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. It was first described very briefly by Marsh (1890) 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 noted only that the caudals resembled those of *Diplodocus* but were proportionally shorter than in that genus and did not retain pneumatic features so far back along the tail.

The caudal vertebrae described by Marsh (1890) were part of a substantial partial specimen, YPM 492. More of this individual was subsequently excavated and prepared, and Lull (1911) wrote an important monographic description. Since Lull’s monograph, *Barosaurus* has become known from additional specimens. The most influential of these is AMNH 6341, the specimen that provided most of the material for the iconic rearing mount in the rotunda of the American Museum of Natural History (Figure A).

AMNH 6341 was briefly described as part of McIntosh’s (2005) revision of the genus *Barosaurus*, but has yet to be described in detail. Nevertheless, the mounted skeleton has been enormously significant culturally, and it is due to this that *Barosaurus* is universally recognised as proportionally long necked, even by sauropod standards (e.g. Bartram et al. 1983, Lindsay 1992, Lambert 2000). Along with the Carnegie *Diplodocus* CM 84 and *Apatosaurus* CM 3018, and the Berlin brachiosaur 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 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

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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# References

Bakker, Robert T. 1986. *The Dinosaur Heresies: New Theories Unlocking The Mystery of the Dinosaurs and Their Extinction*. Morrow, New York. 481 pages.

Bartram, Alan, B. Booth, M. Chinery, E. N. K. Clarkson, B. Cox, D. Edwards, C. Maynard and W. D. I. Rolfe. 1983. *The Prehistoric World*. Galley Press (London).

Borsuk-Bialynicka, Magdalena. 1977. A new camarasaurid sauropod *Opisthocoelicaudia skarzynskii* gen. n., sp. n. from the Upper Cretaceous of Mongolia. *Palaeontologica Polonica* **37**:4–64 and plates 1–14.

Dingus, Lowell. 1996. *Next of Kin: Great Fossils at the American Museum of Natural History*. Rizzoli, New York.

Hatcher, Jonathan B. 1901. *Diplodocus* (Marsh): its osteology, taxonomy and probable habits, with a restoration of the skeleton. *Memoirs of the Carnegie Museum* **1**:1–63 and plates I–XIII.

Jensen, James A. 1988. A fourth new sauropod dinosaur from the Upper Jurassic of the Colorado Plateau and sauropod bipedalism. *Great Basin Naturalist* **48(2)**:121–145.

Lambert, David. 2000. *DK Guide: Dinosaurs*. Dorling Kindersley (London). 64 pages.

Lindsay, William. 1992. *Barosaurus: on the trail of the gigantic plant-eating dinosaur*. Dorling Kindersley (London). 32 pages.

Lull, R. S. 1919. The sauropod dinosaur *Barosaurus* Marsh. *Memoirs of the Connecticut Academy of Arts and Sciences* **6**:1–42 and plates I–VII.

Mallison, Heinrich. 2011. Rearing giants: kinetic-dynamic modeling of sauropod bipedal and tripodal poses. pp. 237-250 in: Nicole Klein, Kristian Remes, Carole T. Gee and Martin P. Sander (eds.), *Biology of the Sauropod Dinosaurs*. Indiana University Press, Bloomington, Indiana.

Marsh, Othniel C. 1890. Description of new dinosaurian reptiles. *American Journal of Science*, third series, **39**:81–86. doi:10.2475/ajs.s3-39.229.81

McIntosh, John S. 2005. The Genus *Barosaurus* Marsh (Sauropoda, Diplodocidae). pp. 38–77 in Virginia Tidwell and Ken Carpenter (eds.), *Thunder Lizards: the Sauropodomorph Dinosaurs*. Indiana University Press, Bloomington, Indiana. 495 pp.

Norell, Mark A., Lowell W. Dingus and Eugene S. Gaffney. 1991. *Barosaurus* on Central Park West. *Natural History* **100(12)**:36-41. <http://hdl.handle.net/2246/6497>

Osborn, Henry. F. 1899. A skeleton of *Diplodocus*. *Memoirs of the American Museum of Natural History*, **1**:189–214 and plates 24–28.

Taylor, Michael P. 2010. Sauropod dinosaur research: a historical review. pp. 361-386 in: Richard T. J. Moody, Eric Buffetaut, Darren Naish and David M. Martill (eds.), *Dinosaurs and Other Extinct Saurians: a Historical Perspective*. Geological Society of London, Special Publication 343. doi: 10.1144/SP343.22

Tschopp, Emanuel, Octávio Mateus and Roger B. J. Benson. 2015. A specimen-level phylogenetic analysis and taxonomic revision of Diplodocidae (Dinosauria, Sauropoda). *PeerJ* **2**:e857. doi:10.7717/peerj.857

Wedel, Mathew J. 2007. *Postcranial pneumaticity in dinosaurs and the origin of the avian lung*. Ph.D dissertation, Integrative Biology, University of California, Berkeley, CA. Advisors: Kevin Padian and Bill Clemens. 290 pages.

# 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.