the intervening medium and not to the properties of the source of light. Thus those times when thin cirrus clouds, fog, or smoke cover the sun, which are well known by solar observers to be the times when "boiling" is apt to be diminished, and which are the most favorable opportunities for visual and photographic observations, are quite unsuitable for bolometric work. Indeed, the best time for this is somewhat after noon on those clear October days when "boiling" is apt to be at a maximum, but cloudiness at a minimum, and it is probable that the definition obtained in such conditions will never be the best.

Trials made thus far have demonstrated the great value of the stirring apparatus, not only to diminish "boiling," but to preserve a constant focal length and tolerable definition. "Boiling" is still of course noticeable, because the long reach of air above the cœlostat is not stirred, but the image is far better than could be obtained with the earlier appliances, and owing to the massive piers and to the simplicity of driving mechanism, it is less subject to jars and wandering.

THE BRONTOSAUR. HOW A GIANT PREHISTORIC ANIMAL WAS DISCOVERED, TRANSPORTED AND RESTORED.

In 1897 Mr. Walter Granger, of the expedition sent out in that year by the American Museum of Natural History of New York, found in the southeastern part of central Wyoming, not far from the Medicine Bow River, the first fruits of the greatest collection of the fossilized remains of extinct reptiles that has ever been discovered in any one locality. Previous prospectors had taken fossils from the region, but had abandoned it for other fields, so that Mr. Granger really rediscovered it. It will be remembered, from various accounts published since then, that weathered fragments of dinosaur bones were so common at this place that they were taken for bowlders of peculiar shape, and that a couple of Mexican sheep herders had used these fossils for the foundations of their hut. This Bone Cabin Quarry, as it came to be called, was about ten miles south of the famous Como Bluffs, from which a considerable number of fossilized skeletons had previously been taken. The finest specimen among these is Prof. Marsh's *Brontosaurus excelsus*, now one of the treasures of the Yale Museum.

When fossil bones of one kind are found in different places within a reasonable distance of one another, they usually occur in one stratum, which has cropped out at different points. This is true of the remains found at the Como Bluffs and at the Bone Cabin Quarry, the bone layers there exposed being of the same age, and originally an unbroken level stratum which may be designated as "the dinosaur beds." When the contiguous Laramie Mountains and the Freeze-Out Hills were formed by the shrinking of the earth's crust, this stratum was correspondingly warped and wrinkled into numbers of great folds or rock waves. Surface erosion of wind and water has been responsible for the subsequent removal of great portions of the crests and upfolds or "anticlines" of these waves, thus exposing the edges and allowing the weathering out of the fossilized contents of the strata. This layer, usually about two hundred and seventy feet in thickness, is entirely of fresh-water origin, but both above and below it are strata which show that there had been previous and subsequent invasions of the sea, the first forming the ichthyosaur and the latter the mosasaur beds. Owing to the uplift of the various mountain ranges, this great dinosaur graveyard is found to crop out along the entire eastern face of the Rocky Mountains, around the Black Hills and in all parts of the Laramie Plains. Dinosaur bones may be found almost everywhere, but up to the present, in no locality have they been seen in such profusion as in the two well-known places mentioned before.

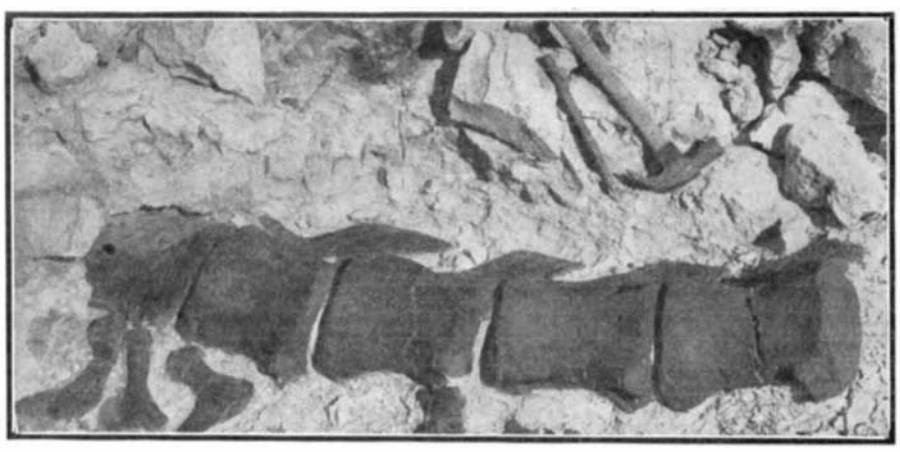
In the excavations at the Como Bluffs the remains were found thoroughly scattered and from twenty to a hundred feet apart, an entire skeleton or even the larger part of one being extremely rare. In the Bone Cabin Quarry, on the other hand, the American Museum expedition found a vast number of skeletons, not only close together, but often closely commingled, remains of most of the animals of that region at that period, from the largest of the giant dinosaurs to the smallest and most bird-like kind. The Bluffs appear to represent the ancient shore line of a muddy estuary or lagoon, such as is depicted in the accompanying drawing of a Brontosaurus restoration by Charles R. Knight. Prof. Henry Fairfield Osborn, curator of the Department of Vertebrate Palæontology at the American Museum, believes that at the Bone Cabin Quarry, on the other hand, the conditions were different; that this was the area of an old river bar which, in its shallow waters, arrested the more or less decomposed and scattered carcasses that had slowly drifted down stream toward it, from almost the entire region through which the river took its course.

The greatest of these creatures were the giant dinosaurs, and very probably no animals existing on land have ever approached them in size and bulk. The evidence of the freely commingled remains shows us that at least three distinct kinds of these giant dinosaurs existed at the same time in the same region.

The dinosaur named *Diplodocus* by Marsh is most completely known. The American Museum's first find in the Bone Cabin Quarry was the previously unknown hind limb of this dinosaur, a find that showed it was distinguished by relatively long, slender members and may popularly be called the "long-limbed dinosaur." The major portion of a great skeleton unearthed in the Bluffs and a larger one found about ten miles north of the Bone Cabin Quarry furnished practically complete knowledge of the great bony frame of this giant lizard. By contrast the second, the Brontosaurus, or "thunder saurian" of Marsh, was relatively shorter in body and more compactly built, but more massive in structure. Considerable portions of the skeletons of perhaps a score of the great herbivorous dinosaurs are preserved in the Yale, Carnegie (Pittsburg), Field Columbian and American museums, while much less abundant and more incomplete remains have been found in England near Oxford. Of another type, and much smaller in size, were the carnivorous dinosaurs. They were bipeds with bird-like feet and sharp claws, and, in contrast with the two foregoing types, had large heads with sharp, pointed teeth. The marks of these teeth have been found upon the tail vertebræ of both *Diplodocus* and *Brontosaurus*, showing that if the carnivora did not destroy the ponderous and slow-witted lizards of the other types, they at least fed upon their carcasses.

Covering the Excavated Bones with Plaster of Paris.

The figures on the plaster show what each bone is and where it was found.



Appearance of the Fossil Bones when Uncovered.

THE RESTORATION OF THE GIANT LIZARD, THE BRONTOSAUR, AT THE AMERICAN MUSEUM OF NATURAL HISTORY, NEW YORK.

In 1898 the largest known and at the same time the most complete Brontosaurus skeleton was discovered about three miles west of the Bone Cabin Quarry. It was worked out with great care, and is now being restored and mounted complete at the American Museum under the direction of Prof. Osborn. When finished it will be the only mounted skeleton of a Brontosaurus in the world, though at the Yale Museum the pelvis and hind legs of a dinosaur of this kind are mounted, and another splendid skeleton of a Diplodocus is being reconstructed at the Carnegie Museum, Pittsburg.

As can be readily understood, the natural processes incident to the preservation of these fossils almost preclude the possibility of finding an entire skeleton. Especially is this true of the smaller bones, such as those of the head, or those not firmly bound together by strong ligaments. These often become scattered or so badly crushed by the weight of the strata which accumulate above them that it is not worth while to mount or even reconstruct them. The Brontosaurus now in course of erection at the American Museum is unusually well preserved, and it is, fortunately, of nearly the same size as the Yale Museum specimen. This fact smoothed over a number of difficulties. The skull was not found, and in fact is known only by incomplete portions of the jaw and of the back of the head. The reconstructed skull is based on these fragments and on the known skull of a nearly related species. The heads of these herbivorous dinosaurs, by the way, were comparatively small in size and altogether out of proportion with the ponderous body. We can hardly understand how this very small head with its light jaws and slender, spoon-shaped teeth could adequately supply the food necessary to nourish the great creature. Prof. Osborn is of the opinion that the animals fed on some very plentiful and nutritious water-plant, which was swallowed in large quantities without mastication, there being no grinders or molars in the head.

The Brontosaurus was among the most highly specialized of the herbivorous dinosaurs—probably the last of the race. Evidence of this is found in the wonderful construction of the bones, especially of the vertebræ. The bones were excessively light for their size and strength. They are so shaped that every unnecessary particle is dispensed with, are hollowed out wherever possible and braced wherever necessary, and are porous in the centra. The accompanying photograph of the vertebræ clearly shows the remarkably efficient construction, from an engineering standpoint, to withstand the enormous strains and stresses incident to moving the huge bulk of a creature from 60 to 70 feet long. It shows also how similar the principle of structure is to the modern T-iron one. From the tip of the tail to the head the structure of the vertebræ changes with the mechanical requirements. Exactly what these were, however, has not been thoroughly studied, as little is known about the musculature of the body. A further demonstration that the Brontosaurus was highly specialized is given by the pelvis. In primitive vertebrates there is little connection between the pelvis and the backbone. Here the pelvis and the adjacent vertebræ are intimately connected. The anterior tail vertebræ are peculiarly shaped to strengthen the pelvis, and the one nearest to this is, in fact, a part of it. The lateral flange of this vertebra is in part probably a modified rib, being deepened to give added strength with which to resist the tremendous torsional strains on this portion of the frame, the pivotal center of motion undoubtedly being at the hips.

It is supposed that the two inverted V-shaped prongs under the hind legs were used to rest upon in a sitting posture, and that there was a great pad of cartilage or connective tissue at the point of each V. It is not believed that the Brontosaurus was able to sit up on the hind legs and tail like the modern kangaroo, as at no point of the tail is found the peculiar bend or the fusion of vertebræ usual in this case.

The Brontosaurus was supposedly aquatic, but not marine. As in most aquatic animals, the ends of the bones at the joints are rough instead of smooth. It is, in fact, beginning to be doubted whether it ever came out on land, though the comparative lightness of its bones, usual in walking or flying animals, but not in swimming ones, seems to indicate that part, at least, of its life was spent out of the water. The five toes on the hind feet are thought to have been used to force the body along the muddy bottoms of the shallow lagoons which the Brontosaurus supposedly frequented. Palæontologists have not, however, accounted for the single claw on each forefoot. The fact that there really was only one claw on each forefoot is proven by the numerous fossilized footprints that have been found.

The mental and physical labor, the time and patience necessary successfully to complete a restoration of this kind, can hardly be appreciated by the layman. The expeditions that are sent out each year to search for fossils or to recover those already found, entail great labor and expense. The real work begins, though, with the removal of the fossils from the rock, clay, or shale matrix, and this excavation is a very delicate operation, as the bones are brittle and fracture easily. As they are uncovered little by little, the bones are closely covered with tissue paper or very thin muslin and gum arabic. Over this, as they are gradually laid bare, plaster of Paris is applied, till the entire bone is covered. Sometimes, if the bones are much shattered, no attempt is made in the field to excavate them, but the surrounding matrix is cut out and shipped in a block. In the case of the large bones, the plaster envelope is strengthened with wooden ribs and the whole bound with wet rawhide which is then allowed to shrink and closely bind the whole. The fossils are next carefully crated and hauled to the nearest railroad siding for shipment. This sometimes means a bad trip of many miles over rough country and is frequently the cause of much difficulty.

The actual laboratory work of patching up fractured bones, restoring or reproducing missing ones, of putting them properly together and in a proper posture, means months of thought and labor. It can readily be understood that it is a matter of some difficulty to pose a skeleton 60-odd feet long and 15 feet high at the pelvis. Some of the individual bones are enormous. The femur of the hind leg is 5 feet 10½ inches long, the total length of the body being estimated at 66 feet, while the remarkably small head is only 27 inches long. In the Field Columbian Museum are preserved the limb bones of a related species, the Brachiosaurus, the femur of the hind leg being 6 feet 8 inches long. Assuming the proportions to be the same, the Chicago specimen would have been 70 to 72 feet over all.

The construction of the iron framework used in a restoration of this kind is no mean feat of practical engineering. The photographs of the hind and fore limbs give a clear idea of the way in which this is done. For supporting the weight of the large bones of the limbs and backbone, heavy wrought-iron pipe of large size is used. This is bent and curved so as to conform closely to the natural angularities, as shown. The bones are fastened to this by means of lighter piping and reducing crosses. Light channel irons and flat bands are also used, as may be seen in the manner in which the bones of the pelvis are supported and bound together. The photograph of the vertebræ shows how these are joined to the heavy supporting pipe by means of smaller pipe and reducing tees.

Some idea of the length of time that work of this kind takes may be gathered from the fact that it took two men at least a year to work the bones out of the matrix, at least six months to restore the missing parts, and at least ten months to mount the bones, weld and bend irons, etc. Nor does this include the time spent by the field parties or by Prof. Osborn and other scientists, and Mr. Adam Hermann, head preparator of the department, in planning and laying out the work.

This department of the American Museum is one of the most interesting ones in the institution. The collection comprises the extensive material collected by the late Prof. E. D. Cope, chiefly between 1870 and 1890, and the much larger collections made by the expeditions which have been sent out by the Museum every year beginning with 1891.

We are indebted to Prof. Osborn for courtesies in the preparation of this article.

The Congo (Belgian) Telegraph.

The telegraph and telephone lines of the Belgian Congo region show some peculiarities both in the construction of the lines and their operation, owing to the climate and the character of the country. Where the lines run through the forests, the wires are placed as much as possible upon trees and in other cases upon iron poles. The wire, which is of phosphor-bronze, is painted black, so as not to attract the attention of the natives, who lay hands upon all the copper they can find. The other brilliant objects of the line, such as the insulators, are also painted black. A cutting 30 feet wide is made through the forest for the line, so that there is no risk of fire or from falling trees. Besides the telegraph offices of Leopoldville, Kwamouth, and Coquithatville, there are nine telephone offices and six cabins. The latter are used for communicating with the steamboats on the river. The first hours after sunset are the best for telephoning, and it is possible to telephone direct from Matada to Kwamouth, or 380 miles. From the latter point to Boma, or 410 miles, the voice is still heard. After 10 o'clock A. M. the heat makes it impossible to use the telephone, especially in the rainy season. This is due to the fact that a return wire is not used, and the use of the earth return is accompanied by great disturbances in the middle of the day. The greatest enemies of the telephone lines are the wild animals. In the rainy season atmospheric discharges often strike the wires, therefore the lines need to be constantly inspected and repaired. Within the last two years the government has been experimenting with a wireless telegraphy system between Boma and Ambrizette to connect the land lines with the submarine cable.

THE TASMANIAN BLUE GUM—AN IDEAL TIMBER FOR HARBOR BUILDING.

BY HAROLD J. SHEPSTONE.

The erection of the great National Harbor, at Dover, on the south coast of England, has called attention to the wonderful properties of the Tasmanian blue gum (*Eucalyptus globulus*). It is at once one of the strongest as well as the most durable and densest timber in the world. It is so heavy that it will sink like a piece of lead, while it is also practically immune from the attacks of the seaworm. These facts have only lately been more or less known to timber experts, but the presence of a large number of piles of Tasmanian blue gum at Dover, where they were tested together with other timber, has shown in the most striking manner the superiority of this wood for the erection of staging in salt water.

Before dealing further with the wonderful strength and remarkable density of the blue gum, it is as well to note that the harbor where this wood is being extensively employed is one of the biggest engineering feats ever undertaken. It is being formed by extending the well-known Admiralty Pier at Dover some 2,000 feet, the erection of an eastern arm 3,320 feet in length, and the building of a breakwater 4,200 feet long. Naturally, the carrying out of such a huge undertaking called for an enormous amount of timber, the minimum quantity required being given as follows: Hardwoods, principally greenheart and rock elm, 25,000 cubic feet; and softwood, pitch pine, redwood, etc., 75,000 cubic feet for permanent work; and for merely temporary staging, 550,000 cubic feet of blue gum and other hardwood; and pitch pine, etc., for superstructure, 850,000 cubic feet; or some 1,500,000 cubic feet of timber in all.

It was not necessary, of course, to go to Tasmania for the execution of such an order, so far as quantity was concerned; indeed, some of the timber used for piles at Dover has been imported from Vancouver's Land, and on the whole there has been very little fault to find with it. Then why, one may well ask, did the contractors avail themselves of the services of their timber expert, Mr. W. Heyn, and dispatch him on a journey of 14,000 miles to Tasmania, to bring home piles which could have been purchased cheaper in America or Canada? The reasons were many. To secure Oregon piles 100 feet in length and 18 to 20 inches square (the necessary dimensions) was by no means difficult; but Tasmanian blue gum piles were preferable, chiefly on account of their greater specific gravity. In the first place, it was found impossible to get a pile of Oregon 100 feet in length into position for driving into the ground through 47 feet of water at low tide, on account of the strength of the tides and currents, unless it was "weighted" with iron at the end. This at once entailed an extra expense in material and labor of nearly $50 per log.

But the blue gum possessed other advantages over its rival Oregon. The *Teredo navalis*, or seaworm, literally honeycombing its way through the latter, rendered it after some time unfit for further use as a pile. As a rule, the timber was injured through the ravages of this little animal after a period of about eighteen months to two years. Now, it is not difficult to see that as the piles are only employed to carry temporary staging, so as to enable the 40-ton concrete blocks of which the harbor walls are being built to be placed in position, a great saving is effected by using them over and over again as the blocks are laid. That was impossible for any great length of time in the case of Oregon wood, but with Tasmanian blue gum it was entirely different. Being immune from the attack of the sea insect, the greater proportion of the blue gum piles at Dover have been in constant use for over three years, some having been driven three or four times, and there is no reason why they should not be re-employed in this manner till the whole work is completed. On account of their high gravity it is not necessary to weight them, and should they get carried away by accident they would sink where they fell, and could easily be recovered, instead of floating about as Oregon would do, a menace to the works or to ships or steamers. Some idea of the density of this wood may be the better understood when it is stated that it has a specific gravity of 75 pounds to the square foot, whereas water is but 65 pounds. A pile of blue gum, therefore, 100 feet long and 20 inches square, would turn the scale at nearly 10 tons, while an Oregon log of similar dimensions, having only a specific gravity of 48 pounds per square foot, would only weigh 6 tons, and consequently float.

To obtain a pile 100 feet in length and 20 inches square, parallel from top to bottom, demands a tree 15 to 18 feet in girth 5 feet from the ground, and about 150 feet to the first branch. The Tasmanian blue gum easily attains this height. Indeed, so far as height and general beauty are concerned, the blue gum is no mean rival to the famous Redwoods of California. A large quantity of the timber to be seen at Dover came from the yards of Messrs. Gray Brothers, of Adventure Bay. Mr. Gray, the head of the firm, states that they often come upon trees from which they could cut piles 160 feet long (that is, 60 feet longer than required by the contractors at Dover), before the first branch is reached, and others 230 feet high measure 7 feet through at the butt. Nor are these figures by any means the largest recorded for Tasmanian blue gum. Mr. Perrin, formerly Inspector of Forests in Tasmania and afterward in Victoria, mentions having measured a fallen blue gum at Geeveston (on the Huon River) which had a length of 330 feet; and Mr. R. M. Johnston, the eminent government statistician, speaks of "the Tolosa blue gum," also 330 feet high; and Baron von Meuller, the well-known Australian naturalist, says of a blue gum growing at Southport in Tasmania that it contained "as much timber as would suffice to build a 90-ton schooner." And when speaking of these giants, it should be borne in mind that they are not isolated cases, mere curiosities, but that trees of from 200 to 250 feet are fairly common in the forests, extending over thousands of acres in the Huon and Peninsula districts of Tasmania, rising high and clear of boughs like the masts of great ships.

The wonderful strength and lasting qualities of the Tasmanian blue gum have been more than demonstrated at the Dover Harbor Works, where their employment has given the greatest satisfaction, thus calling attention in the most emphatic manner to the commercial value of Tasmanian timber. Tests very carefully made and at long intervals show that the Tasmanian wood will sustain about double the weight of English oak before breaking, and will even regain its elasticity after bearing a weight at which oak breaks, while as to its longevity under water no limit appears so far to have been reached. Many instances could be quoted in confirmation of this statement. An old ferry-boat built of blue gum in 1818, and which for more than fifty years has been lying a wreck between high and low water mark on the banks of the Derwent in Tasmania, shows no signs of decay to-day, and the wood, beyond a few stains from the iron fastenings, is perfectly sound. A portion of this old vessel is shown at the Hobart Museum, among a collection of Tasmanian timber. In speaking of the commercial value of this particular wood, one must not forget that a good deal of it is to be found growing within six to ten miles of the seashore, thus considerably reducing the difficulties of transportation to the timber ships, which is effected on rudely-formed tramways.

Another Tasmanian tree deserving of mention here is the stringy bark (*Eucalyptus obliqua*). In height and size this tree is quite equal to its brother, the blue gum, and when cut it is by no means easy to distinguish it from the blue gum. Its specific gravity is usually about five pounds per cubic foot less, but it is often found with knots, which render it less desirable for piles required to carry very heavy loads, besides being more liable to seaworm attacks. It closely resembles English oak, particularly when used for flooring, for which it is well adapted.

It is interesting here to note that sleepers cut from the stringy bark and blue gum are most excellent. They have been used on the Dover Harbor Works for four years, exposed to the most trying weather, salt and fresh water, very heavy traffic of locomotives, goliath cranes, etc., being continually shifted and relaid as the engineers of the service require, and yet they are in as good condition to-day as they were when first put down. Large quantities of these sleepers are being sent from Hobart to South Africa, where they are highly esteemed. Their great feature is their durability, their average life being no less than twenty years. They cost about $1.50 each, against $1 for Baltic or soft timber sleepers, which do not last one-third of the time. This wood is also admirably adapted for wood paving, and if properly laid on a good concrete foundation, will last under heavy traffic fifteen to twenty years, and does not polish through use, thus giving a sure foothold for horses.

The Huon pine is another Tasmanian wood deserving of notice here. For exquisite beauty when polished and for all decorative purposes it certainly comes before the stringy bark. Of this timber Mr. R. M. Johnston says: "It is the grandest and most beautiful of all Tasmanian soft woods." Though so beautiful that it appears little short of wicked waste to use it for any but decorative purposes, it is, in truth, remarkably long lasting, declining to succumb to the attacks of insects, whether in water or on land. It is largely used in boat building. Still another beautiful wood is the Tasmanian blackwood, a species of acacia, which very closely resembles mahogany, and which is used by the English government at Woolwich Arsenal in the manufacture of gun carriages. It is also employed in the making of billiard tables, sideboards, and decorative work.

For much of the above information, and for the loan of the photographs accompanying this article, the writer has to acknowledge his indebtedness to Mr. W. Heyn, head of the timber department of Messrs. S. Pearson & Son, the contractors for the Admiralty Harbor Works at Dover. As already mentioned, Mr. Heyn was sent

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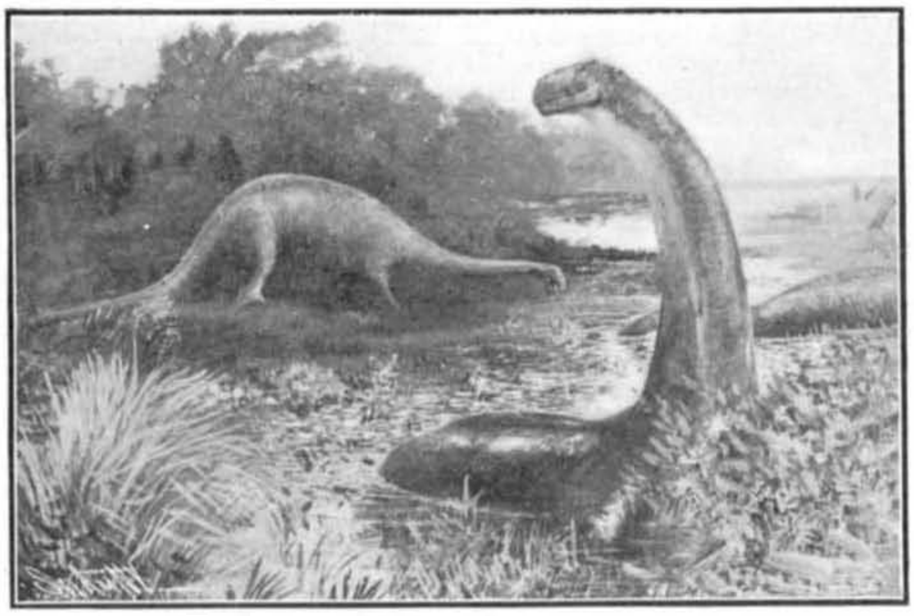
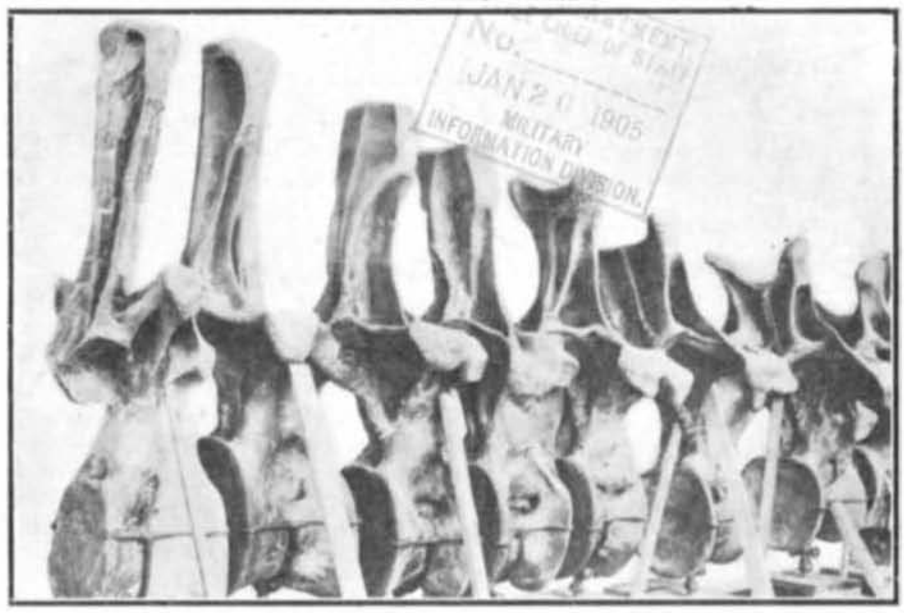
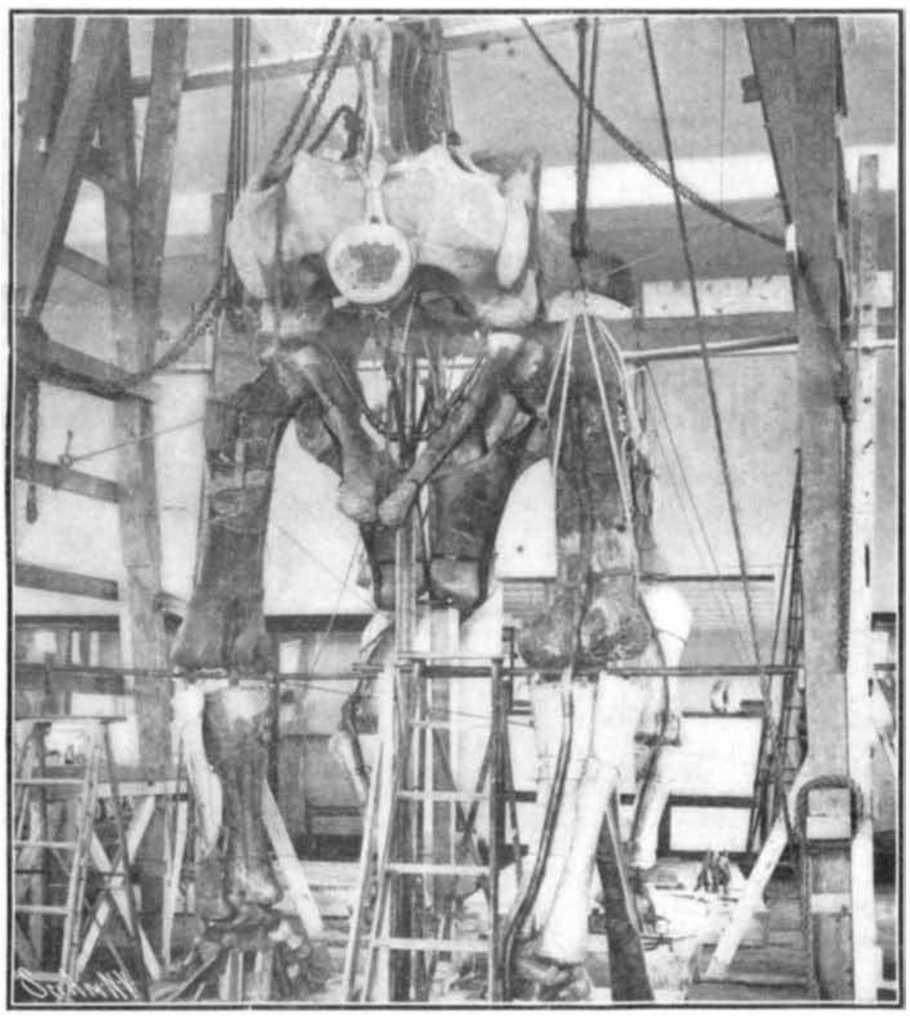


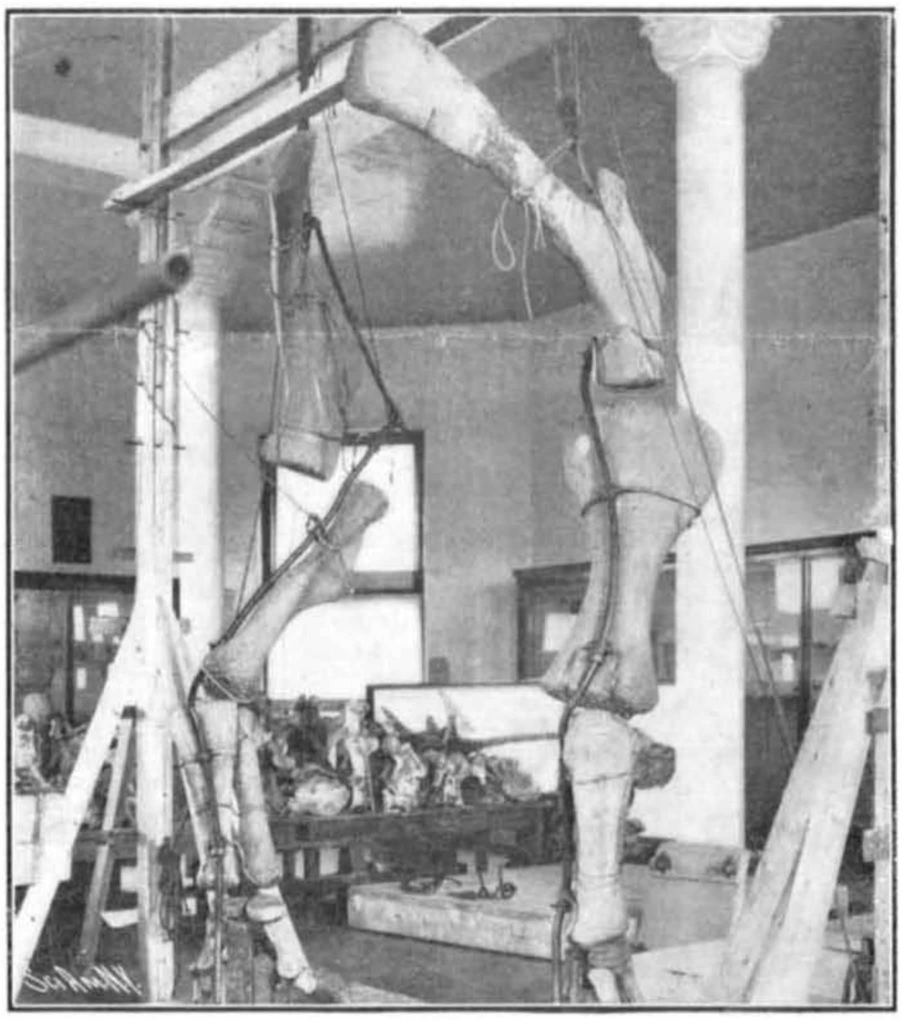
Drawing by Charles R. Knight. Brontosaurs as They Probably Appeared at a Period Estimated at Seven Million Years Ago.



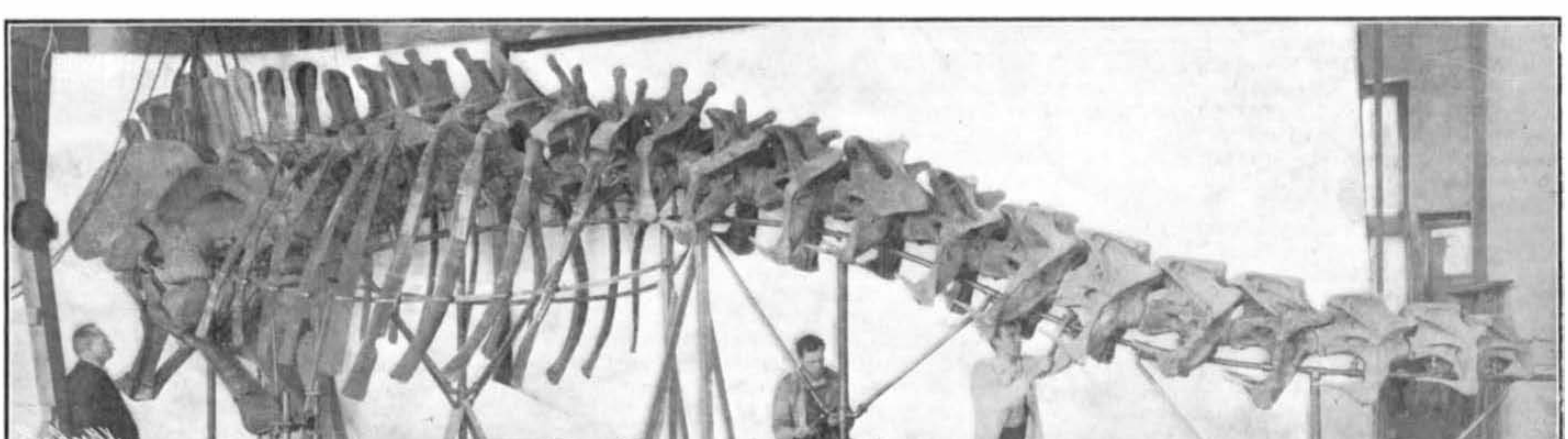
Part of the Vertebral Column. The Structural Similarity with the Modern T-shape is Apparent.



The Hind Legs. Height of the Reptile at the Hips, About 15½ Feet.



Fore Legs, Showing Method of Mounting.



A Portion of the Brontosaurus Skeleton, from the Hips to the Head, Showing the Iron Work Used in the Reconstruction. The Total Length of the Animal is Estimated at 62 Feet

THE RESTORATION OF THE GIANT LIZARD, THE BRONTOSAUR, AT THE AMERICAN MUSEUM OF NATURAL HISTORY, NEW YORK.—[See page 42.]