

= Cryolophosaurus =

Cryolophosaurus (/ ˈkraʊʔoʊloʊfoʊsʔrʔs / or / kraʊʔloʊfoʊsʔrʔs / ; " CRY @-@ oh @-@ loaf @-@ oh @-@ SAWR @-@ us ") is a genus of large theropods known from only a single species Cryolophosaurus ellioti , known from the early Jurassic period of Antarctica . It was about 6 @.@ 5 metres (21 @.@ 3 ft) long and 465 kilograms (1 @,@ 025 lb) in weight , making it one of the largest theropods of its time . Individuals of this species may have grown even larger , because the only known specimen probably represents a sub @-@ adult . Cryolophosaurus is known from a skull , a femur and other material , the skull and femur of which have caused its classification to vary greatly . The femur possesses many primitive characteristics that have classified Cryolophosaurus as a dilophosaurid or a neotheropod outside of Dilophosauridae and Averostra , where as the skull has many advanced features , leading the genus to be considered a tetanuran , an abelisaurid , a ceratosaur and even an allosaurid . Since its original description , the consensus is that Cryolophosaurus is either a primitive member of the Tetanurae or a close relative of that group .

Cryolophosaurus possessed a distinctive crest on its head that spanned the head from side to side , similar to a Spanish comb . Based on evidence from related species and studies of bone texture , it is thought that this bizarre crest was used for intra @-@ species recognition . The brain of Cryolophosaurus was also more primitive than those of other theropods .

Cryolophosaurus was first excavated from Antarctica 's Early Jurassic , Sinemurian to Pliensbachian aged Hanson Formation , formerly the upper Falla Formation , by paleontologist Dr. William Hammer in 1991 . It was the first carnivorous dinosaur to be discovered in Antarctica and the first non @-@ avian dinosaur from the continent to be officially named . The sediments in which its fossils were found have been dated at ~ 194 to 188 million years ago , representing the Early Jurassic Period .

= = Description = =

The holotype FMNH PR1821 is the only fully described specimen of Cryolophosaurus . The specimen consists of an incomplete skull and mandibles lacking most of their front half ; nine maxillary teeth ; a fragmentary sixth cervical centrum ; cervical vertebrae 7 @-@ 10 ; several posterior cervical ribs ; several anterior dorsal vertebrae ; most mid and posterior dorsal vertebrae ; several dorsal ribs ; the fifth sacral vertebrae ; three chevrons ; many partial and complete caudal vertebrae and centra ; two partial humeri ; a proximal radius ; a proximal ulna ; a partial ilium ; a proximal pubis ; both ischia , but only one distal ; two incomplete femora ; the distal end of a tibia ; the distal end of a fibula , and the astragalus and calcaneum . In 2013 , new material of Cryolophosaurus was unearthed in Antarctica . The description of this material has not yet been published in a non @-@ abstract form .

Cryolophosaurus was a large , well @-@ built theropod , one of the largest of its time . The genus has been described by Roger Benson and colleagues (2012) as a top predator in Antarctica . It had slender proportions . Cryolophosaurus was estimated as being 6 to 7 m (19 @.@ 7 to 23 @.@ 0 ft) in length by William R. Hammer & William J. Hickerson (1999) . A 2007 study by Nathan Smith et al. revised the length to 6 @.@ 5 m (21 @.@ 3 ft) . Its weight estimated at 465 kilograms (1 @,@ 025 lb) . Based on these length and weight estimates , Cryolophosaurus is currently the largest known Early Jurassic theropod . Smith et al . (2007b) and Benson et al . (2012) noted that the holotype individual probably represents a sub @-@ adult , so adults could have been larger .

= = = Skull = = =

The holotype of Cryolophosaurus consists of a high , narrow skull , which was discovered articulated with the rest of the skeleton . The skull is an estimated 65 centimetres (26 in) long . It has a peculiar nasal crest that runs just over the eyes , where it rises up perpendicular to the skull and fans out . It is thin and highly furrowed , giving it a Spanish comb @-@ like appearance . The crest is an extension of the skull bones , near the tear ducts , fused on either side to orbital horns

which rise from the eye sockets . While other theropods like the Monolophosaurus have crests , they usually run along the skull instead of across it .

An unpublished study conducted by Vernon Meidinger @-@ Chin in 2013 suggested that previous studies lacked focus on endocranial details . The study found that the Cryolophosaurus fossil has a nearly complete , undistorted cranial cavity which is complete enough to give an approximate shape and size of the living brain . The endocast features clarified the dissimilarity of the skull with those of Allosauroids and Coelurosaurs giving Cryolophosaurus a basal position in Theropoda .

= = Classification = =

Classification of Cryolophosaurus is difficult because it has a mix of primitive and advanced characteristics . The femur has traits of early theropods , while the skull resembles much later species of the clade Tetanurae , like China 's Sinraptor and Yangchuanosaurus . This led Paul Sereno et al . (1994) to place Cryolophosaurus in the taxon Allosauridae . Originally , Hammer and colleagues suspected that Cryolophosaurus might be a ceratosaur or even an early abelisaur , with some traits convergent with those of more advanced tetanurans , but ultimately concluded that it was itself the earliest known member of the tetanuran group . While a subsequent study by Hammer (along with Smith and Currie) again recovered Cryolophosaurus as a tetanuran , a later (2007) study by the same authors found that it was more closely related to Dilophosaurus and Dracovenator . Sterling Nesbitt et al . (2009) , using the characters of Tawa found Cryolophosaurus to be a neither dilophosaurid nor averostran neotheropod but instead the sister group of a clade composed of dilophosaurids and averostrans . However , in 2012 , Matthew Carrano found that Cryolophosaurus was a tetanuran , related to Sinosaurus , but unrelated to Dilophosaurus .

The following family tree illustrates a synthesis of the relationships of the early theropod groups compiled by Hendrickx et al. in 2015 .

= = Discovery and naming = =

Cryolophosaurus originally was collected during the 1990 ? 91 austral summer on Mount Kirkpatrick in the Beardmore Glacier region of the Transantarctic Mountains . The discovery was made by Hammer , a professor at Augustana College , and his team . The fossils were found in the siliceous siltstone of the Hanson Formation , formerly the upper Falla Formation , and dated to the Pliensbachian stage of the early Jurassic . Cryolophosaurus was the second dinosaur , and first theropod , to be discovered in Antarctica . It was discovered after Antarctopelta , but named earlier .

In 1991 , both Hammer and the Ohio State University geologist David Elliot excavated separate outcroppings near Beardmore Glacier , sharing logistical expenses . Elliot 's team first came across the remains of Cryolophosaurus in a rock formation around the altitude of 4 @,@ 000 m (13 @,@ 000 ft) high and about 640 km (400 mi) from the South Pole . When the discovery was made , they soon notified Hammer . Over the next three weeks , Hammer excavated 2 @,@ 300 kg (5 @,@ 100 lb) of fossil @-@ bearing rock . The team recovered over 100 fossil bones , including those of Cryolophosaurus . The specimens were formally named and described in 1994 by Hammer and Hickerson , in the journal Science .

During the 2003 season , a field team returned and collected more material from the original site . A second locality was discovered about 30 metres (98 ft) higher in the section on Mt . Kirkpatrick .

The name Cryolophosaurus ellioti is derived from the Greek words ????? (meaning ' cold ' or ' frozen ' , in reference to its discovery in Antarctica) , ????? (meaning ' crest ') and ????? (meaning ' lizard ') , thus " cold crest lizard " . Hammer and Hickerson named the species C. ellioti , after David Elliot , who had made the initial discovery of the fossils .

= = Paleobiology = =

= = Cranial ornamentation = =

Cranial display features , such as the one possessed by Cryolophosaurus , make sense in social , gregarious animals , where other members of the species are available to observe and interpret messages of sexual status . Kevin Padian et al . (2004) challenged conventional hypotheses that the purpose of bizarre cranial structures and post @-@ cranial armor in dinosaurs , was either for attracting mates , intimidating / fighting rivals in the group , or intimidating potential predators of other species . Padian et al. noted that based on phylogenetic , histological , and functional evidence these bizarre structures can be explained by the phenomenon of intra @-@ species recognition , which is supported by the fossil evidence . Thomas R. Holtz Jr . (2010) found that the bizarre crest of Cryolophosaurus was primarily for intra @-@ species recognition , based on evidence from related species and studies of bone texture . According to Thomas Rich and his colleagues , the crest would have been ineffective as a weapon and may have possibly functioned as a display feature during certain types of social behavior such as mating .

= = = Diet = = =

When the type specimen was discovered , several long cervical ribs , of a supposed prosauropod dinosaur were found in the mouth of Cryolophosaurus , which led Hammer (1998) to conclude that it was feeding on the prosauropod when it died . Hammer further noted that since the ribs were found extending all the way back to the theropod 's neck region , this individual may have choked to death on these ribs . However , Smith et al. concluded that these remains belonged to the Cryolophosaurus specimen itself , and not to Hammer 's " prosauropod " . Hammer also concluded that a post @-@ canine tooth belonging to a tritylodont (an early mammal relative) , found with the remains , was part of its stomach contents when it died .

= = = Paleopathology = = =

Some Cryolophosaurus bones have pathologies that show evidence of scavenging . Broken teeth from at least two different theropods have also been found nearby . Another possible pathology is found in the astragalus (ankle bone) of Cryolophosaurus . This bone was preserved with a small splint from the fibula located just above the ankle . The splint , however , may also be just a unique morphological feature of Cryolophosaurus .

= = Paleoecology = =

All known specimens of Cryolophosaurus have been recovered in the Hanson Formation , which is one of only two major dinosaur @-@ bearing rock formations found on the continent of Antarctica . It was discovered in " tuffaceous " siltstone deposited in the Sinemurian to Pliensbachian stage of the Early Jurassic , approximately 194 to 188 million years ago . This geological formation is part of the Victoria Group of the Transantarctic Mountains , which is approximately 4 @, @ 000 metres (13 @, @ 000 ft) above sea level . The high altitude of this site supports the idea that early Jurassic Antarctica had forests populated by a diverse range of species , at least along the coast . The Hanson Formation was deposited in an active volcano ? tectonic rift system formed during the breakup of Gondwana .

In the Early Jurassic , Antarctica was closer to the equator and the world was considerably warmer than today , but the climate was still cool temperate . Models of Jurassic air flow indicate that coastal areas probably never dropped much below freezing , although more extreme conditions existed inland . Cryolophosaurus was found about 650 kilometres (400 mi) from the South Pole but , at the time it lived , this was about 1 @, @ 000 km (621 mi) or so farther north . This formation has produced the remains of Glacialisaurus (a large basal sauropodomorph) , a crow @-@ sized pterosaur (a dimorphodontid) , a synapsid (a tritylodont , which is a type of synapsid about the size of a rat) , herbivorous synapsid , and another unknown theropod . In 2004 , paleontologists Judd Case and James Martin informally recovered the partial remains of a large sauropod dinosaur that

has not been formally described as of 2004 . There are also the remains of many plant genera recovered from the Early Jurassic Camp Hill Formation , around the same age as fossils of Cryolophosaurus , proving that dense plant matter had once grown on Antarctica 's surface before it drifted southward .