Transitional species of duckbilled dinosaurs illuminate relationship between evolution and growth

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An emergent field of research in dinosaur paleobiology investigates the relative importance of linear, non-branching evolution (anagenesis) compared with branching evolution (cladogenesis). Increasingly, paleontologists are discovering that many dinosaur species are arranged into anagenetic lineages of rapidly evolving "transitional" species which do not overlap in time. These transitional species usually differ only slightly from their forebears, typically in the shape and size of display structures such as horns or crests.

At the SVP 2015 annual meeting, Dr Elizabeth Freedman Fowler of the Museum of the Rockies, and Great Plains Dinosaur Museum, Montana, presented on two new transitional species of duckbilled (*hadrosaurid*) dinosaurs from the Upper Cretaceous Judith River Formation of northern Montana.

"This particular part of the Judith River Formation is important because it yields a dinosaur fauna that is intermediate in age between an older fauna from the Two Medicine Formation of western Montana, and a younger fauna from the famous Oldman and Dinosaur Park Formations of Alberta". Dr Freedman Fowler continued, "because the formation is intermediate in age, then it is exactly where we might expect to find new, intermediate kinds of dinosaur".

The first new dinosaur described by Dr. Freedman Fowler is a

transitional form of *Brachylophosaurus*, a large hadrosaurid with a broad paddle shaped crest over the back of its head. The second, a transitional *Gryposaurus hadrosaurid*, has an arched nasal crest on its snout, and is known from a bonebed of at least 10 individuals, ranging from juvenile to adult.

"The *Gryposaurus* bonebed is a fantastic site because the different growth stages show us that as *Gryposaurus* grew, the arch on its nose gets larger and moves backward, so that the nose of a one year old looks very different from the nose of a three year old", Dr. Freedman Fowler explained, "the most interesting thing is that we see the same morphological trend through time as *Gryposaurus* evolves. The preceding species from the Two Medicine Formation has a low crest over the middle of the nose, whereas in the succeeding species the crest is taller and more retracted towards the eyes"

This suggests that successive generations of *Gryposaurus* grew larger crests by changing the timing or pace of crest development during growth. Fragmentary juveniles of the transitional *Brachylophosaurus* species suggest that this same process is also occurring in that lineage. Changing of timing or rate of development is called heterochrony, a process which is being increasingly recognized as a major driving force in evolution.

"Heterochrony is key to understanding how evolution actually occurs in these dinosaurs, but to study heterochrony we need large collections of dinosaurs with multiple growth stages, and a really precise time framework for the rock formations that we collect them from" said Dr. Freedman Fowler.

This kind of research has only really become possible with recent technical advances in the radiometric dating of rocks, coupled with increased intensity of fossil collecting in North America.

"The Late Cretaceous of western North America is the only place in the world where we can do these kinds of intense paleobiological studies on dinosaurs. Nowhere else combines the precise dating of rocks coupled with an exceptional fossil record that has been so extensively collected."

Dr. Freedman Fowler predicts that many more transitional species remain to be discovered; "We've been collecting dinosaurs in this region for over a century, yet there are still exciting discoveries being made every year".

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