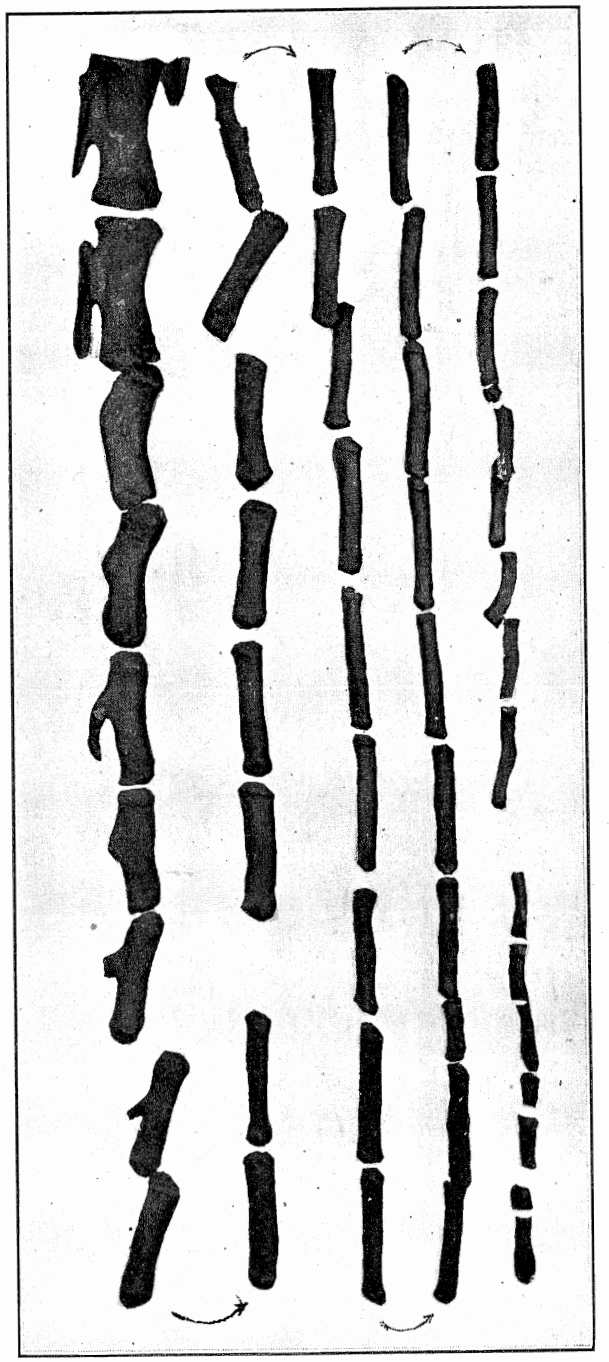
HEADS AND TAILS; A FEW NOTES RELATING TO THE STRUCTURE OF THE SAUROPOD DINOSAURS.

By W. J. Holland.

(Issued June 1, 1915.)

Reprinted from Annals of the Carnegie Museum, Vol. IX, Nos. 3–4, 1915

Plate LIX.



Caudal vertebræ of Sauropod Dinosaur found in serial order in Carnegie quarry near Jensen, Utah. The cut shows the caudals from No. 34 to No. 82, arranged for convenience in photographing in five rows, The curved arrows indicate the order. (Greatly reduced.)

[Reprinted from ANNALS OF THE CARNEGIE MUSEUM, Vol. IX, Nos. 3–4, 1915.]

XVI. HEADS AND TAILS; A FEW NOTES RELATING TO THE STRUCTURE OF THE SAUROPOD DINOSAURS.[1]

By W. J. Holland.

(Plate LIX.)

For several years past, under the oversight of Mr. Earl Douglass, the Carnegie Museum has been carrying on extensive excavations in Uinta County, Utah. The result of this work has been the discovery of a very large number of skeletons, principally of sauropod dinosaurs, although there have also been uncovered more or less imperfect skeletons of several Stegosaurs, and recently the skeleton of an *Allosaurus*, or closely related theropod dinosaur, which promises to be sufficiently perfect to permit a restoration to be made, the skull, the vertebræ, and limb bones of the specimen seeming to be, according to reports received from Mr. Douglass, quite well preserved, and not much dislocated. One of the remarkable features of this deposit of bones is the fact that in the majority of cases the skeletons of the animals have been but slightly disturbed in position since having been laid down. In several instances the entire vertebral series has been found articulated, or but little displaced, so that it is possible to reach correct conclusions as to the number of vertebræ entering into the composition of the skeleton.

The deposit appears to represent a section of the bed of a small stream or river. At the bottom is a layer of cobblestones and coarse gravel more or less firmly cemented together by lime. Superincumbent upon this are sandstones, the material composing which varies from coarse sand in some places to finer sand in other places. The sandstones composing the matrix when exposed to the weather rapidly disintegrate, especially the layers which are composed of the finer materials, which after a few weeks become soft and resolve themselves into loose sand. There are several layers represented in this quarry lying more or less conformably in relation to each other, but disclosing pockets and irregularities which naturally would occur in the bed of a small stream subject to the action of drouth succeeded

[1] Read before the meeting of the Paleontological Society of America, at the meeting held in Philadelphia, December 31, 1914.

by freshets. There is evidence of the existence of a current which flowed from west to east. Mussel-shells and remains of tortoises prove the fluviatile origin of the beds.

In the lowermost of the strata which have been investigated we have succeeded in finding skeletons, more or less complete, of nearly a score of dinosaurs, large and small. One of the largest of these skeletons, representing an animal provisionally referred to *Brontosaurus*, or *Apatosaurus*, has been already taken from the matrix and the skeleton is being installed in the Carnegie Museum. This is probably one of the most perfect skeletons of a sauropod dinosaur which has ever been recovered. All the vertebræ from the axis to very near the end of the tail were found in place; the whole of the pelvis, the right hind limb, the two scapulæ, all of the ribs, and the entire right fore limb with the manus, as well as most of the left fore limb, were discovered in such a position as to leave no doubt whatever that we are dealing in the case of these remains with one individual. Numerous sternal ribs were also found. With this skeleton, lying about twelve feet from the atlas, and in the same layer, was a skull the condyle of which shows perfect adaptation to the atlas. Had nothing in the past been written in reference to the structure of the skull of *Brontosaurus* the conclusion would naturally and almost inevitably have been reached that this skull belongs to the skeleton the remainder of which has been recovered. The skull is decidedly like that of *Diplodocus*, though very much larger in size than any skull representing that genus of which the writer has knowledge. It is characterized by the same feeble dentition. The fact that in this particular layer, exposed to view in the quarry, there are also the remains of one or two comparatively small animals, which may be referred to *Diplodocus*, naturally suggests that the skull in question might possibly have belonged, in spite of its apparent relationship to the specimen of which I have spoken, to one of these other skeletons. The curious fact, however, should here be mentioned, that in this particular stratum, which thus far has only yielded one or two skeletons which are referable to the *Diplodocidæ* (in the accepted meaning of that term), we have recovered the remains of at least eleven skulls, all of which are characterized by the same general style of dentition, although the skeletons, exclusive of the two which we can refer without much doubt to *Diplodocus*, undoubtedly belonged either to animals much more closely related to *Brontosaurus*, or some of them

possibly to allied genera not yet defined. There is not a single trace in the bed from which these remains have come of any animal possessing the peculiar dentition belonging to the skull which Professor Marsh originally attributed to his *Brontosaurus*. Such a skull has indeed been found by us, but it lay far to the west of the remains of the *Brontosaurus* which we are assembling, according to Mr. Douglass, and in a layer at least eight feet higher than that in which the *Brontosaurus* remains were discovered, a layer which was deposited at a later time and is now found to contain remains provisionally referred by Douglass to *Barosaurus*, or an allied sauropod, characterized by cervical vertebræ the centra of which are from three to four feet in length. This skull cannot have belonged to the *Brontosaurus* which we are engaged in mounting. Skulls do not wash up stream against the current, nor do they burrow upward eight feet through superincumbent sand. This skull of which I am speaking by no possibility can be attributed to the large skeleton which we are setting up.

Under the circumstances and in view of these facts the writer has undertaken an investigation of the subject, with the following results:

Professor R. S. Lull, with the most obliging courtesy, has examined the records preserved at the Peabody Museum in relation to the material collected and utilized by Professor Marsh when making his restoration of *Brontosaurus*. Without going into the details of the matter I may say that Dr. Lull reports to me that the skull attributed by Marsh to *Brontosaurus* was found in Wyoming, near Como Bluffs, at a locality approximately four miles distant from the spot where the remainder of Marsh's type of *Brontosaurus* was obtained by William H. Reed. Professor Lull in his written statement thus confirms the oral statement made to me years ago by W. H. Reed, who informed me that the skull utilized by Marsh did not in the judgment of Mr. Reed belong to the same individual as the rest of the specimen, and had nothing to do with it.

There is another somewhat fragmentary skull of the same animal preserved at the United States National Museum, in reference to which Mr. C. W. Gilmore has written to me at my request. This skull was obtained at the well-known locality near Canyon City, Colorado, in what was known as "the Felch quarry." Mr. Gilmore informs me that an examination of the charts of the quarry shows that this skull was not associated with any other skeletal material referable to the genus *Brontosaurus*. It is plain from these facts that

Professor Marsh associated the skulls, which he had studied, with the remains of *Brontosaurus* as the result of a process of ratiocination, rather than as the result of ocular evidence that the skull actually belonged with the skeleton. The only circumstance which would seem to confirm the correctness of Marsh's view is the fact, to which my attention is directed by Professor Lull, that when taking up the remains of the *Brontosaurus* now on exhibition in the American Museum of Natural History he found in the deposit a tooth evidently belonging to the same genus, the skull of which Marsh has associated with the skeleton of *Brontosaurus*. Professor Lull is of the opinion that Marsh made no error, and that the presence of this tooth in the quarry, which Lull explored in Wyoming, attests the correctness of the conclusions of Marsh. The writer of these paragraphs confesses to feeling a certain measure of doubt and uncertainty as to the matter, and is disposed to the view that we do not yet positively know what really is the skull which should be attributed to the genus *Brontosaurus*, and is strongly inclined, in spite of the opinion of Dr. Lull, to think that perhaps an error has been made, and that *Brontosaurus*, which is so like *Diplodocus* in many of its skeletal features, may have had a skull like that of *Diplodocus*, characterized by feeble dentition, dentition, however, which is not inserted in the maxillæ vertically as in the case of *Diplodocus*, but which, as the skull before the writer at this moment shows, was more or less procumbent.

There is no intention in these paragraphs to dogmatize, but to express a doubt, founded upon observation, as to the correctness of Professor Marsh's surmise, which up to the present time has been unquestioningly accepted. To sum the matter up, the writer does not believe that any man is in a position to declare with positive assurance that the skull heretofore attributed to the genus *Brontosaurus* actually belonged to it. The two skulls used by Marsh were found, one four miles from the rest of his skeleton, the other about four hundred miles from it. Were it not, as I have already intimated, for Professor Marsh's action, the writer would be tempted to declare that the skull of *Brontosaurus* was not very different from that of *Diplodocus* in its main structural features in view of the fact that the skull in his possession lay only twelve feet from the cervical vertebræ and other skeletal remains before him. We know that the specimen we are mounting must have had a skull. If we refuse to affix to it the skull which lay within twelve feet of the cervical vertebræ, we must

admit that our specimen is so far forth defective. We cannot by any possibility, for physical reasons, attribute to it the skull, which we possess, and which is like that employed by Professor Marsh, because it was found in a higher layer, further up stream, associated with the remains of so-called *Barosaurus*.

The problem is naturally perplexing, and in certain aspects amusing. My good friend, Dr. Osborn, has in a bantering mood "dared" me to mount the head, which we have found associated with our *Brontosaurus*, on the atlas, which it fits. At moments I am inclined to take his "dare," in spite of Professor Marsh's action, being not trained unquestioningly to accept the *ipse dixit* of even so learned an authority as Professor Marsh was. I feel that there is quite as much reason for putting this kind of a head on the animal as for topping off the beast with the style of headgear which Professor Marsh has associated with it. So much for heads.

And now as to tails. One of the most interesting results of the excavations made by us, has been the discovery of the fact that in at least three cases the reptiles which we have exhumed have preserved in place the so-called "whip-lash," which we know to have characterized *Diplodocus*. The large skeleton of *Brontosaurus*, which we are setting up, has a tail relatively as long as that of *Diplodocus*, and the posterior vertebræ of the tail were found in a more or less continuous series in such a position as not to admit of any doubt that they belonged to the same individual. A second skeleton of a smaller dinosaur, also related to *Brontosaurus*, but probably belonging to a genus which may not as yet have been defined, likewise has a very long tail, in which the posterior caudals were found articulated one with another, as was the case with the one provisionally referred to *Brontosaurus*. A still more remarkable specimen was found embedded in a layer of fine white sand at the western end of the quarry, all the vertebræ from the atlas to the tip of the tail being *in situ*. There are in this specimen eighty-two caudal vertebræ. A lantern slide which I am herewith communicating to the meeting (Plate LIX) shows the terminal caudals from thirty-four to eighty-two, inclusive, arranged in order. This "whip-lash," as it has been styled, recalls the long tail of the Monitors, and must have been a weapon of defence in the case of these colossal reptilia, as it is in the case of the Monitors. My friend and associate, Dr. L. E. Griffin, long connected with the Bureau of Science in the Philippines, informs me that for some time

he had a *Monitor* tied up in the courtyard of his house in Manila, and that, when approached by a dog, it would deal it a sharp blow with its tail which would cause the animal to retreat with a howl of pain and never again attempt to renew acquaintance with the reptile. Such a function was no doubt that of the extremely long tail which we may believe characterized most, if not all, of the Sauropoda.