

The Recapitation of *Apatosaurus*

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INTRODUCTION

In 1915 the Carnegie Museum of Natural History's magnificent skeleton of the sauropod dinosaur *Apatosaurus louisae*, discovered in 1909 at what is now Dinosaur National Monument in northeastern Utah, took its place alongside the equally impressive skeleton of *Diplodocus carnegii* in the Hall of Dinosaurs. At that time and for the next 17 years, however, it stood conspicuously headless. It was not until December of 1932 that the skeleton was completed, and then with the wrong head—a *Camarasaurus* skull. How this came about and how the error was corrected requires the untangling of a long series of events that began with the first discoveries and descriptions of the giant sauropod dinosaurs of North America over a century ago.

EARLY HISTORY

The year 1877 marks the beginning of what was undoubtedly one of the most notable periods in the field of vertebrate paleontology, the discoveries on a large scale of the first gigantic, quadrupedal, sauropod dinosaurs from the Upper Jurassic (about 150 million years ago) deposits of western North America. The limelight of these discoveries was shared simultaneously and almost exclusively by two of the most energetic and respected paleontologists of the time: Edward Drinker Cope of the Academy of Natural Sciences of Philadelphia, and Othniel Charles Marsh of Yale University. Unfortunately, both scientists were engaged in a bitter rivalry that lasted until their deaths at the end of the century and, although they can be credited with advancing paleontology at an unprecedented rate, their often short, hastily written scientific publications frequently resulted in confusion and misconceptions about the animals they described that lasted long after their deaths. The first description of *Apatosaurus* by Marsh (1877b) and of *Camarasaurus* by Cope (1877), both of which appeared over a century ago, were very brief and without any illustrations. In their

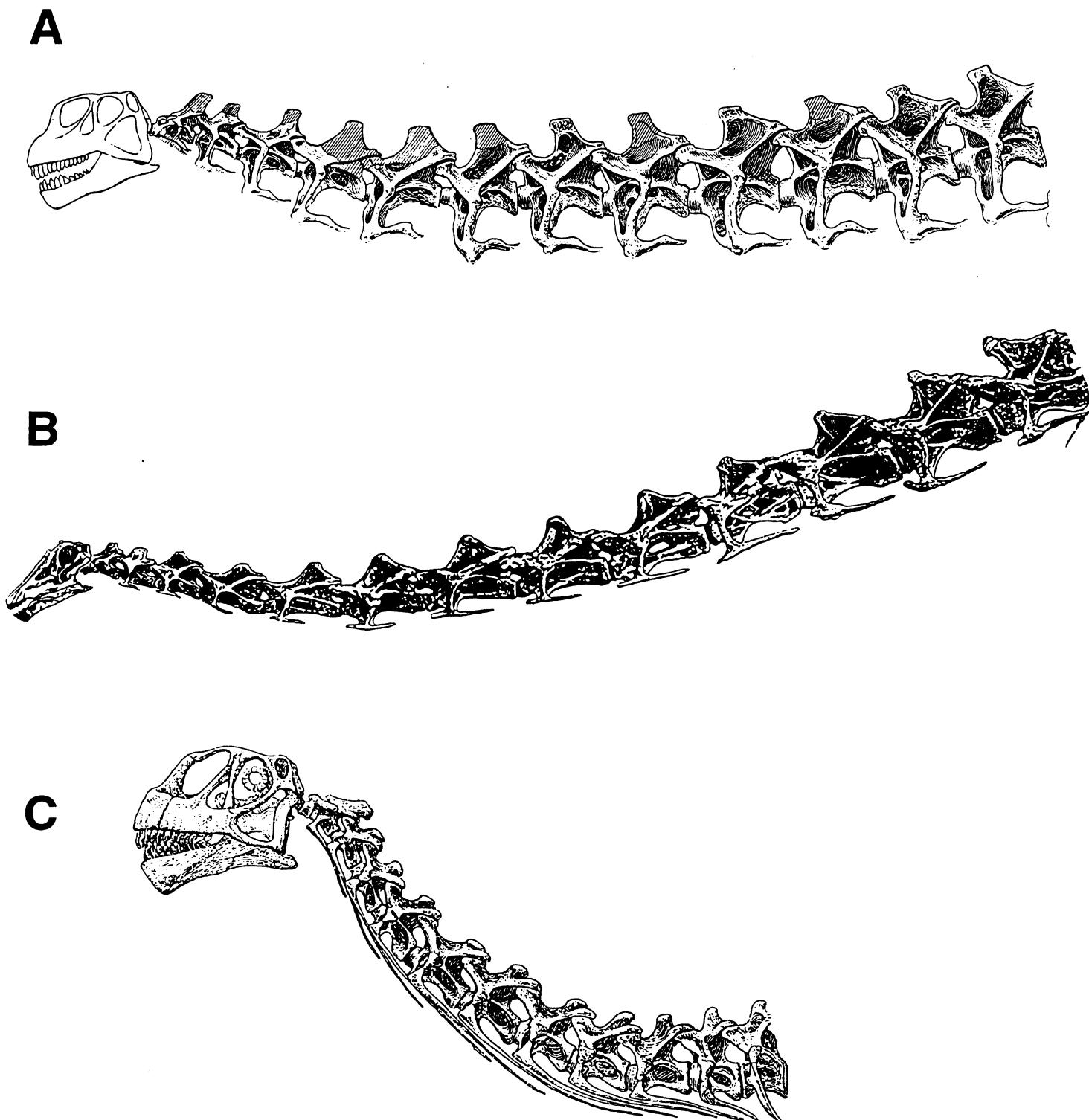


Figure 1. Skeletal reconstructions of A, *Apatosaurus louisae* CM 3018 shown restored with *Camarasaurus*-like skull (after Gilmore, 1936), B, *Diplodocus carnegiei* (after Holland, 1906), and C, *Camarasaurus lentus* CM 11338 (after Gilmore, 1925). Scales: A, B = $\times \frac{1}{30}$. C = $\times \frac{1}{10}$.

zeal to describe the first large sauropod of North America, both Marsh and Cope rushed into publication with descriptions of the first few bones they received from their collectors in the field, even though they knew that the greater parts of the skeletons were still being excavated.

During the next year and a half, as more material was collected and prepared, these descriptions were only slightly expanded, but neither animal received the attention it merited and thereafter they were essentially ignored. Adding to the confusion, at this time Marsh (1878b, 1879) also described two more sauropod dinosaurs, *Morosaurus* and *Brontosaurus*, both of which are now recognized as being the same animals as *Camarasaurus* and *Apatosaurus*, respectively. "*Morosaurus*" and "*Brontosaurus*" were based on good, more complete specimens and were described in detail and with many excellent illustrations. However, of the half dozen or more partial skeletons Marsh had identified as "*Morosaurus*", all were juveniles or subadults and were considerably smaller than the two large skeletons of "*Brontosaurus*" that he had. Because he did not recognize that "*Morosaurus*" was a juvenile *Camarasaurus*, he came to the erroneous conclusion that "*Morosaurus*" was a much smaller animal than "*Brontosaurus*". As a result, Marsh misidentified the few adult *Camarasaurus* specimens he had as "*Brontosaurus*" because of their large size. Further, Marsh and others had also recognized that the skeletons of *Apatosaurus* ("*Brontosaurus*") and, to a somewhat lesser extent, of *Camarasaurus* ("*Morosaurus*") are very robustly built and their hindlimbs are nearly indistinguishable (Fig. 1). On the other hand, it was also recognized that the skeleton of *Diplodocus*, another sauropod described by Marsh (1878a) and the third sauropod of this story, is very slender in build, and its hind limbs are easily identified (Fig. 1). Thus, it was mistakenly believed that the skeletons of *Apatosaurus* and *Camarasaurus* are much closer in overall structure than either is to *Diplodocus*. These errors in reasoning became firmly fixed in the literature with Marsh's reconstructions of "*Brontosaurus*" in 1883 and 1891, which were based on one of the most complete sauropod skeletons ever found.

His 1883 reconstruction was the first published for any North American sauropod. Although it was remarkably good in many ways, especially for its interpretation of sauropod posture (particularly the elephant-like stance with the slightly bent limbs directed beneath the shoulders and hips), it contained many inaccuracies that gave *Apatosaurus* a distinctly *Camarasaurus*-like appearance. As examples, for the missing forelimb and foot Marsh used a partial skeleton of a large *Camarasaurus* in which the elements are narrower and longer. The neck was shown as having 12 vertebrae, as in *Camarasaurus*, instead of the 15 known for *Apatosaurus*. The tail was restored short, as in *Camarasaurus*, since Marsh had no way of knowing that *Apatosaurus* had a long whip-lash tail that contained almost twice as many vertebrae as in *Camarasaurus*. However, the most serious error in this reconstruction was the skull. For that, Marsh used a large, incomplete *Camarasaurus* skull found in a quarry a considerable distance from the quarry with the *Apatosaurus* skeleton. This second quarry has

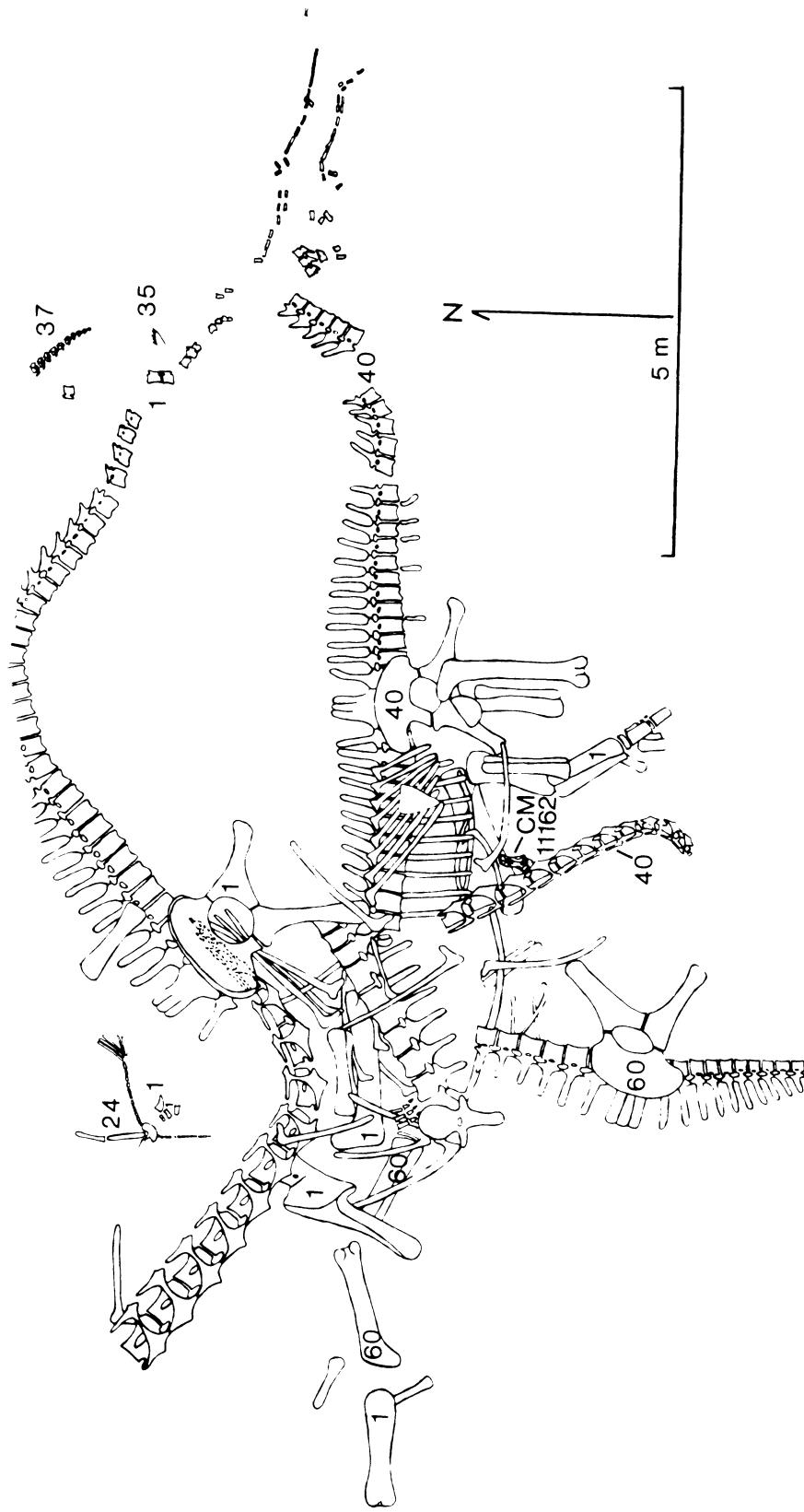


Figure 2.—Redrawn portion of Dinosaur National Monument quarry map on file at Carnegie Museum of Natural History showing the relative positions of sauropod dinosaurs removed by that institution and discussed in text. Field no. 1, holotypic postcranial skeleton of *Apatosaurus louisae* CM 3018 on exhibit at the Carnegie Museum of Natural History; field no. 40, postcranial skeleton of *Apatosaurus* now at the Los Angeles County Museum, California; CM 11162, skull very probably belonging to field no. 1 or possibly no. 40; field no. 60, postcranial skeleton of *Apatosaurus*; field no. 24, portion of postcranial skeleton of a juvenile *Apatosaurus* (CM 3390), field no. 37, series of cervical vertebrae; and field no. 35, anterior portion of small jaw with *Diplodocus*-like teeth, probably belonging to one individual of *Apatosaurus*.

yielded four *Camarasaurus* skeletons and other bones of that animal, but none of *Apatosaurus*. Marsh's revised 1891 reconstruction was in some ways less accurate than his first. Although he added a thirteenth vertebra to the neck, bringing it closer to the correct number of 15, he also increased the number of the trunk vertebrae from ten, the correct number, to 14. *Camarasaurus* has 12. In this revised reconstruction a second, somewhat more complete, *Camarasaurus* skull was used; however, this skull was found in a quarry some 400 miles from the skeleton. This distant quarry did contain *Apatosaurus* bones, but also those of at least four other kinds of sauropods, and the skull itself was not associated with any other bones.

Had Marsh realized that "*Morosaurus*" grew to the same size as "*Brontosaurus*" he might not have used the large *Camarasaurus* skulls or forelimb and foot in his reconstructions of "*Brontosaurus*". Yet, these specimens are not especially large when compared to the *Camarasaurus* specimen described by Cope in 1877. The fact that Marsh never indicated his use of secondary specimens, their selection seemingly made on purely speculative grounds, to complete his reconstructions of "*Brontosaurus*" undoubtedly helped to perpetuate many of the misconceptions about the anatomy of *Apatosaurus*. As if the confusion created by Marsh's reconstructions was not enough, in 1898 Henry Fairfield Osborn of the American Museum of Natural History, by then the most dominant paleontologist of the time, described a "*Brontosaurus*" skeleton as *Camarasaurus*, apparently believing the two animals were the same.

APATOSAURUS SPECIMENS FROM CARNEGIE QUARRY

The single most important event with regard to this story was the discovery in 1909 by Earl Douglass of the Carnegie Museum of Natural History of the well-known, richly fossiliferous dinosaur quarry at Dinosaur National Monument, then known as the Carnegie quarry. The first specimen he discovered and excavated, designated field no. 1, was important not only in being the most complete *Apatosaurus* skeleton ever found, but in having a large skull closely associated with it (Fig. 2). Lying beside field no. 1 was a second, almost as complete but slightly smaller, skeleton of *Apatosaurus*, field no. 40. Alongside the neck of no. 40 and about 12 feet from the end of the neck of no. 1 was a large *Diplodocus*-like skull without the lower jaws which was given the Carnegie Museum of Natural History catalogue number CM 11162 (Fig. 2). Although the rear part of a medium-sized *Apatosaurus* skeleton lay only about nine feet from the skull, their relative size difference eliminated any possibility that they were part of the same individual. William Jacob Holland, then Director of the Carnegie Museum of Natural History, and Earl Douglass, field collector in charge of quarrying operations at the Carnegie quarry, immediately recognized that the skull (Figs. 3, 4) must be that of *Apatosaurus*. However, since this skull resembled that of *Diplodocus* (Fig. 5A), it contradicted the long and widely accepted belief that *Apatosaurus* had a skull

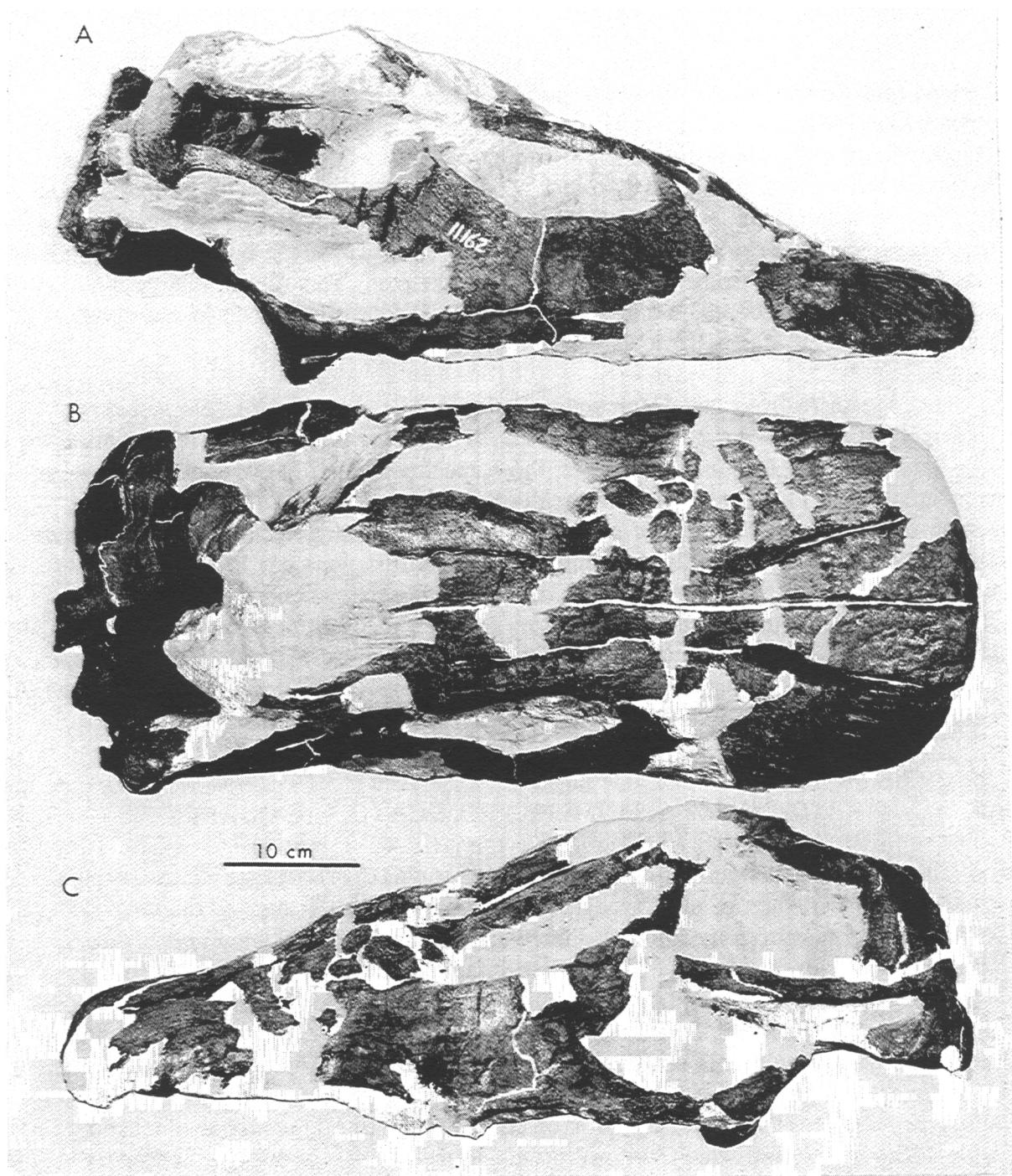


Figure 3.—Probable *Apatosaurus* skull CM 11162 from Dinosaur National Monument quarry. A, right lateral; B, dorsal; and C, left lateral views. Functional teeth have been lost, but pencil-like replacement teeth of right maxilla are partially exposed due to loss of surface bone.

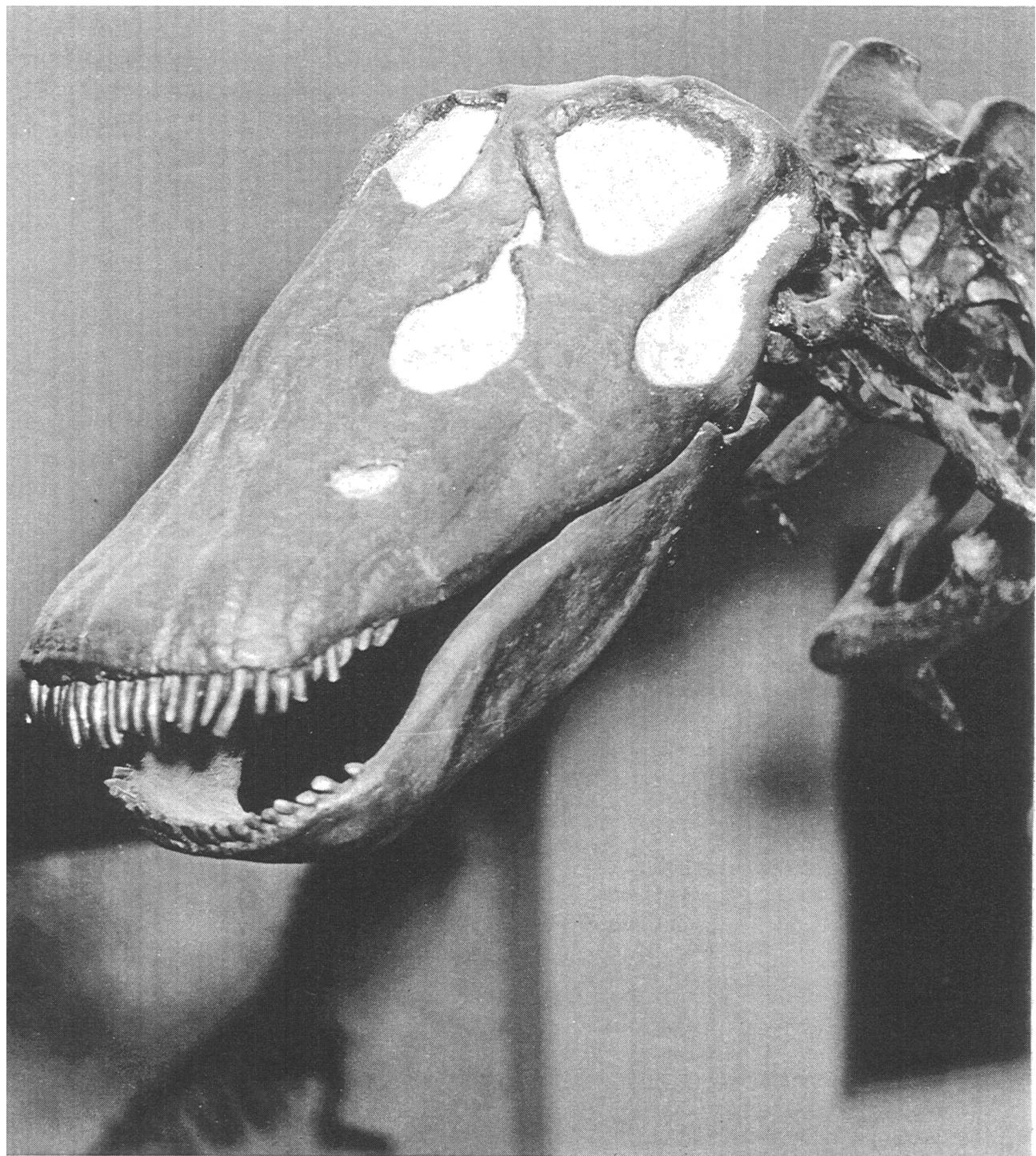


Figure 4.—Cast of restored probable *Apatosaurus* skull CM 11162 shown mounted on *A. louisae* skeleton CM 3018 at Carnegie Museum of Natural History.

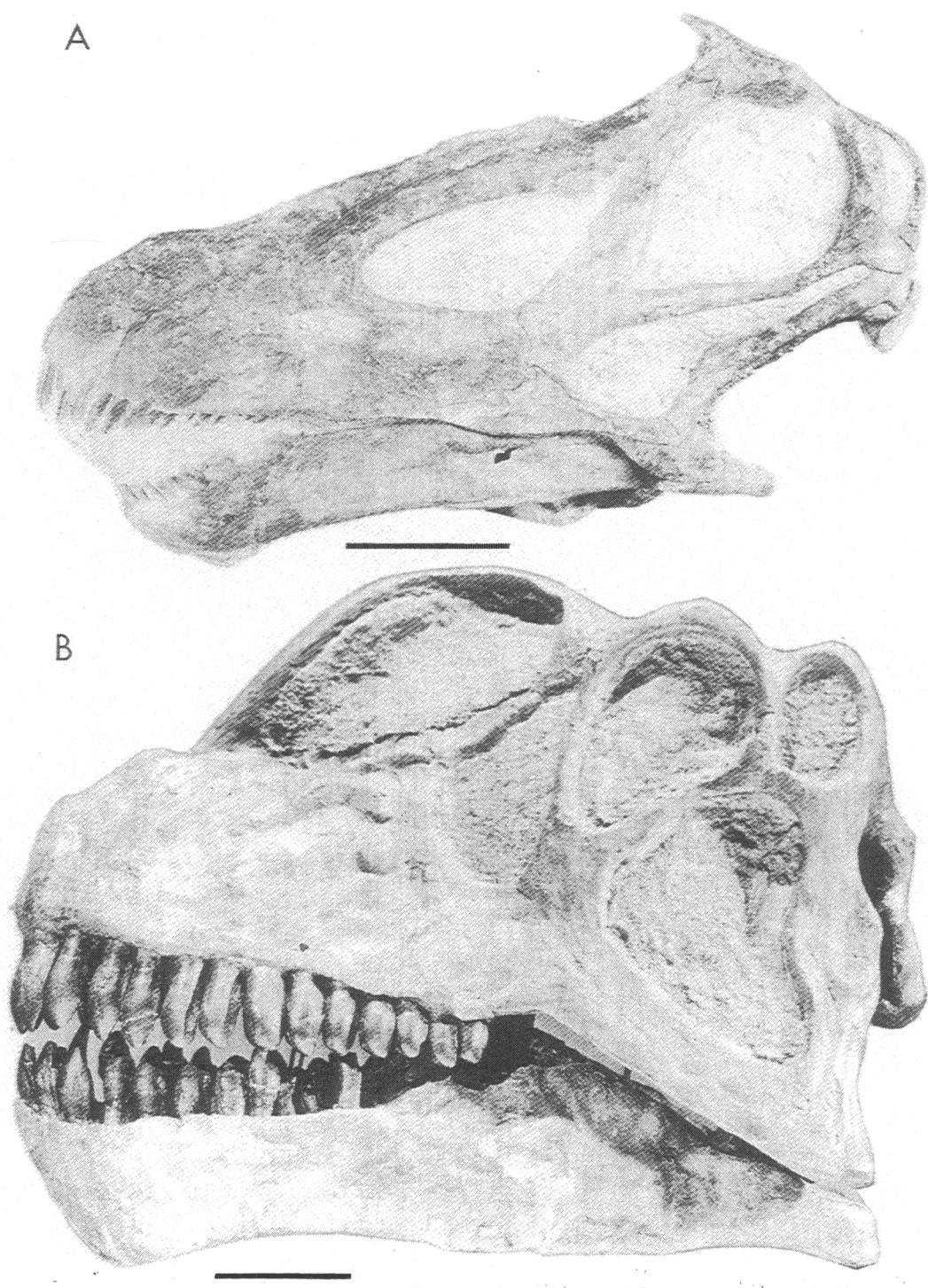


Figure 5.—Skulls of A, *Diplodocus longus* CM 3452; and B, *Camarasaurus lentus* CM 12020 from Dinosaur National Monument in left lateral view. Scales = 10 m.

resembling that of *Camarasaurus* (Fig. 5B). In a letter to Douglass dated December 3, 1914, Holland wrote,

I however have the impression, as I have already stated to you in conversation, that other genera and species had skulls very much like *Diplodocus*, and I should not be at all surprised to find in the end that *Brontosaurus* and *Apatosaurus* and all the rest of them really belonged to the [Family] *Diplodocidae*, when the structure of their skull comes to be known, and that the separation into families of certain of these animals is in error. This of course is mere surmise and is not capable of verification, but as you know things point in that direction.

Professor Marsh's material upon which he based his restoration of the skull of his so-called *Brontosaurus* was derived from two sources. The first was a fragment found by W. H. Reed fifteen hundred feet away from the spot where he excavated Marsh's type of *Brontosaurus excelsus*. It was found in the talus of Como Bluff. The remainder of the material upon which Marsh based his conclusions was obtained at Felch's Canon City quarry, which is hundreds of miles from Como Bluff. The latter material is in the U. S. National Museum and has never been published upon except as utilized by Marsh in bringing about his restoration. The association of this skull material with what Marsh denominates the type of *Brontosaurus* is wholly arbitrary, and I doubt its correctness, as I have repeatedly told you. ...I...hope you will send us by freight such material as you may have succeeded in recovering which bears closely upon the problem of the skull which we are at present discussing.

In 1915 Holland briefly described the postcranial skeleton of field no. 1, given the catalogue number CM 3018, as a new species, *Apatosaurus louisae*. Most significantly, on the basis of the skull associated with it, Holland also challenged Marsh's use of *Camarasaurus*-like skulls in his 1883 and 1891 reconstructions of "*Brontosaurus*". Noting the close proximity of the skull CM 11162 to the skeleton CM 3018, their position in the same layer, and the exact fit of the skull with the first neck vertebra of CM 3018, Holland concluded that the *Diplodocus*-like skull represented the true skull of *Apatosaurus*. He stated (p. 274) that

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.

But this new evidence on the true nature of the skull of *Apatosaurus* never gained serious consideration among paleontologists, and when the skeleton of *Apatosaurus louisae* was mounted at Carnegie Museum of Natural History, Holland refrained from

using the skull found with it. This headless state apparently reflected an unwillingness of Holland to oppose fully the opinions of his paleontological colleagues. The only clue we have to explain Holland's reluctance is his remark (1915:277) that "My good friend, Dr. Osborn, has in a bantering mood 'dared' me to mount the head...." And so *Apatosaurus* continued to be restored in journals, textbooks, museum exhibits, and cartoons as having a *Camarasaurus*-like skull. Holland retired on July 1, 1922, and became Director Emeritus of the Museum and Curator Emeritus of Paleontology but continued to work on a description of the osteology of *Apatosaurus* until his death on December 13, 1932. *Apatosaurus louisae* continued to stand headless in the Hall of Dinosaurs. And the same month that Holland died the Carnegie Museum of Natural History decided, probably at the persuasion of the highly influential Charles W. Gilmore of the United States National Museum (and a former field employee of Carnegie Museum of Natural History), to complete the mount with a cast of a large *Camarasaurus* skull that had been found a considerable distance from the skeleton at Dinosaur National Monument. This skull and the greater part of a postcranial skeleton of an adult *Camarasaurus* were collected together under the same field number and later both received the same catalogue number (CM 11393). There is no doubt that the skull and postcranial skeleton belong to the same individual and, further, no *Apatosaurus* material was found nearby to suggest otherwise. When the *Camarasaurus* skull was placed on *Apatosaurus louisae* it was recatalogued CM 12020, an action of questionable propriety. *Apatosaurus* no longer stood headless. Thus, the most dramatic vestige of Holland's important argument was eliminated and seemingly quickly forgotten.

In 1936 additional opposition to Holland's argument appeared when the Museum published a detailed description by Charles Gilmore of the postcranial skeleton of *Apatosaurus louisae*. Seemingly the force was taken out of Holland's argument by Gilmore's contention that the large *Diplodocus*-like skull purported to have been found with this skeleton had actually been confused with a much smaller *Diplodocus* skull, CM 11161, found closely associated with a medium-sized *Apatosaurus* specimen, field no. 160 (CM 3378), isolated at the far western end of the quarry. If this was the case, as pointed out by Gilmore, the skull CM 11161 was too small to have belonged to either *Apatosaurus louisae* postcranial skeleton no. 1 or no. 40, whereas the first skull, CM 11162, is far too big to have belonged to the skeleton of no. 160 (CM 3378). Gilmore made his assertion on the basis of conversations with J. Leroy Kay, at that time Assistant-in-Charge of Vertebrate Paleontology at Carnegie Museum of Natural History, who, beginning in 1915, had been a workman at the quarry. Why Kay suggested that the two skulls had been interchanged is unclear, since he was not involved in collecting them. That Holland was correct in the quarry positions of the two skulls has been positively documented by letters from Douglass to Holland. Concerning the discovery of the skull during the excavations of the *Apatosaurus* postcranial skeletons nos. 1 and 40 (Fig. 2) Douglass wrote to Holland on November 16, 1910, that "It seems pretty large to me—about 26 inches in length.... The mandible is not with the skull but may be near." Both the length and

the absence of the lower jaw clearly identify this skull as CM 11162. In a second letter dated November 29, 1912, he wrote, "Our work has of late been principally in the West Extension of the quarry.... One skeleton, No. 160 [CM 3378] is of especial interest.... Yesterday—Thanksgiving Day—I found a skull complete, with lower jaw nearly or quite in place...under the anterior portion of the tail." There can be no doubt that the latter skull is CM 11161.

What started out as a working hypothesis, that *Apatosaurus* and *Camarasaurus* are similar in overall structure and most likely had similar types of skulls, apparently became so entrenched in the literature and in the thinking of paleontologists that it ended up as a loafing hypothesis. With Gilmore's description of *Apatosaurus* in 1936 enough information had accumulated about the Jurassic sauropods of North America that an objective reconsideration of Holland's claim that *Apatosaurus* possessed a *Diplodocus*-like skull not only would have been timely, but might have swung opinion in Holland's favor. The skeletons of the three principal characters of this scenario, *Apatosaurus*, *Camarasaurus*, and *Diplodocus*, were now known in great detail, save the head of *Apatosaurus*, and even a cursory comparison of their postcranial skeletons (Fig. 1) would have revealed that *Apatosaurus* is not only quite distinct from *Camarasaurus*, but shares a great number of significant features with *Diplodocus*. By this time also it had been demonstrated that the names "*Morosaurus*" and "*Brontosaurus*" were merely synonyms of *Camarasaurus* and *Apatosaurus*, and they no longer clouded the picture. Therefore, if given the choice between a *Diplodocus*-like or a *Camarasaurus*-like skull for *Apatosaurus* and knowing nothing more than what the postcranial skeletons of these three animals look like, the obvious and unavoidable selection would surely have to be a *Diplodocus*-like skull. The soundness of this logic is reinforced if one takes into account Holland's disclosure of the source of the *Camarasaurus* skulls used by Marsh in his reconstructions of *Apatosaurus* and that there never existed any direct evidence to support such an association.

A Second Probable *Apatosaurus* Skull

There is now known a second, partial *Diplodocus*-like skull that most likely belongs to *Apatosaurus*; it also has had a long and extremely complicated history. In 1877 Marsh received from his collectors a partial sauropod skull as part of a large shipment that included specimens from three different quarries near Morrison, Colorado, nos. 1, 8, and 10. Apparently the importance of the skull was not realized at the time it was uncrated, since the specimen was not marked as to which quarry it was found in. However, circumstances leave little doubt that it had to have come from either quarry no. 1 or, more likely, quarry no. 10. Quarry no. 1 yielded a large, very incomplete sauropod sacrum, described by Marsh (1877a) as *Atlantosaurus montanus*, and *Camarasaurus* vertebrae. On the other hand, the total yield from quarry no. 10 was two very large postcranial skeletons of *Apatosaurus ajax*. One was catalogued as Yale Peabody Museum specimen YPM 1860 and is the specimen on

which Marsh (1877b) based his original description of *Apatosaurus*, whereas the other was catalogued as YPM 1840 and was originally described by Marsh (1878a) as representing a new species of *Atlantosaurus*, *A. immanis*, but is now recognized as a second specimen of *A. ajax*. Because, for reasons unknown to us, Marsh (1896) figured the skull as *Atlantosaurus montanus*, it would appear that he believed it to be from quarry no. 1, since this species is known otherwise only by a sacrum from that quarry. As it turns out, however, the sacrum is not only too fragmentary to assign to either *Apatosaurus* or *Camarasaurus*, but also to any known sauropod family. In sorting out the specimens from Morrison, Colorado, S. W. Williston, a preparator of Marsh's who later became a highly respected paleontologist in his own right, assigned the skull to the "*Atlantosaurus immanis*" (=*A. ajax*) specimen YPM 1840, indicating he believed it to be from quarry no. 10. The partial skull now bears the catalogue number YPM 1860, but we do not know when, by whom, or on what basis it was given this number. It is possible that either Williston or Marsh may have received more precise locality information for the skull well after it arrived at the Yale Peabody Museum and that this was never recorded in the catalogues. At any rate, in 1958 Theodore E. White, then paleontologist at Dinosaur National Monument, quite reasonably assumed that the catalogue number YPM 1860 on the skull meant that it belonged to the postcranial skeleton of *Apatosaurus* YPM 1860 and that Marsh had erred in describing it as *Atlantosaurus montanus*. Further, White thought the skull closely resembled that of *Camarasaurus* and therefore provided evidence of a close relationship between *Apatosaurus* and *Camarasaurus*. White's observations could have sounded the final death knell to Holland's assertion. However, a more recent study (McIntosh and Berman, 1975) of the Morrison skull revealed that, in contrast to White's claim, it is *Diplodocus*-like. Also of great importance to this debate is a pair of large, identical, quadrate bones (the skull bone on which the lower jaw hinges) definitely known to have been collected from quarry no. 10 at Morrison, which yielded two excellent skeletons of *Apatosaurus* and no remains of any other sauropod. The quadrates are essentially indistinguishable from those of *Diplodocus* and, in turn, are quite distinct from those of *Camarasaurus*. On the basis of size and color there is a very strong possibility that the quadrate bones and the partial skull not only belong to the same individual, but to the *Apatosaurus ajax* postcranial skeleton YPM 1860 (McIntosh and Berman, 1975; Berman and McIntosh, 1978). It is surprising that White (1958) apparently was not aware of the pair of quadrates, since, if he had examined them, he surely would have recognized their *Diplodocus*-like structure and so might also have noticed the *Diplodocus*-like nature of the skull.

A FINAL ANALYSIS LEADS TO SKULL CHANGE

Although not absolutely conclusive, the evidence strongly supports Holland's argument that the skull of *Apatosaurus* looked like that of *Diplodocus*. If Marsh had not arbitrarily assigned isolated *Camarasaurus* skulls to "*Brontosaurus*" there can be little doubt that the large *Diplodocus*-like skull (Figs. 3, 4) found at Dinosaur

National Monument would have been readily and widely accepted as the true skull of *Apatosaurus*. Holland recognized this, stating (1915:275),

It is plain...that Professor Marsh associated the skulls, which he had studied, with the remains of *Brontosaurus* as a result of a process of ratiocination, rather than as the result of ocular evidence that the skull actually belonged with the skeleton.

Concluding, Holland believed that no

man is in a position to declare with positive assurance that the skull heretofore attributed to the genus *Brontosaurus* actually belonged to 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 vertebrae and other skeletal remains [of *Apatosaurus louisae*] before him.

The long-neglected controversy raised by Holland (1915) was not reopened again until over a half century later (McIntosh and Berman, 1975; Berman and McIntosh, 1978). With a new analysis of the old evidence, it has been shown that there now is little doubt that Holland was correct. Even the most casual observer will be struck by the obvious differences between the two types of skull: the skull of *Camarasaurus* (Fig. 5B) is short-snouted and high-crowned, stoutly constructed, and possesses large, spatulate-shaped teeth, whereas, in contrast, the nearly indistinguishable skulls of *Apatosaurus* and *Diplodocus* (Figs. 3, 4, 5A) are low, long-snouted, and delicately constructed with narrow, pencil-like teeth.

With this realization, on October 16, 1979, the *Apatosaurus louisae* skeleton of the Carnegie Museum of Natural History was given a new look with the replacement of its *Camarasaurus* skull with a restored replica of the *Diplodocus*-like skull discovered with it at Dinosaur National Monument (Fig. 6)—an event that surely would have greatly pleased W. J. Holland. In the years following this event the skeletons of *Apatosaurus* on exhibit at the University of Wyoming, the Field Museum of Natural History, the Yale Peabody Museum of Natural History (home of the first mounted *Apatosaurus* skeleton, done under the direction of Marsh), and the American Museum of Natural History have also been changed to portray them as possessing a *Diplodocus*-like skull, using casts of the restored probable *Apatosaurus* skull CM 11162 of the Carnegie Museum of Natural History.

SIGNIFICANCE OF SKULL CHANGE

Now that *Apatosaurus* has been restored with a dramatically different type of head not only must our views on its relationships to the other sauropods be drastically revised, but our speculations—often quite controversial—on its life habits. In addition

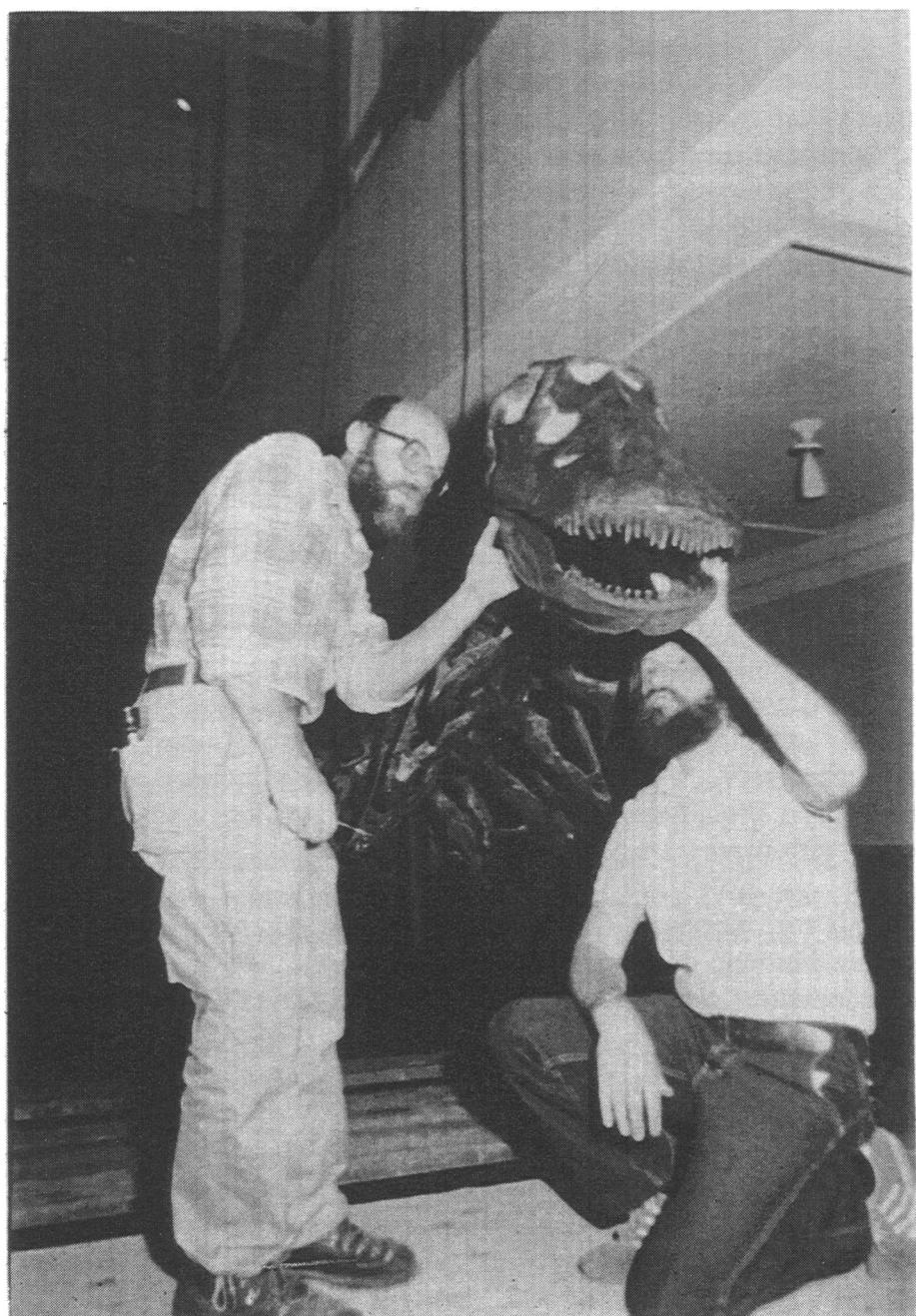


Figure 6.—Cast of restored probable *Apatosaurus* skull CM 11162 being installed on *A. louisae* skeleton CM 3018 at Carnegie Museum of Natural History.

to the recognition that the postcranial skeletons of *Apatosaurus* and *Diplodocus* share many significant features that give them a much closer resemblance to one another than either exhibits with *Camarasaurus*, the same can now be said to be even much truer regarding their skulls. The skulls of *Apatosaurus* and *Diplodocus* differ from one another in only subtle proportions or minor structural details (Berman and McIntosh, 1978) and are quite distinct from that of *Camarasaurus*. With this new information on the anatomy of *Apatosaurus*, it becomes apparent that it is not closely related to *Camarasaurus*, but rather is more appropriately united with *Diplodocus* as a member of the family Diplodocidae. With its former, short-snouted, *Camarasaurus*-like skull with broad, spatulate-like teeth *Apatosaurus* was most commonly envisioned as a dry-land dweller capable of browsing on rather coarse vegetation at considerable heights. With its newly acquired *Diplodocus*-like skull *Apatosaurus* will probably be pictured by most scientists as a herbivorous inhabitant of swamps and lagoons. The fragile forward-slanting, pencil-like teeth concentrated at the front of its relatively long jaws indicate a specialized diet, or at least a diet quite different from that of *Camarasaurus*. It is not unlikely that the dentition of *Apatosaurus*, as well as that of *Diplodocus*, was adapted for cropping the soft, succulent, bottom vegetation of a shallow-water habitat. Supporting this view is the fact that with its elongated snout and nostrils positioned high atop the skull, *Apatosaurus* could graze with its head almost completely submerged, yet continue to breathe.

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