The skeletal reconstruction of *Barosaurus lentus* in the American Museum of Natural History

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John S. McIntosh (deceased).

**Abstract**

XXX to follow

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# Introduction

*Barosaurus* is a diplodocid sauropod from the Late Jurassic of North America, found in the extensive Morrison Formation of the western states. It closely resembles its relative *Diplodocus* in most respects but is characterised by an extremely long neck, even by sauropod standards. In the popular imagination, it is typified by the iconic rearing mount in the rotunda of the American Museum of Natural History (Figure A).

Although the material that the mount is based on (the partial skeleton AMNH 6341) has never been described in detail, the mounted skeleton has been enormously significant culturally, and it is due to this that *Barosaurus* is universally recognised as proportionally long necked in popular books (e.g. Bartram et al. 1983, Lindsay 1992, Lambert 2000). Along with the Carnegie *Diplodocus* CM 84 and *Apatosaurus* CM 3018, and the Berlin *Giraffatitan* MB.R.2181, it has been one of the keystone specimens in establishing the perception of sauropods by the general public.

There are two popular accounts of the *Barosaurus* mount (Norell et al. 1991, Dingus 1996:21–26) but as yet no scientific account has been published. In this paper, we will review the history of *Barosaurus*, and consider composition of the mounted *Barosaurus* skeleton in the spirit of Janensch’s (1950) review of the original Berlin mounting of *Giraffatitan* (= “*Brachiosaurus*” of his usage) *brancai*. We will determine which parts are cast from the main specimen AMNH 6341, which from other specimens, which sculpted, etc. We will discuss how scaling was calculated and how the pose was decided on, and discuss the controversy generated by the mount.

## Institutional Abbreviations

* AMNH — American Museum of Natural History, New York, New York, USA.
* CM — Carnegie Museum of Natural History, Pittsburgh, Pennsylvania, USA.
* MB — Museum für Naturkunde Berlin, Berlin, Germany; specimen numbers for fossil reptiles take the form MB.R.*nnnn*.
* YPM — Yale Peabody Museum, New Haven, Connecticut, USA.

# Historical background

## Early discoveries

As recounted in McIntosh (2005:40–41), the first fossils of what is now *Barosaurus* were discovered in the 1880s by Mrs. E. R. Ellerman on land owned by Mrs. Rachel Hatch half a mile east of Piedmont on the eastern rim of the Black Hills of South Dakota. In the summer of 1189, O. C. Marsh visited the site with J. B. Hatcher, and collected part of the tail, obtaining a promise from Ellerman and Hatch that they would protect the rest of the specimen until it could be collected. Based on six caudal vertebrae and a chevron from this initial excavation, Marsh (1890) very briefly described and named the new genus and species *Barosaurus lentus* in a six-page paper in which he also cursorily described the theropod *Ornithomimus* and two new species of *Triceratops*. The only *Barosaurus* elements mentioned in Marsh’s description were caudal vertebrae, and a single mid-caudal centrum was illustrated (Marsh 1890: figures 1–2). Marsh’s diagnosis noted only that the caudals resembled those of *Diplodocus* but varied from them in several ways that subsequently turned out to be errors brought about by comparing more anterior *Barosaurus* caudals with more posterior *Diplodocus* caudals.

It was not until eight years later that Marsh attempted to have the rest of the skeleton collected, sending George Wieland in late August 1898. In the intervening time, Mrs. Ellerman had died and parts of the skeleton had been taken by locals, but Wieland was able to reunite much of this material and excavate what remained underground, apparently working alone (Wieland 1920:529). All the material was shipped to Yale and added to the holotype under the specimen number YPM 429.

However, Marsh died the next year, and work on the specimen stalled. Almost two further decades passed before YPM 429 was fully prepared and Richard S. Lull was able to make a presentation of the specimen at the end of 1916 at the eighth annual meeting of the Paleontological Society in Albany, NY. Unfortunately, his abstract (Lull 1917), at only 74 in length, is largely uninformative. More happily he described the specimen in detail in a significant monograph (Lull 1919), which remained the definitive publication on *Barosaurus* until McIntosh’s (2005) revision. Since Lull’s monograph, *Barosaurus* has become known from several additional specimens including a specimen from what is now Dinosaur National Monument, north of Jensen, Utah, which was broken up into a cervical sequence CM 1198 (consisting of cervicals ?12, ?13 and ?16) and the postcervical skeleton ROM 3670 — now reunited at the Royal Ontario Museum in Canada. Also from Dinosaur National Monument is CM 11984, another partial cervical sequence consisting of C7–C15 but still not fully prepared.

However, the most complete and informative *Barosaurus* specimen to date is AMNH 6341, the individual that provided most of the material for the AMNH rotunda mount. It was briefly described as part of McIntosh’s (2005) revision of the genus *Barosaurus*, but has yet to be described in detail.

## The AMNH specimen

XXX This section is heavily based on Dingus’s (1996) account, and needs more detail.

The specimen that would become AMNH 6341 was discovered by Earl Douglass in about 1912 at what is now Dinosaur National Monument near Vernal, Utah. During excavation in 1912–14, the specimen was thought to represent the better known *Diplodocus*, and so parts of it were sent to various museums to fill in the missing portions of their *Diplodocus* skeletons: part of the tail to the Carnegie Museum, part of the neck to the Smithsonian, and the rest to the University of Utah. In 1929, Barnum Brown realised that these sections all belonged to a single specimen of *Barosaurus*, and acquired from the for the AMNH (Dingus 1996:21–22).

Some plans were initiated to mount the *Barosaurus* skeleton in the early 1950s, but came to nothing. Four more decades were to pass before the skeleton (or at least a cast based on it) was mounted.

# Materials and Methods

## The creation of the mount

— Dingus and Gaffney independently came up with the idea of a rearing mount. “The first drawings were blurry sketches made on damp napkins” (Norell et al. 1991:38).

— preliminary planning for atrium refurb completed in 1989.

— May and crew took the fossils back to Toronto in fall 1990 for casting.

— Early 1991: test erection in Toronto parking lot.

— erected in Nov 1991.

— unveiled in December 1991. At that time the only publicly exhibited *Barosaurus* (Norell et al. 1991:36)

## Composition of the mount

The exact length of the neck of *Barosaurus* is difficult to determine as no complete neck is known. AMNH 6341 preserves the last nine cervical vertebrae, which McIntosh (2005:45) considered to be C8–C16. (The number of cervicals is reckoned to be 16 on the basis that there are only nine dorsals, compared with ten in the closely related *Diplodocus*, and the most likely reason is that the first dorsal was recruited into the neck.) The anterior neck of the mount was completed using casts of seven anterior vertebrae from the Carnegie *Diplodocus* — probably cervicals 10, 8, 6 and 4–1 (Peter May, pers. comm., 2022). The atlas was most likely a cast of the one incorporated into the Carnegie mounted skeleton.

Only one known specimen referred to *Barosaurus* preserves the anterior cervicals: AMNH 7535 is a juvenile, consisting of cervicals 2–8, referred by Tschopp et al. (2015:220) to *Barosaurus* sp. Wedel (2007:207) scaled these vertebrae up to match those of AMNH 6341 (C8 is preserved in both specimens), to arrive at his total neck length estimate of 8.5 m. It seems that John S. McIntosh independently performed a similar scaling operation using these vertebrae, as shown by notes hand-written around 1990 on a printed draft of what would become the table of measurements in his subsequent *Barosaurus* paper (Peter May, pers. comm. 2022). Summing the known centrum lengths of AMNH 6341 cervicals 8–16 from this table (McIntosh 2005:table 2.1) together with the scaled-up centrum lengths of AMNH 7535 cervicals 2–7 written onto the manuscript yields a total of XXX see email.

# Results

XXX Size of the AMNH 6341 animal

XXX Comparison of mount with total height of Berlin brachiosaur

# Discussion

## Rearing pose

The mounted *Barosaurus* is in a spectacular rearing pose, as though to defend its offspring against a threatening *Allosaurus* individual. This pose was controversial when the mount was first unveiled

XXX examples include Hicks and Badeer (1992), Taylor (1992), Choy and Altmann (1992), Dennis (1992), Landry (1992), Badeer and Hicks (1996) XXX get these in the right order, add references, see what else they cite that I have missed.

However, the notion of rearing sauropods has a heritage going back at least to Osborn (1899:213), who wrote that the tail of *Diplodocus* “functioned as a lever to balance the weight of the dorsals, anterior limbs, neck, and head, and to raise the entire forward portion of the body upwards. […] Thus the quadrupedal Dinosaurs occasionally assumed the position characteristic of the bipedal Dinosaurs — namely, a tripodal position, the body supported upon the hind feet and the tail”. In his classic monograph of *Diplodocus carnegii*, Hatcher (1901:57–58) strongly implied, without quite explicitly stating, that *Diplodocus* habitually reared, and Charles Knight was painting rearing diplodocids as early as 1907 (see Taylor 2010:figure 6B). From time to time, bipedality has also been proposed for other sauropods, including for example *Opisthocoelicaudia* (Borsuk-Bialynicka 1977:51) and *Cathetosaurus* (Jensen 1988:124–128) as well as diplodocids including *Barosaurus* itself (Bakker 1986:190–192). in more recent times, biomechanical modelling has been used to establish the feasibility of elevated postures such as that of the AMNH *Barosaurus*. Mallison (2011) argued compellingly from kinetic–dynamic modelling that diplodocines such as *Barosaurus* were particularly well adapted to bipedal rearing and sustained tripodal (tail-supported) standing. So the pose selected for the AMNH mount seems fully justified.

# Acknowledgements

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# Figure Captions

**Figure A.** The mounted skeleton of *Barosaurus lentus* AMNH 6341 in the Theodore Roosevelt Rotunda of the American Museum of Natural History, New York.

**Figure B.** Skeletal reconstruction of *Barosaurus lentus* based primarily on AMNH 6341, by kind permission of Scott Hartman.