

Pachycephalosauria ("thick-headed reptiles")

The most obvious feature of pachycephalosaurs is

Pachycephalosaurs are bipedal herbivores. How does this group differ from other dinosaur groups?

How are they similar to other groups?

In your text, pachycephalosaurs are divided into two separate groups: Homalocephalids are known as "**flat-headed**," while the Pachycephalosaurids are "**dome-headed**." This is now outdated. What is the present thought on this?

Distribution

Pachycephalosaur evolution paralleled their ceratopsian cousins. They have been found in the Early Cretaceous of Europe and in the Late Cretaceous of North America, Mongolia and China.

What are the differences in how pachycephalosaur remains are found in Asia and America?

Asian members include *Prenocephale*, *Goyocephale* and *Tylophale*

American members include *Stegoceras*, *Gravitholus*, *Sphaerolitholus*, *Stygimoloch* and *Pachycephalosaur*

Representative Members

Pachycephalosaurus

The first description of *Pachycephalosaurus* was made in 1872 by

Pachycephalosaurus wyomingensis is one of the largest of the known pachycephalosaurs. It is known from one complete skull and a few other domes. The complete skull is 64 cm long, the thickest part measuring 22 cm. No postcranial material is known, so the total length of this animal must be estimated (about 3 m).

Certain parts of pachycephalosaurs, like the hands, have not yet been discovered. They are commonly reconstructed with 5 fingers, a reasonable number considering that the basal number of manual digits in Cerapoda is 5, and bipedal cerapodians typically have either 4 or 5.

Stegoceras

Stegoceras were bipedal Cretaceous dinosaurs (1.5-2 m long) that were bipedal and carried their heads dome-forward and nose down. They used their stiff tails as a counter balance.

What did their skull look like?

Beyond the head, the skeleton was similar to other bipedal ornithischians, having relatively short forelimbs, long four-toed hind limbs, a stiff vertebral column and a long tail.

Stegoceras lived in inland environments of western North America. It was a contemporary of hadrosaurs, ceratopsians and ankylosaurs along with the predatory tyrannosaurs of that time. Most *Stegoceras* remains consist of isolated domes.

Stygimoloch

Stygimoloch spinifer is the only pachycephalosaur that had spikes on its head. Some of these spikes were up to 13 cm long, and would have been covered in horn so that in life they would easily have measured up to 15 cm. The animal was approximately 3 m long with a narrow skull.

The first scientific report of *Stygimoloch* was made in 1896 by

In the summer of 1994, a remarkable specimen of *Stygimoloch* was discovered by Michael Triebold in northwestern South Dakota. The locality lies in the middle part of the Hell Creek Formation (Late Maastrichtian, Upper Cretaceous).

Why is the Hell Creek Formation so important?

Paleobiology and Paleoecology

Feeding

The herbivorous habits of these animals are evident not only by their dentition, but also by the impressive volume of their abdominal region.

What food processing equipment do they have in their head?

The wear on the teeth differs for every pachycephalosaur. What does this tell us?

To digest all the plant fibers, the pachycephalosaurs must have had a large fermentation vat in their guts.

What anatomical modifications can we see in the skeleton to support this theory?

Most Pachycephalosaurs had delicate hands that may have been less effective at food collection.

Speed and Gait

Pachycephalosaurs had forelimbs that were relatively short but they were extremely strong, as can be deduced from the robustness of the ulna and radius. What are their hindlimbs like?

What is an estimate of speed for pachycephalosaurs?

Brains

Pachycephalosaur neuroanatomy suggests that, despite having only an average-sized brain for their body size, these animals may have had a quite acute sense of smell.

Head Butting?

Pachycephalosaurs skulls could be more than 10 - 20 cm thick in a fully-grown animal. In 1951, Edwin H. Colbert (American Museum of Natural History) suggested that the function thickened skull roofs was as battering rams. In the 1970s, Peter Galton (U. of Bridgeport, Connecticut) suggested that they were employed in intraspecific competition citing anatomical evidence favoring this interpretation.

In 1978, Hans-Dieter Sues made the first functional morphologic study of the pachycephalosaur dome. He noted that the outside of the very thick dome is commonly quite smooth, although some specimens bear what look like scars on external surfaces.

How is the internal skull structure similar to a football helmet?

The most comprehensive treatment of pachycephalosaur sexual dimorphism was by Smithsonian paleontologist and morphometrician Ralph E. Chapman and several of his colleagues. They found heterogeneity in size and shape occurs in the sizes of domes

and braincases of *Stegoceras*. Two groups were recognized among the sample of sympatric *Stegoceras*. How did they distinguish between males and females?

These assignments to male or female came out to be about a one-to-one ratio.

What did this study say about pachycephalosaur behavior?

If you're going to support the head-butting theory, you should look for adaptations in the skeleton like the orientation of the head on the neck. Some of these adaptations are

Arguments Against Head-butting

Mark Goodwin, (UC Berkeley's Museum of Paleontology) and several colleagues proposed that that pachycephalosaurs did not butt heads. According to them, the skulls of pachycephalosaurs are not really suited for head-butting. The evidence they cite includes

There is no evidence of remodeled bone from any healed injuries on any of the skulls examined. Many feel that it was more likely that pachycephalosaurs would have engaged in flank butting or side pushing to settle confrontations.

Arguments For Side-butting

Sexual Selection

The establishment of dominance hierarchy gave some males preferred access to females. The females probably not only chose their mates, but by their very actions determined what preferred features or signals were. These same males must also have fended off competitors for access to females. To do so required some sort of threat display and/or offensive weaponry to establish dominance between greater and lesser males.

In general, this practice of female choice and its effect on establishing dominance hierarchies is called

In pachycephalosaurs, this emphasis was on the prominence of domes, knobs and spikes and teeth - structures that acted in ritual display and should the need have arisen, in actual, violent clashes. The winner, presumably the male with the best-fashioned dome got to perpetuate his family line.