

= Species of Allosaurus =

There have been a number of potential species assigned to the carnosaurian dinosaur genus *Allosaurus* since its description in 1877 by Othniel Charles Marsh, but only a handful are still regarded as valid. *Allosaurus* was originally described from material from the Upper Jurassic Morrison Formation of the western United States of America; the type species *A. fragilis* became one of the best @-@ known species of dinosaur.

The genus *Allosaurus* was part of the Marsh / Cope "Bone Wars" of the late 19th century, and its taxonomy became increasingly confused due to the competition, with several genera and species named by Cope and Marsh now regarded as synonyms of *Allosaurus* or *A. fragilis*. Since the description of *Allosaurus*, scientists have proposed additional species from such far @-@ flung locales as Portugal, Siberia, and Tanzania.

= = Query about type specimen = =

The issue of synonyms is complicated by the type specimen of *Allosaurus fragilis* (catalogue number YPM 1930) being extremely fragmentary, consisting of a few incomplete vertebrae, limb bone fragments, rib fragments, and a tooth. Because of this, several scientists have noted that the type specimen, and thus the genus *Allosaurus* itself or at least the species *A. fragilis*, is technically a *nomen dubium* ("dubious name", based on a specimen too incomplete to compare to other specimens or to classify). In an attempt to fix this situation, Gregory S. Paul and Kenneth Carpenter (2010) submitted a petition to the ICZN to have the name *A. fragilis* officially transferred to the more complete specimen USNM4734 (as a neotype). This request is currently pending review.

= = Potentially valid species = =

It is unclear how many species of *Allosaurus* there were. Eight species have been considered potentially valid since 1988 (*A. amplexus*, *A. atrox*, *A. europaeus*, the type species *A. fragilis*, the as @-@ yet not formally described "*A. jimmadseni*", *A. lucasi*, *A. maximus*, and *A. tendagurensis*), although only about half are usually considered valid at any given time. There are also at least ten dubious or undescribed species that have been assigned to *Allosaurus* over the years, along with the species belonging to genera now sunk into *Allosaurus*. In the most recent review of basal tetanuran theropods, only *A. fragilis* (including *A. amplexus* and *A. atrox*), "*A. jimmadseni*" (as an unnamed species), and *A. tendagurensis* were accepted as potentially valid species, with *A. europaeus* not yet proposed and *A. maximus* assigned to *Saurophaganax*.

*A. fragilis* is the type species and was named by Marsh in 1877. It is known from the remains of at least sixty individuals, all found in the Kimmeridgian ? Tithonian Upper Jurassic @-@ age Morrison Formation of the United States, spread across the states of Colorado, Montana, New Mexico, Oklahoma, South Dakota, Utah, and Wyoming. Details of the humerus (upper arm) of *A. fragilis* have been used as diagnostic among Morrison theropods, but the discovery of "*A. jimmadseni*" indicates that this will no longer be the case at the species level.

*A. amplexus* was named by Gregory S. Paul for giant Morrison allosaur remains, and included in his conception *Saurophagus maximus* (later *Saurophaganax*). *A. amplexus* was originally coined by Cope in 1878 as the type species of his new genus *Epanterias*, and is based on what is now AMNH 5767, parts of three vertebrae, a coracoid, and a metatarsal. Following Paul's work, this species has been accepted as a synonym of *A. fragilis*.

*Allosaurus* material from Portugal was first reported in 1999 on the basis of MHNUL / AND.001, a partial skeleton including a quadrate, vertebrae, ribs, gastralia, chevrons, part of the hips, and hindlimbs. This specimen was assigned to *A. fragilis*, but the subsequent discovery of a partial skull and neck (ML 415) near Lourinhã, in the Kimmeridgian @-@ age Porto Novo Member of the Lourinhã Formation, spurred the naming of the new species *A. europaeus*. It differs from other species of *Allosaurus* in cranial details. However, more material may show it to be *A. fragilis*, as

originally described .

Daniel Chure 's work on Morrison allosaurid remains has been responsible , directly or indirectly , for " *A. jimmadseni* " and *A. maximus* . " *A. jimmadseni* " is the proposed name for a new species of Morrison allosaur , based on a nearly complete skeleton and skull . *A. sp . 2* , as it is also known , differs from *A. fragilis* in several anatomical details including a jugal or cheekbone with a straight lower margin , and is also found only in the Salt Wash Member of the Morrison Formation , with *A. fragilis* only present in the higher Brushy Basin Member . *A. maximus* was coined by David K. Smith for Chure 's *Saurophaganax maximus* , a taxon created by Chure in 1995 for giant allosaurid remains from the Morrison of Oklahoma . These remains had been known as *Saurophagus* , but that name was already in use , leading Chure to propose a substitute . Smith , in his 1998 analysis of variation , concluded that *S. maximus* was not different enough from *Allosaurus* to be a separate genus , but did warrant its own species , *A. maximus* . This reassignment was rejected in the most recent review of basal tetanurans .

= = Biological variation , *A. atrox* , and *A. fragilis* = =

The perception that there were two common *Allosaurus* species in the Morrison Formation was popularized in Gregory S. Paul 's 1988 book *Predatory Dinosaurs of the World* . Paul proposed that *A. fragilis* had tall pointed horns and a slender build compared to a postulated second species *A. atrox* , and was not a different gender due to rarity . *Allosaurus atrox* was originally named by Marsh in 1878 as the type species of its own genus , *Creosaurus* , and is based on YPM 1890 , an assortment of bones including a couple of pieces of the skull , portions of nine tail vertebrae , two hip vertebrae , an ilium , and ankle and foot bones . Although the idea of two common Morrison allosaur species has had support in semi @-@ technical and popular works , it has generally been rejected in the technical literature .

David K. Smith , examining *Allosaurus* fossils by quarry , found that the Cleveland Lloyd Dinosaur Quarry ( Utah ) specimens are generally smaller than those from Como Bluff ( Wyoming ) or Brigham Young University 's Dry Mesa Quarry ( Colorado ) , but the shapes of the bones themselves did not vary between the sites . A later study by Smith incorporating Garden Park ( Colorado ) and Dinosaur National Monument ( Utah ) specimens found no justification for multiple species based on skeletal variation ; skull variation was most common and was gradational , suggesting individual variation was responsible . Further work on size @-@ related variation again found no consistent differences , although the Dry Mesa material tended to clump together on the basis of the astragalus , an ankle bone . Kenneth Carpenter , using skull elements from the Cleveland Lloyd site , found wide variation between individuals , calling into question previous species @-@ level distinctions based such features as the shape of the horns , and the proposed differentiation of " *A. jimmadseni* " based on the shape of the jugal .

= = Invalid and synonymous species = =

A number of species assigned to *Allosaurus* are no longer recognized as valid , for one reason or another . Species " *A. agilis* " , seen in Zittel , 1887 , and Osborn , 1912 , is a typographical error for *A. fragilis* . Marsh 's *A. ferox* ( 1896 ; not to be confused with his 1884 *Labrosaurus ferox* , also part of *Allosaurus* taxonomy ) was coined for a partial skull in a footnote , and has been recognized as a specimen of *A. fragilis* . *A. lucaris* , another Marsh name , was given to a partial skeleton in 1878 . He later decided it warranted its own genus , *Labrosaurus* , but this has not been accepted , and *A. lucaris* is also regarded as another specimen of *A. fragilis* . *Allosaurus lucaris* , is known mostly from vertebrae , sharing characters with *Allosaurus* . Paul and Carpenter stated that the type specimen of this species , YPM 1931 , was from a younger age than *Allosaurus* , and might represent a different genus . However , they found that the specimen was undiagnostic , and thus *A. lucaris* was a *nomen dubium* . " *A. whitei* " , an informally described species coined by Pickering in 1996 , is a recasting of the *A. atrox* versus *A. fragilis* debate using a better specimen to represent the *A. atrox* form , and has not been recognized .

Several species coined in genera other than *Allosaurus* are also now thought to be synonymous with *A. fragilis*. *Labrosaurus ferox* was named in 1884 by Marsh for an oddly formed partial lower jaw, with a prominent gap in the tooth row at the tip of the jaw, and a rear section greatly expanded and turned down. Later researchers suggested that the bone was pathologic, showing an injury to the living animal, and that part of the unusual form of the rear of the bone was due to plaster reconstruction. It is recognized as most likely a specimen of *A. fragilis*. *Allosaurus valens* is a typo for *Antrodemus valens* accidentally used by Friedrich von Huene in 1932; *Antrodemus valens* itself may also pertain to *Allosaurus fragilis*, as Gilmore suggested in 1920. *Apatodon mirus*, based on a scrap of vertebra Marsh first thought to be a mammalian jaw, may or may not be the same as *Allosaurus*.

= = Misassigned species = =

Several species initially classified within or referred to *Allosaurus* do not belong within the genus. *A. medius* was named by Marsh in 1888 for "various specimens" from the Early Cretaceous of Maryland, although most of the remains were removed by Richard Swann Lull to the new ornithomimid species *Dryosaurus grandis*, except for a tooth. Gilmore considered the tooth nondiagnostic but transferred it to a new species, *Dryptosaurus medius*. The referral was not accepted in the most recent review, and *Allosaurus medius* was simply listed as a dubious species of theropod. *Allosaurus sibiricus* was described in 1914 by A. N. Riabinin on the basis of a bone, later identified as a partial fourth metatarsal, from the Early Cretaceous of Buryatia, Russia. It was transferred to *Chilantaisaurus* in 1990.

*Allosaurus meriani* was described in 1870 by Greppin as a species of *Megalosaurus*, based on a tooth from the Late Jurassic of Switzerland. It has occasionally been referred to *Allosaurus*, but recent reviews have listed it as dubious theropod species *Megalosaurus meriani*, or included it in *Ceratosaurus* sp. *Allosaurus stechowi* was described in 1920 by Janensch as *Labrosaurus stechowi* for isolated *Ceratosaurus* @-@ like teeth from the Tendaguru beds of Tanzania. With the synonymization of *Labrosaurus* and *Allosaurus*, Donald F. Glut listed it as a species of *Allosaurus*, but it is now either assigned to *Ceratosaurus* sp. or considered a dubious ceratosaurian.

There are also several species left over from the synonymizations of *Creosaurus* and *Labrosaurus* with *Allosaurus*. *Creosaurus potens* was named by Lull in 1911 for a vertebra from the Early Cretaceous of Maryland. It is now regarded as a dubious theropod. *Labrosaurus fragilis* is a typographical error by Marsh (1896) for *Labrosaurus ferox*. *L. sulcatus*, named by Marsh in 1896 for a Morrison theropod tooth, which like *L. stechowi* is now regarded as either *Ceratosaurus* sp. or a dubious ceratosaurian.

*A. tendagurensis* was named in 1925 by Werner Janensch for a partial shin (HM 67) found in the Kimmeridgian @-@ age rocks of Tendaguru, in Mtwara, Tanzania. This species has not had strong support in recent years, with opinions on its identity ranging from a tentatively valid species of *Allosaurus*, to a basal tetanuran. The most recent analysis has placed it in *Carcharodontosauridae*. Although obscure, it was a large theropod, possibly around 10 meters long (33 ft) and 2 @.@ 5 metric tons (2 @.@ 8 short tons) in weight.

= = Specimens misassigned to *Allosaurus* though not described as new species = =

Kurzanov and colleagues in 2003 designated six teeth from Siberia as *Allosaurus* sp. (meaning the authors found the specimens to be most like those of *Allosaurus*, but did not or could not assign a species). Also, reports of *Allosaurus* in Shanxi, China go back to at least 1982.

An astragalus (ankle bone) thought to belong to a species of *Allosaurus* was found at Cape Paterson, Victoria in Early Cretaceous beds in southeastern Australia. It was thought to provide evidence that Australia was a refugium for animals that had gone extinct elsewhere. This identification was challenged by Samuel Welles, who thought it more resembled that of an ornithomimid, but the original authors defended their identification. With fifteen years of new specimens and research to look at, Daniel Chure reexamined the bone and found that it was not

Allosaurus , but could represent an allosauroid . Similarly , Yoichi Azuma and Phil Currie , in their description of Fukuiraptor , noted that the bone closely resembled that of their new genus . This specimen is sometimes referred to as " Allosaurus robustus " , an informal museum name . It may have belonged to something similar to , or the same as , Australovenator , or it may represent an abelisaur . A speculative " polar " or " dwarf allosaur " was used for the " Spirits of the Ice Forest " episode of Walking with Dinosaurs .