The competition for existence was not only with the great carnivorous dinosaurs, but with other kinds of herbivorous dinosaurs (the iguanodonts), which had much smaller bodies to sustain and a much superior tooth mechanism for the taking of food.

The cutting off of this giant dinosaur dynasty was nearly if not quite simultaneous the world over. The explanation which is deducible from similar catastrophes to other large types of animals is that a very large frame, with a limited and specialized set of teeth fitted only to a certain special food, is a dangerous combination of characters. Such a monster organism is no longer adaptable; any serious change of conditions which would tend to eliminate the special food would also eliminate these great animals as a necessary consequence.

There is an entirely different class of explanations, however, to be considered, which are consistent both with the continued fitness of structure of the giant dinosaurs themselves and with the survival of their especial food; such, for example, as the introduction of a *new enemy* more deadly even than the great carnivorous dinosaurs. Among such theories the most ingenious is that of the late Professor Cope, who suggested that some of the small, inoffensive, and inconspicuous forms of Jurassic mammals, of the size of the shrew and the hedgehog, contracted the habit of seeking out the nests of these dinosaurs, gnawing through the shells of their eggs, and thus destroying the young. The appearance, or evolution, of any egg-destroying animals, whether reptiles or mammals, which could attack this great race at such a defenseless point would be rapidly followed by its extinction. We must accordingly be on the alert for all possible theories of extinction; and these theories themselves will fall under the universal principle of the survival of the fittest until we approximate or actually hit upon the truth.