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A long, long time ago, magnificent creatures roamed the Earth. Although these creatures may have varied greatly in size, shape, color, or dietary needs, the one thing that these creatures all had in common was a specific clade: Dinosauria. A part of this clade was one dinosaur in particular, Triceratops horridus, which is Greek for "three-horn face". They received this name because of the three horns protruding from their face: two long ones above their eyes and a shorter one from their nose. Fossil evidence shows that Triceratops horridus lived during the Late Cretaceous period and was one of the last dinosaurs to exist before the Cretaceous-Tertiary extinction occurring approximately 65 million years ago.[1] Although these dinosaurs have long since been extinct, they have certainly left their mark on Evolution. Their presence in fossils can tell us about the organisms themselves, what the environment was like during the time they lived, and can help us understand what led to their extinction in the first place.

Fossils

Fossils, or the buried remains of once living organisms, are one of the greatest tools to help us increase our knowledge of the past and the organisms it contained.[2] Without fossils, we would not be able to surmise what kind of organisms once lived, what weather patterns have occurred over time, how the continents have shifted, how traits evolved, and what kind of divergence has occurred in phylogeny. Likewise, the fossils of Triceratops horridus are invaluable because of the library of information each one contains. However, it can be difficult to discover fossils due to a variety of reasons. Predators can prey on a dead body, taking body parts away from the original location and moving them elsewhere, remains can be broken by other animals, and weathering can take place).[3] Because bone is made out of calcium-sodium hydroxyl apatite, which is more susceptible to weathering, it usually loses the calcium-sodium hydroxyl apatite after fossilization and fills up with other minerals.[4] There are also many other types of dinosaur fossils that are not bones. For example, scientists have dug up fossilized feces, called coprolites, which tell them about the diet of dinosaurs; they have also found fossilized eggs, skin impressions, and footprints in sedimentary rock.[5]

Not only is it hard for an organism's remains to become fossils, it is a challenge for paleontologists to recover those fossils. Successful extraction revolves around four steps: planning, prospecting, collecting, and preparation/curating.[6] Planning involves putting together and expedition team and figuring out where to look based on scientific calculations. The expedition teams consist of scientists with varying specialties who not only have been studying the field for many years, but who have also had years of experience. [7] It is important to have professionals perform the excavation, especially for dinosaurs, because the fossils are limited and any damage done during the process can destroy any hope of having access to the same information again. The planning side to paleontology focuses on a few questions to help determine where a fossil could be located. What was the dinosaur's environment? When did it live? What caused its death? Scientists then work to find rocks that match the location and the time period.[8] After planning comes prospecting, or searching for the fossils. Once fossils

[1] National Geographic, "Triceratops Horridus." Accessed December 4, 2012.

[2] David Fastovsky and David B. Weishampel. Dinosaurs: A Concise Natural History. New York: Cambridge University Press. 2009.

[3] Ibid.

[4] Ibid.

[5] Ibid.

[6] Ibid.

[7] Ibid.

[8] Ibid.

have been located, the collecting stage begins. This is always a delicate process and takes time to do it properly. One of the challenges in prospecting comes in transporting the fossils to a place where they can be studied safely. The fossil and its matrix, or the rock encasing the fossil, has the potential to be large in size and can weigh hundreds of pounds.[9] Once a fossil has finally been removed from the rock, it is taken to be studied in a lab. It undergoes many processes to remove it from its matrix and prepare it for study or show. Even though the entire process is time consuming and tedious, it is one that leads to better understanding of an extinct species.[10] Up to this point, paleontologists have found skulls, complete skeletons, and partial skeletons of the Triceratops horridus.

Meet the Triceratops Horridus

The Triceratops horridus was an intimidating dinosaur that was very distinctive from the other members of its clade. Fossils have been excavated that indicated the Triceratops was about thirty feet long, ten feet tall, and weighed approximately four to six tons. It is easily recognized by its unique anatomy. Its most distinguishing features are its three facial horns and its bony frill, which measured approximately six feet across and sits just behind the face. There are many theories surrounding the purpose of the frill. Some scientists believe it was meant to protect the neck from attacking predators, for attracting mates, or for regulating body temperature.[11]

Even though the frill was a distinguishing trait of Triceratops, it was not the trait that gave the genus its name. The genus was so named because of their three facial horns. After a juvenile Triceratops skull was excavated, scientists began to question how the horn growing out of the nose came to be. Based on the stage of growth the juvenile was in, scientists determined that the horn was a separate bone that, over time, fused to the skull where it continued its growth.[12] After excavating more juvenile skulls, scientists were able to determine how the small nubs above each eye developed into the larger horns seen in the adult form. The small projections in baby skulls point forward, backwards and curved up in juveniles, and forward with an upward curve at the end in adults. This evidence suggests that the horns grow from their bases.[13] Perkins says that because about one third of the adult horn was hollow in its base, it was unlikely that the horns were used for combat.[14] If Triceratops had used them for fighting predators or each other, they would have suffered damage easily. It is more likely that the horns were used for species recognition or for sexual displays.[15]

Cretaceous Climate

What was it like for these dinosaurs to live during the Cretaceous time period? During the first half of the time period, the temperatures were warm and there was not much seasonality. There were mountain formations, sea-floor spreading, high sea levels, and broad seas. In the late Cretaceous period, the continents appeared similar to how they look now, except North America was extremely isolated.[16] This could be the reasoning as to why Triceratops was confined to North America: they were terrestrial dinosaurs and could not cross the sea to reach any other land mass.

The Cretaceous time period was the time when the beginnings of our modern organisms appeared. Scientists found the first fossils of "many insect groups, modern mammal and bird groups, and the first flowering plants," [17]

[9] David Fastovsky and David B. Weishampel. Dinosaurs: A Concise Natural History. New York: Cambridge University Press. 2009.

[10] Ibid.

[11] National Geographic, "Triceratops Horridus."

[12] Sid Perkins. "How did Triceratops grow its horns?" In Science News, vol. 160. 2001.

[13] Ibid.

[14] Ibid.

[15] Ibid.

[16] Fastovsky and Weishampel. Dinosaurs: A Concise Natural History.

[17] University of California Museum of Paleontology, "The Cretaceous Period." Last modified June 15, 2011.

Flowering plants, or Angiosperms, appeared in the fossil record approximately 125 million years ago. They thrived in many different environments such as arid, damp, and at high altitudes. Conifers, cycads, and other gymnosperms, went through the Cretaceous period unchanged, but by the middle, species diversification took off.[18] By the end of the Cretaceous period, the forests began to look similar to the forests we have today in North America. They contained oaks, hickories, and magnolias.[19]

The Extinction of Triceratops Horridus

Did these environmental changes cause extinction? Some scientists speculate that it could have been the driving force. According to National Geographic, "the shifted continents, expanded coasts, and widened oceans had cooled and moistened the planet's climate and set in motion dramatic changes to the flora and fauna,".[20] Organisms may not have been able to respond and adapt to the quickly changing environmental conditions, which could have caused a mass extinction.

There are many extinction theories that were dismissed due to insufficient evidence or timing issues. There was theory that a volcano eruption could have caused their extinction. This extinction theory was dismissed because the timing of the eruptions occurred approximately 400,000 years too soon. Researches actually came to the conclusion that the eruptions warmed the Earth, making life easier for many animals, not harder.[21] A more prominent theory revolves around the idea that an asteroid is the culprit behind the extinction of the dinosaurs. Even though this theory is still subject to revision, after years of discussion, it has been decided that a massive asteroid is the cause of the mass extinction. The asteroid that killed the dinosaurs created the Chicxulub Crater found on Mexico's Gulf Coast.[22] Some scientists suggest that there were multiple asteroids, but there is a lack in supporting evidence. They are basing their theory on the discovery of several sites near Chicxulub that looked as if there had been various impacts, but it is likely the asteroid mixed up the layers of sediment and spread it across locations around the crash site.

The Chicxulub theory has been upheld because there is ample evidence to support it. Iridium—an element found in extraterrestrial material—was located at three hundred and fifty sites around the world. These traces of Iridium could be traced back to the Chicxulub location. In fact, in some areas of the crater, the layer was eighty meters thick which points to a single impact.[23] Scientists have discovered that the asteroid was approximately ten kilometers wide, causing the crater to be one hundred kilometers wide and twenty-five to thirty kilometers deep. An impact by an object so large would have caused earthquakes, tsunamis and landslides, all of which are enough to cause extinction.[24] In addition, the crash would have been the cause of acid rain in darkness—both of which would be devastating to plant life in particular because they rely on water and sun for photosynthesis. If the plants were wiped out, the entire food chain would be altered, first by herbivores then by carnivores.[25]

Triceratops Horridus Today

Although it has been centuries, even millennia, since Triceratops Horridus have roamed the earth, their existence has not been erased or forgotten. During the 1880s, a fossil of the great creature was found in Wyoming by John

[18] University of California Museum of Paleontology, "The Cretaceous Period." Last modified June 15, 2011.

[19] Ibid.

[20] National Geographic, "Cretaceous Period." Accessed December 2, 2012.

[21] Katherine Harmon. Scientific American , "A Theory Set in Stone: An Asteroid Killed the Dinosaurs, After All." Last modified March 4, 2010.

[22] Ibid.

[23] Ibid.

[24] Ibid.

[25] Ibid.

Bell Hatcher.[26] Currently, it resides in the Smithsonian National Museum of National History. The first exhibit of the Triceratops opened in 1905 and was comprised of bones from about twenty different dinosaurs.[27]As discussed earlier, the fossils of the Triceratops are extremely fragile. It is easy for cracks to develop, and some bones are infected with pyrite disease, which causes them to break from the inside out.[28] The scientists at the Smithsonian are taking careful precautions to keep the bones well preserved. Originally, curators used glues and other chemicals to attempt preservation, but over time and after human interaction, these materials began to deteriorate and even caused internal damage to the bones.[29] Today, the skeletal mount on display in the museum is not even the real fossil. Nowadays, it is common to make moldings and castings of the real bones and put those on display instead of the original fossil. This is a process known as stereolithography. With the help of advanced technology, the Smithsonian was able to use "data from the original bones that [they] have manipulated in the computer to produce far more accurate replacements,".[30] The bones were three-dimensional laser scanned, sent to a three-dimensional prototyping machine, and then cast in fiberglass and plaster.[31] For appearances sake, the castings are drilled so that internal framework can be used to lend support.[32]

According to the Smithsonian's website, the bones that have been computer generated are the skull, the left humerus, the left shoulder blade, and part of the left hip bone.[33] Some people may think that an exhibit without the original fossils would not be as exciting as one with plaster representations. However, according to Perkins, Ralph Chapman, a Smithsonian paleontologist, believes that although the plaster bones are "less-real", they are able to portray a more accurate representation of how the Triceratops appeared while they were alive.[34] These preservation techniques allow for museum goers to enjoy the sight of the Triceratops without harming its last remains so that scientists can continue studying the fossils, possibly making more discoveries in the future.

[26] Smithsonian National Museum of Natural History, "Triceratops." Last modified May 2001.

[27] Sid Perkins. "A Makeover for an Old Friend". In Science News, 300-302. 2000.

[28] Smithsonian, "Triceratops".

[29] Perkins, "A Makeover for an Old Friend".

[30] Smithsonian, "Triceratops."

[31] Ibid.

[32] Perkins, "A Makeover for an Old Friend."

[33] Smithsonian, "Triceratops."

[34] Perkins, "A Makeover for an Old Friend."

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