Ceratopsids Wall in Past Worlds Gallery

Question: What is the logic behind the numbering of the ceratopsids?
Answer: There is somewhat of a reason at the large scale, but that's it. As you can see, the family tree of ceratopsid (horned) dinosaurs has two main branches - the Centrosaurinae and the Chasmosaurinae. The centrosaurines are numbers 1-7, and the chasmosaurines are 8-12. The early branches of frilled dinos that are outside of Ceratopsidae are 13-14. As far as within each branch, there is no reasoning. For example it doesn't matter that Nasutoceratops is 6 versus 7.

As such, we could place our newest Ceratopsid, Utahceratops, on the cladogram somewhere between #'s 12, 10, and 11.

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01 Einiosaurus procurvicornis
Einiosaurus is an exclusively Montanan dinosaur, and all its known remains are currently held at the Museum of the Rockies in Bozeman, Montana. At least fifteen individuals of varying ages are represented by three adult skulls and hundreds of other bones from two low-diversity (one species) bonebeds, which were discovered by Jack Horner in 1985 and excavated from 1985-1989 by Museum of the Rockies field crews. These bonebeds were originally thought to contain a new species of *Styracosaurus* and are referred to as such in the comprehensive taphonomic study by Ray Rogers from 1990. The same year Stephen Czerkas published the name *Styracosaurus makeli*, honouring Robert Makela, but without description so that it remained an invalid *nomen nudum*. In 1992 Horner discerned three species in the material from the bonebeds in this region, that he indicated as Type A, B and C. In 1995 Scott D. Sampson formally described and named Type B as the type species *Einiosaurus procurvicornis*; in the same article he named Type C as *Achelousaurus horneri*. The holotype of *Einiosaurus* is MOR 456.

In 2010 Paul renamed *E. procurvicornis* into *Centrosaurus procurvicornis*, but this has found no acceptance.

02 Pachyrhynosaurus lakustai
Pachyrhinosaurus canadensis, was described in 1950 by Charles Mortram Sternberg based on the holotype incomplete skull NMC 8867, and the paratype incomplete skull NMC 8866, which included the anterior part of the skull but was lacking the right lower mandible, and the "beak". These skulls were collected in 1945 and 1946 from the sandy clay of the Horseshoe Canyon Formation in Alberta, Canada. In the years to come, additional material would be recovered at the Scabby Butte locality of the St. Mary River Formation near Lethbridge, Alberta, from terrestrial sediments considered to be between 74 and 66 million years old. These were among the first dinosaur sites found in the province, in the 1880s. The significance of these discoveries was not understood until shortly after World War II when preliminary excavations were conducted.

Another *Pachyrhinosaurus* skull was taken out of the Scabby Butte locality in 1955, and then in 1957 Wann Langston Jr. and a small crew excavated additional pachyrhinosaur remains. The University of Calgary has plans to reopen this important site some day as a field school for university-level paleontology students. Several specimens, NMC 21863, NMC 21864, NMC 10669 assigned in 1975 by W. Langston, Jr. to *Pachyrhinosaurus* were also recovered at the Scabby Butte locality.

Another *Pachyrhinosaurus* bonebed, on the Wapiti River south of Beaverlodge in northwestern Alberta, was worked briefly by staff of the Royal Tyrrell Museum in the late 1980s but is now worked annually for a couple weeks each summer (since 2006) by the University of Alberta. Material from this site appears referable to *Pachyrhinosaurus canadensis*. In 1974, Grande Prairie, Alberta science teacher Al Lakusta found a large bonebed along Pipestone Creek in Alberta. When the area was finally excavated between 1986 and 1989 by staff and volunteers of the Royal Tyrrell Museum of Palaeontology, paleontologists discovered an amazingly large and dense selection of bones—up to 100 per square meter, with a total of 3500 bones and 14 skulls. This was apparently the site of a mass mortality, perhaps a failed attempt to cross a river during a flood. Found amongst the fossils were the skeletons of four distinct age groups ranging from juveniles to full grown dinosaurs, indicating that the *Pachyrhinosaurus* cared for their young. The adult skulls had both convex and concave bosses as well as unicorn-style horns on the parietal bone just behind their eyes. The concave boss types might be related to erosion only and not reflect male/female differences.

In 2008, a detailed monograph describing the skull of the Pipestone Creek pachyrhinosaur, and penned by Philip J. Currie, Wann Langston, Jr., and Darren Tanke, classified the specimen as a second species of *Pachyrhinosaurus*, named *P. lakustai* after its discoverer.

In 2013, Fiorillo et al. described a new specimen, an incomplete nasal bone attributable to *Pachyrhinosaurus perotorum* which was collected from the Kikak-Tegoseak Quarry in northern Alaska. This bone, designated DMNH 21460 belongs to an immature individual. This discovery expands the known age profile of this dinosaur genus from this particular site. The specimen has nasal ornamentation that is dorsally enlarged, representing an intermediate stage of growth. Of note, the authors pointed out that the posterior part of the nasal shows evidence for "a degree of integument complexity not previously recognized in other species" of *Pachyrhinosaurus*. It was determined that the dorsal surface of the nasal boss bore a thick, cornified pad and sheath.

03 Achelousaurus horneri

The genus and the one named species (*A. horneri*) were both named by paleontologist Scott Sampson in 1995. The specific name honors Jack Horner, an influential American paleontologist famous for his Montana Two Medicine Formation dinosaur discoveries, who in 1987 headed the team that excavated the holotype skull of *Achelousaurus*, MOR 485. The Holotype (MOR 485) is an almost complete skull.

04 Styracosaurus albertensis

The first fossil remains of *Styracosaurus* were collected in Alberta, Canada by C.M. Sternberg (from an area now known as Dinosaur Provincial Park, in a formation now called the Dinosaur Park Formation) and named by Lawrence Lambe in 1913. This quarry was revisited in 1935 by a Royal Ontario Museum crew who found the missing lower jaws and most of the skeleton. These fossils indicate that *S. albertensis* was around 5.5 to 5.8 meters in length and stood about 1.65 meters high at the hips. An unusual feature of this first skull is that the smallest frill spike on the left side is partially overlapped at its base by the next spike. It appears that the frill suffered a break at this point in life and was shortened by about 6 centimeters (2 in). The normal shape of this area is unknown because the corresponding area of the right side of the frill was not recovered

Barnum Brown and crew, working for the American Museum of Natural History in New York, collected a nearly complete articulated skeleton with a partial skull in 1915. These fossils were

also found in the Dinosaur Park Formation, near Steveville, Alberta. Brown and Erich Maren Schlaikjer compared the finds, and, though they allowed that both specimens were from the same general locality and geological formation, they considered the specimen sufficiently distinct from the holotype to warrant erecting a new species, and described the fossils as *Styracosaurus parksi*, named in honor of William Parks. Among the differences between the specimens cited by Brown and Schlaikjer were a cheekbone quite different from that of *S. albertensis*, and smaller tail vertebrae. *S. parksi* also had a more robust jaw, a shorter dentary, and the frill differed in shape from that of the type species. However, much of the skull consisted of plaster reconstruction, and the original 1937 paper did not illustrate the actual skull bones. It is now accepted as a specimen of *S. albertensis*.

In the summer of 2006, Darren Tanke of the Royal Tyrrell Museum of Palaeontology in Drumheller, Alberta relocated the long lost *S. parksi* site. Pieces of the skull, evidently abandoned by the 1915 crew, were found in the quarry. These were collected and it is hoped more pieces will be found, perhaps enough to warrant a redescription of the skull and test whether *S. albertensis* and *S. parksi* are the same. The Tyrrell Museum has also collected several partial *Styracosaurus* skulls. At least one confirmed bonebed (bonebed 42) in Dinosaur Provincial Park has also been explored (other proposed *Styracosaurus* bonebeds instead have fossils from a mix of animals, and nondiagnostic ceratopsian remains). Bonebed 42 is known to contain numerous pieces of skulls such as horncores, jaws and frill pieces.

A third species, *S. ovatus*, from the Two Medicine Formation of Montana, was described by Gilmore in 1930. The fossil material is limited, with the best being a portion of the parietal bone of the frill, but one unusual feature is that the pair of spikes closest to the midline converge towards the midline, rather than away from it as in *S. albertensis*. There also may only have been two sets of spikes on each side of the frill, instead of three. The spikes are much shorter than in *S. albertensis*, with the longest only 295 millimeters (11.6 in) long. A 2010 review of styracosaur skull remains by Ryan, Holmes, and Russell found it to be a distinct species, and in 2010 McDonald and Horner placed it in its own genus, *Rubeosaurus*.

Several other species which were assigned to *Styracosaurus* have since been assigned to other genera. *S. sphenocerus*, described by Edward Drinker Cope in 1890 as a species of *Monoclonius* and based on a nasal bone with a broken *Styracosaurus*-like straight nose horn, was attributed to *Styracosaurus* in 1915. "S. makeli", mentioned informally by amateur paleontologists Stephen and Sylvia Czerkas in 1990 in a caption to an illustration, is an early name for *Einiosaurus*. "S. borealis" is an early informal name for *S. parksi*.

05 Centrosaurus apertus

The first *Centrosaurus* remains were discovered by paleontologist Lawrence Lambe in strata along the Red Deer River in Alberta, Canada. Later, vast bonebeds of *Centrosaurus* were found in Dinosaur Provincial Park, also in Alberta. Some of these beds extend for hundreds of meters and contain thousands of individuals of all ages and all levels of completion. Scientists have speculated that the high density and number of individuals would be explained if they had perished while trying to cross a flooded river. A discovery of thousands of *Centrosaurus* fossils near the town of Hilda, Alberta, is believed to be the largest bed of dinosaur bones ever discovered. The area is now known as the Hilda mega-bonebed

The species *C. brinkmani*, which was described in 2005, was moved to the new genus *Coronosaurus* in 2012.

06 Nasutoceratops titusi

Nasutoceratops is known from the holotype UMNH VP 16800, a partially associated nearly complete skull, a coronoid process, a syncervical, three partial anterior dorsal vertebrae, a shoulder girdle, an associated left forelimb, parts of the right forelimb and skin impressions. Two specimens were referred: UMNH VP 19466, a disarticulated adult skull consisting of an incomplete premaxilla, maxilla and nasal, and UMNH VP 19469, an isolated squamosal of a subadult. The holotype was discovered and collected in 2006 during the Kaiparowits Basin Project, initiated by the University of Utah in 2000. It was recovered from channel sandstone from the middle unit of the upper Kaiparowits Formation within the Grand Staircase-Escalante National Monument, in sediment that dates to the late Campanian stage of the Cretaceous period, approximately 75 million years ago. It was first named and described in a thesis by its discoverer Eric Karl Lund in 2010 as *Nasutuceratops titusi*, remaining at first an invalid *nomen ex dissertatione*. Scott D. Sampson, Lund, Mark A. Loewen, Andrew A. Farke and Katherine E. Clayton validly named it in 2013, emending the generic name to *Nasutoceratops*. The type species is *Nasutoceratops titusi*. The generic name comes from *nasutus* in Latin meaning "large-nosed", and *ceratops*, "horned-face" in Greek. The specific name honors Alan L. Titus for recovering fossils of *Nasutoceratops* from the GSENM.

07 Diabloceratops eatoni

The only two specimens of *Diabloceratops eatoni* were recovered at the Wahweap Formation, in Kane County, Utah. Type specimen UMNH VP 16699 was collected by Don DeBlieux in 2002, at the Last Chance Creek locality of this formation, in intraclastic sandstone that was deposited during the Campanian stage of the Cretaceous period, approximately 81 to 76 million years ago. It consists of a partial skull with a piece of the lower jaw, with the right side being intact and part of the left side, which has been weathered. Another specimen UMNH VP 16704 was discovered years earlier in 1998 by Joshua A. Smith at the Nipple Butte locality of the same formation, but was not described until 2010, when it was assigned to *Diabloceratops*. These specimens are housed in the collection of the Natural History Museum of Utah.

08 Anchiceratops ornatus

The first remains of *Anchiceratops* were discovered along the Red Deer River in the Canadian province of Alberta in 1912 by an expedition led by Barnum Brown. The holotype, specimen **AMNH 5251**, is the back half of a skull, including the long frill, and two other partial skulls, specimens AMNH 5259 (the paratype) and AMNH 5273, were found at the same time, which are now stored in the American Museum of Natural History in New York City. A complete skull designated NMC 8535, was discovered by Charles M. Sternberg at Morrin in 1924, and was described as *A. longirostris* five years later, in 1929. but this species is widely considered a junior synonym of *A. ornatus* today. In total, at least ten incomplete skulls have been recovered. The skulls are different with respect to their proportions (e.g. size of the supraorbital horn cores, the dimensions of the frill) which had led researchers to conclude that the disparity is a result of interspecific differences or due to sexual dimorphism.

Another specimen, NMC 8547 (or CMN 8547) collected by Sternberg in 1925, lacks the skull but is otherwise the most complete skeleton known from any ceratopsid, preserving a complete spinal column down to the last tail vertebra. Sternberg's material is now housed in the Canadian

Museum of Nature in Ottawa. NMC 8547 is displayed as a half-mount with the better preserved right side showing, and completed with a cast skull replica of NMC 8535. Other material has been found since, including one or two possible bonebed deposits in Alberta, but very little *Anchiceratops* material has been described.

Most *Anchiceratops* fossils have been discovered in the Horseshoe Canyon Formation of Alberta, which belongs to the later part of the Campanian stage of the Late Cretaceous Period (*Anchiceratops* remains are known from the lower part of the formation, and range in age between 72.5-71 million years ago). Frill fragments found in the early Maastrichtian Almond Formation of Wyoming in the United States resemble *Anchiceratops*. However, brown horn fragments (specimens NMC 9590 and 10645) and frill pieces (specimina NMC 9813, 9814 and 9829) have been found from two localities in the older Oldman and Dinosaur Park Formations (late Campanian, 76.5-75 million years ago) with the characteristic pattern of points seen in *Anchiceratops* frills. These may represent early records of *A. ornatus* or possibly a second, related species. *Anchiceratops* remains were also recovered in terrestrial sediments from the St. Mary River Formation at the Scabby Butte locality in southwestern Alberta, however, the fossils cannot be referred to a specific species.

In 2012, Mallon concluded that many more *Anchiceratops* fossils had been collected than previously had been realised. These included the specimens TMP 1983.001.0001, a nearly complete skull of a juvenile; UW 2419, a nearly complete skull; ROM 802, a skull lacking the snout; FMNH P15003, the upper side of a skull lacking the snout; CMN 11838, a left skull frill; CMN 12-1915, frill fragments; and UALVP 1618, the rear edge of a frill. This larger number of fossils can be examined by statistical analysis to solve certain long-standing controversies about the genus.

09 Triceratops horridus

In 1888, John Bell Hatcher found the first Triceratops skull in Denver, Colorado. Paleontologist Othniel Marsh named Triceratops in 1889. At first, it was mistakenly identified as an extinct species of buffalo. Since then, about 50 Triceratops skulls and some partial skeletons have been found, mostly in western Canada and the western United States. There is some disagreement about how many species of Triceratops have been found. Some paleontologists (notably Ostrom and Welnhoffer, 1990) believe there is one species, Triceratops horridus. Others believe there are two (C. Forster, 1996) or more species, including Triceratops horridus, Triceratops prorsus, Triceratops albertensis, Triceratops ingens, Triceratops alticornis, and perhaps others.

10 Kosmoceratops richardsoni

Its fossils have been recovered from the Kaiparowits Formation in the Grand Staircase-Escalante National Monument. It was first named by Scott D. Sampson, Mark A. Loewen, Andrew A. Farke, Eric M. Roberts, Catherine A. Forster, Joshua A. Smith, and Alan L. Titus in 2010 along with the chasmosaurine genera *Utahceratops* (also from the monument) and *Vagaceratops* (from Alberta). The type species is *K. richardsoni*, named in honor of Scott Richardson, a volunteer who discovered the holotype specimen and many other fossils within the Grand Staircase-Escalante National Monument.

11 Coahuliaceratops magnacuerna

Sampson spearheaded paleontological expeditions to Coahuila in 2002 and 2003, securing funds from the University of Utah and National Geographic Society.

Coahuilaceratops comes from a rock unit known as the Cerro del Pueblo Formation, which dates to between 71.5 million and 72.5 million years ago. The skeletons, which de Leon discovered in 2001 near the town of Porvenir de Jalpa, approximately 40 miles west of Saltillo, were excavated in 2003. The fossils then were prepared at the Utah Museum of Natural History, requiring two years of meticulous work by skilled volunteer preparator Jerry Golden.

The study, partially funded by the National Geographic Society, was conducted by Mark Loewen, Scott Sampson, Eric Lund and Mike Getty, paleontologists at the Utah Museum of Natural History. Also involved were Andrew Farke of the Raymond M. Alf Museum in Claremont, Calif.; Martha Aguillón-Martínez, Claudio de Leon and Rubén Rodríguez-de la Rosa from the Museum of the Desert in Saltillo, Mexico; and David Eberth of the Royal Tyrrell Museum of Palaeontology in Alberta, Canada.

12 Chasmosaurus belli

In 1898, Lawrence Morris Lambe of the Geological Survey of Canada made at the Berry Creek the first discovery of *Chasmosaurus* remains, holotype **NMC 491**, a parietal bone that was part of a neck frill. Although recognizing that his find represented a new species, Lambe thought this could be placed in a previously-known short-frilled ceratopsian genus: *Monoclonius*. He erected the new species *Monoclonius belli* to describe his finding. The specific name honoured collector Walter Bell.

However, in 1913, Charles Hazelius Sternberg and his sons found several complete "M. belli" skulls in the middle Dinosaur Park Formation of Alberta, Canada. In January 1914, Lambe named all these finds as a separate genus: *Protorosaurus*, the name indicating an ancestry to *Torosaurus*. However, this name quickly was shown to be preoccupied by a Permian reptile, *Protorosaurus* Meyer 1836. Therefore Lambe created the replacement name *Chasmosaurus* in February 1914. It is derived from Greek χάσμα, *khasma*, "opening" or "divide" and refers to the very large parietal fenestrae in the skull frill. Lambe now also assigned a paratype, specimen NMC 2245 found by the Sternbergs in 1913 and consisting of a largely complete skeleton, including skin impressions.

Since that date, more remains, including skulls, have been found that have been referred to *Chasmosaurus*, and several additional species have been named within the genus.Today some of these are considered to only reflect a morphological variation among the known sample of *Chasmosaurus belli* skulls; others are seen as valid species of *Chasmosaurus* or as separate genera. In 1933 Barnum Brown named *Chasmosaurus kaiseni*, honouring Peter Kaisen and based on skull AMNH 5401, differing from *C. belli* in having very long brow horns. This form is perhaps related to *Chasmosaurus canadensis* ('from Canada') named by Thomas M. Lehman in 1990. The latter species, originally *Monoclonius canadensis* Lambe 1902, had been described as *Eoceratops canadensis* by Lambe in 1915. *Eoceratops* and the long-horned *Chasmosaurus kaiseni* are now provisionally thought to be exemplars of *Mojoceratops*. Richard Swann Lull in 1933 named an unusual, short-muzzled skull, specimen ROM 839 (earlier ROM 5436) collected in 1926, as *Chasmosaurus brevirostris*, "with a short snout". This has been seen as a junior synonym of *C. belli*. Charles Mortram Sternberg added *Chasmosaurus russelli* in 1940, based on specimen NMC 8800 from southwestern Alberta (lower Dinosaur Park Formation). The specific name honours Loris Shano Russell. Thomas Lehman described *Chasmosaurus mariscalensis* in 1989 from Texas, which has now been renamed *Agujaceratops*. The most recently described species is *Chasmosaurus irvinensis* named in 2001, which stems from the uppermost beds of the Dinosaur Park Formation. This species was given its own genus, *Vagaceratops*, in 2010.

In 1987, Gregory S. Paul renamed *Pentaceratops sternbergii* into *Chasmosaurus sternbergi*, but this has found no acceptance. In 2000, George Olshevsky renamed *Monoclonius recurvicornis* Cope 1889 into *Chasmosaurus recurvicornis* as its fossil material is likely chasmosaurine; this is a *nomen dubium*.

Today, only two species are seen as valid: *C. belli* and *C. russelli*. They show small differences in morphology and a difference in stratigraphy, as *C. russelli* is found in the older lower Dinosaur Park Formation and *C. belli* in the middle Dinosaur Park Formation of the Campanian, together spanning a time period of 76.5 to 75.5 million years ago. Apart from the holotype and paratype several additional specimens of *C. belli* are known. These include AMNH 5422, AMNH 5402, ROM 843 (earlier ROM 5499) and NHMUK R4948, all (partial) skeletons with skull; and YPM 2016, a skull. Apart from its holotype *C. russelli* is known from its paratype CMN 8803, a skull frill; CMN 41933, a rear skull frill; RTMP 81.19.175, the right side of a skull and CMN 2280, a partial skeleton with skull found by the Sternbergs in 1914.

13 Zuniceratops christopheri

Zuniceratops was discovered in 1996, by 8-year-old Christopher James Wolfe, son of paleontologist Douglas G. Wolfe, in the Moreno Hill Formation in west-central New Mexico. One skull and the bones from several individuals have been found. More recently, one bone, believed to be a squamosal, has since been found to be an ischium of a *Nothronychus*.

14 Protoceratops

Photographer J.B. Shackelford discovered the first specimen of *Protoceratops* in the Gobi desert, (Gansu, Inner Mongolia), as part of a 1922 American expedition looking for human ancestors. No early human fossils were found, but the expedition, led by Roy Chapman Andrews, collected many specimens of the *Protoceratops* genus, along with fossil skeletons of theropods *Velociraptor*, *Oviraptor*, and ceratopsid *Psittacosaurus*.

Walter Granger and W.K. Gregory formally described the type species, *P. andrewsi* in 1923, the specific name in honor of Andrews. The fossils hail from the Djadochta Formation and date from the Campanian stage of the Upper Cretaceous (dating to between 75 and 71 million years ago). Researchers immediately noted the importance of the *Protoceratops* finds, and the genus was hailed as the "long-sought ancestor of *Triceratops*". The fossils were in an excellent state of preservation, with even the sclerotic rings (delicate occular bones) preserved in some specimens.

In 1971, a fossil was found that captured a *Velociraptor mongoliensis* clutched around a *Protoceratops andrewsi* in Mongolia. It is believed that they died simultaneously, while fighting, when they were either surprised by a sand storm or buried when a sand dune collapsed on top of them.

In 1975, Polish paleontologists Teresa Maryanska and Halszka Osmólska described a second species of *Protoceratops*, also from the Campanian stage of Mongolia, which they named *P. kozlowskii*. However, the fossils consisted of incomplete juvenile remains, and are now considered synonymous with *Bagaceratops rozhdestvenskyi*.

In 2001, a second valid species, *P. hellenikorhinus*, was named from the Bayan Mandahu Formation in Inner Mongolia, China and also dates from the Campanian stage of the Upper Cretaceous. It was notably larger than *P. andrewsi*, had a slightly different frill, and had more robust jugal horns. The arch of bone over its nostrils had two small nasal horns, and there were

no teeth at the front of the snout.

In 2011, a specimen of *Protoceratops* first uncovered in 1965 was found to be preserved with its own footprint. It is the first example of a dinosaur to be preserved with footprints.