ARCHOSAURIAN ARTICULATIONS

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Late Jurassic North American Brachiosaurids

SAUROPODS were the grandest animals ever to walk the earth. Adult specimens of the giant *Apatosaurus*, *Diplodocus*, *Barosaurus*, and *Mamenchisaurus hochuanensis* were as much as 25 meters (over 80 feet) long. A sauropod skeleton discovered in China in 1987 by the Canada-China Dinosaur Project has a reported length of about 27 meters (90 feet). Thus a sauropod 15 meters long would be considered rather small, even though a non-sauropod dinosaur this size would be a giant in its class.

Because they were so big, sauropods make spectacular museum displays that attract crowds of customers. It is thus quite frustrating that sauropod specimens are usually fragmentary skeletons or isolated bones. There is a good anatomical reason for this. A close look at a sauropod skeleton shows that the bones, particularly those in the legs, do not "fit together" very well; there is a lot of space between them. In the live dinosaur, this space was taken up by cartilage and ligaments – connective tissue – that held the skeleton together. After death, however, the dinosaur's connective tissue would decay and the skeleton would fall apart; many bones would wash away before burial.

As if this weren't bad enough, sauropod vertebrae – the most tightly articulated bones in a sauropod skeleton and thus the likeliest to be discovered still joined together – are very thin-walled for their size, with large internal cavities called pleurocoels. This makes them prone to crushing and thereby hampers proper measurement and identification. This problem particularly plagues the brachiosaurids, among which are the most massive sauropods known.

Brachiosaurus

The first *Brachiosaurus altithorax* specimen was collected in 1900 from the Late Jurassic Morrison Formation (about 140–160 million years old) of Grand Junction, Colorado by Elmer S. Riggs. It was a quite incomplete skeleton, comprising several vertebrae, parts of the shoulder and pelvis, an upper arm and upper leg, and four ribs, that is now stored at the Field Museum in Chicago. Riggs was struck by the length of the upper arm bone and realized that in life the animal's chest was as high off the ground as the hips, and its back sloped down to the tail. This is why he named it the "high-chested arm-lizard."

It wasn't until 1943 that another *Brachiosaurus* skeleton was found in North America, by uranium prospectors Vivian and Daniel "Eddie" Jones, who donated their find to the Smithsonian Institution. This badly eroded specimen was from the Potter Creek Quarry on the Uncompahgre Upwarp in western Colorado, and it remained undescribed until last year, in a brachiosaur paper by James A. Jensen. In more than two decades of field work, Jensen could find only scattered additional bones of *Brachiosaurus* and related sauropods, but because brachiosaur material of any kind is so scarce, his discoveries are nevertheless extremely significant.

Our knowledge of *Brachiosaurus* would be terribly incomplete were it not for the discovery of considerable material – including skulls – in Tendaguru, Tanzania by German paleontological expeditions a few years before World War I. This was described in a series of papers by Werner Jan-

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ensch, starting in 1914, and it proved possible to construct a complete skeleton from the remains of several individuals. This skeleton, rescued from destruction during the air raids of World War II, now stands, nearly 12 meters (40 feet) tall and 23 meters (75 feet) long, in the Humboldt Museum für Naturkunde in East Berlin. Representing an animal with an estimated body weight of almost 50 tons, it is still the largest mounted dinosaur skeleton in the world.

Janensch discerned the similarity of the Tendaguru brachiosaurs to Riggs's specimen and named them *Brachiosaurus brancai* and *Brachiosaurus fraasi* — two new species of the same genus as Riggs's dinosaur — after the German paleontologists Wilhelm Branca and Eberhard Fraas. It soon became apparent that *B. fraasi* actually represents a smaller *B. brancai* individual, and all the brachiosaur material from Tendaguru is now considered to belong to just the species *B. brancai*.

In a recent paper, Gregory S. Paul of Baltimore, Maryland, summarized what is known of both the North American and African species of *Brachiosaurus*, corrected a few errors that seemingly crept into Janensch's descriptions, and produced a new reconstruction of *B. brancai*, the side view of which is reproduced here as Figure 6. Paul considered *B. brancai* different enough from *B. altithorax* that he placed it into its own subgenus, *Giraffatitan* ("big giraffe"). The full name of the American species thus became *Brachiosaurus (Brachiosaurus) altithorax*, and of the African species *Brachiosaurus (Giraffatitan) brancai*. *B. (B.) altithorax* has longer dorsal vertebrae and relatively longer ribs than *B. (G.) brancai*, so it had a longer, deeper, and presumably heavier body.

Ultrasaurus

In 1972 at the Dry Mesa Quarry in Colorado, Jensen discovered two shoulder blades (scapulacoracoids) and a few other fossilized bones of a very large dinosaur that he nicknamed "Supersaurus." In 1979, also at Dry Mesa, a third scapulacoracoid was found during filming for a Japanese television show. Since it was a bit larger than the "Supersaurus" shoulder blades and evidently belonged to a different kind of dinosaur, Jensen nicknamed that dinosaur "Ultrasaurus." Both names remained informal until Jensen published the dinosaurs' descriptions, in 1985, under the names *Supersaurus vivianae* (named after Vivian Jones) and *Ultrasaurus macintoshi* (after John S. McIntosh, a noted student of the sauropods). According to Jensen, *Supersaurus* is probably a diplodocid sauropod, similar to but larger than *Apatosaurus*, *Diplodocus*, and *Barosaurus*, while *Ultrasaurus* is a brachiosaurid — the second brachiosaurid genus to be described from North America.

The story of *Ultrasaurus* has recently taken a couple of unexpected twists. In the early 1980s — before Jensen formally published *Ultrasaurus macintoshi* — a Korean paleontologist named Haang Mook Kim published a series of short papers describing dinosaurs from South Korea, including material that he also called "Ultrasaurus," thinking that it came from a dinosaur larger than "Supersaurus." In 1983, he formally named his dinosaur *Ultrasaurus tabriensis*. Unfortunately, the remains of *Ultrasaurus tabriensis* seem to have been misidentified, and the dinosaur is considerably smaller than Kim believed. But even more unfortunately, the name *Ultrasaurus* was preempted for the Korean dinosaur, and Jensen's giant dinosaur had to be rechristened.

Then, in the *Brachiosaurus* study noted above, Paul examined Jensen's figures of *Ultrasaurus* and concluded that *Ultrasaurus macintoshi* is simply a large *Brachiosaurus altithorax*. If this is indeed true, then it is not necessary to rename Jensen's dinosaur; it can simply be called *Brachiosaurus*. But Jensen, who has collected material of both *Brachiosaurus* and *Ultrasaurus*, disagrees with Paul's interpretation, and the question of what *Ultrasaurus* really is remains open.

Paul's paper also discussed skeletal material from other gigantic sauropods, to see how it compared with what is known of *Brachiosaurus*. It is too bad that practically all of it is so scrappy — a femur here, a vertebra there — so that much guesswork was involved in Paul's estimates. Paul concluded that Jensen's *Ultrasaurus* specimens represent an animal not too much larger than the largest known *Brachiosaurus* individual, weighing about 55 tons. *Supersaurus*, on the other hand, could well have been 42 meters (140 feet) long, if it had a whiplash tail like that of its smaller

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relative *Diplodocus*. But because diplodocids had smaller and slenderer bodies than brachiosaurids, at 50 tons *Supersaurus* would not have outweighed *Ultrasaurus*.

Of the giant sauropods reported from South America, Paul believed *Antarctosaurus giganteus*, known from a thigh bone 2.31 meters (nearly 7.7 feet) long, was about as large as the biggest *Brachiosaurus* and probably also weighed about 50 tons. None of the sauropods listed in Paul's paper was conclusively shown to be heavier than Jensen's giant.

The last word in giant dinosaurs may reside in an enormous brachiosaurid femur from the Recapture Member of the Morrison Formation, only a third of which was preserved. Illustrated in Jensen's 1987 paper, this fragment is over a meter long and is 1.67 meters around, and the bone itself may have been nearly 3 meters (10 feet) long in life – representing an animal with a possible body weight of as much as 70 tons.

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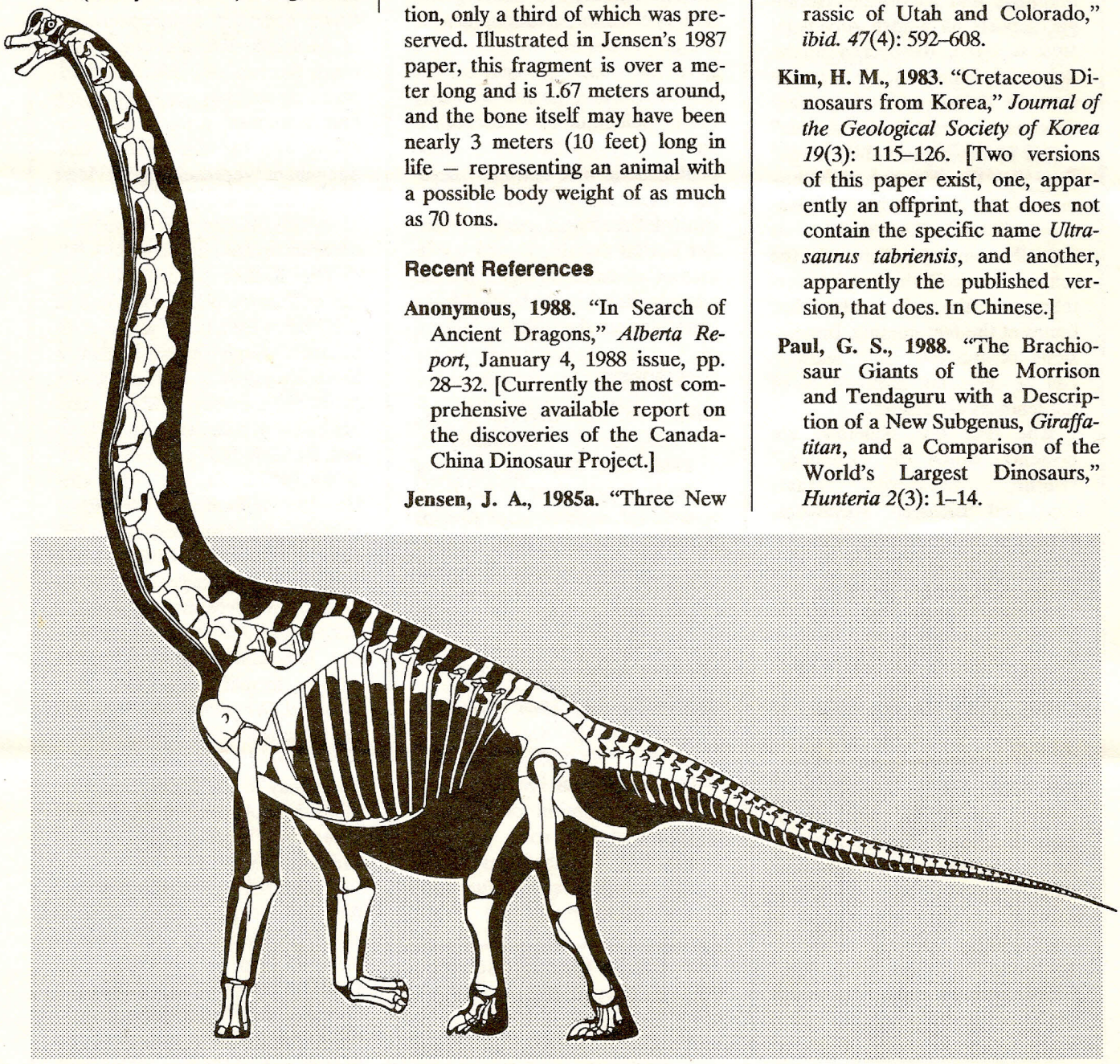

Figure 6 Skeleton of *Brachiosaurus (Giraffatitan) brancai* as restored by Paul, 1988. Based on the composite mounted specimen on display at the Humboldt Museum in East Berlin and various other specimens referred to that species. Height after several corrections (including the addition of a twelfth dorsal vertebra) about 16 meters, length about 25 meters (a somewhat larger individual than the Humboldt skeleton).