



AMERICAN MUSEUM OF NATURAL HISTORY

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DUCK-BILL DINOSAURS HAD PLANT-PULVERIZING TEETH MORE ADVANCED THAN HORSES

NEW BIOMECHANICAL STUDY IS FIRST TO REVEAL MATERIAL PROPERTIES FROM FOSSILIZED TEETH

A team of paleontologists and engineers has found that duck-billed dinosaurs had an amazing capacity to chew tough and abrasive plants with grinding teeth more complex than those of cows, horses, and other well-known modern grazers. Their study, which is published today in the journal *Science*, is the first to recover material properties from fossilized teeth.

Duck-bill dinosaurs, also known as hadrosaurids, were the dominant plant-eaters in what are now Europe, North America, and Asia during the Late Cretaceous about 85 million years ago. With broad jaws bearing as many as 1,400 teeth, hadrosaurids were previously thought to have chewing surfaces similar to other reptiles, which have teeth comprised of just two tissues – enamel, a hard hypermineralized material, and orthodontine, a soft bonelike tissue. But paleontologists who study the fossilized teeth of these animals in detail suspected that they were not that simple.

“We thought for a long time that there was more going on because you could just look at the surface of the tooth and see advanced topography, which suggests that there are many different tissues present,” said Mark Norell, chair of the American Museum of Natural History’s Division of Paleontology and an author on the paper.

To investigate the dinosaurs’ dental structure and properties in depth, Norell worked with lead author Gregory Erickson, a biology professor at Florida State University, and a team of engineers on a series of novel experiments. Erickson sectioned the fossilized teeth and made microscope slides from them. These revealed that hadrosaurids actually had six different types of dental tissues – four more than reptiles and two more than expert mammal grinders like horses, cows, and elephants. Using a technique called nanoindentation, in which a diamond-tipped probe is

indented and/or drawn across the fossilized teeth to mimic the grinding of abrasive food, the researchers determined the differential hardness and wear rates of the dental tissues.

Erickson, who describes hadrosaurid dinosaurs as “walking pulp mills,” said, “We were stunned to find that the mechanical properties of the teeth were preserved after 70 million years of fossilization.” He went on to comment that “if you put these teeth back into a living dinosaur they would function perfectly.”

In addition to the four dental tissues found in mammals—enamel, orthodentine, secondary dentine that helps prevent cavities, and coronal cementum that supports the teeth’s crests—the hadrosaurid teeth include giant tubules and a thick mantle dentine. These extra tissues are thought to provide additional prevention against abscesses. Also unlike mammalian teeth, the dental tissue distribution in hadrosaurids greatly varied in each tooth. Together, these characteristics suggest that hadrosaurids evolved the most advanced grinding capacity known in vertebrate animals, which might have led to their extensive diversification.

“Duck-bills’ advanced tissue modification appears to have allowed them to radiate into specialized ecological niches where they ate extremely tough plants like fern, horsetail, and ground cover that were not as easy for dinosaurs with shearing teeth to eat,” Norell said. “Their complex dentition could have played a major role in keeping them on the planet for nearly 35 million years.”

In addition, the findings provide strong evidence that dental wear properties are preserved in fossil teeth—an idea that was once questioned and overruled in this study with comparative tests on teeth from modern and fossilized horses and bison. This opens the door for studies on the dental biomechanics of fossils from wide-ranging groups of animals to better understand evolutionary modifications in diets.

This research was supported by the National Science Foundation, grant EAR 0959029. Other authors include Brandon A. Krick, Matthew Hamilton, and W. Gregory Sawyer of the University of Florida; Gerald R. Bourne of the Colorado School of Mines; and Erica Lilleodden of the Institute of Materials Research, Materials Mechanics, Helmholtz-Zentrum Geesthacht in Germany.

Research paper: G. M. Erickson, B. A. Krick, M. Hamilton, G. R. Bourne, M. A. Norell, E. Lilleodden, W. G. Sawyer, “Complex Dental Structure and Wear Biomechanics in Hadrosaurid Dinosaurs,” *Science* (2012).

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The American Museum of Natural History, founded in 1869, is one of the world's preeminent scientific, educational, and cultural institutions. The Museum encompasses 46 permanent exhibition halls, including the Rose Center for Earth and Space and the Hayden Planetarium, as well as galleries for temporary exhibitions. Five active research divisions and three cross-disciplinary centers support 200 scientists, whose work draws on a world-class permanent collection of more than 32 million specimens and artifacts, including specialized collections for frozen tissue and genomic and astrophysical data, as well as one of the largest natural history libraries in the Western Hemisphere. Through its Richard Gilder Graduate School, it is the only American museum authorized to grant the Ph.D. degree. In 2012, the Museum began offering a pilot Master of Arts in Teaching with a specialization in earth science. Approximately 5 million visitors from around the world came to the Museum last year, and its exhibitions and Space Shows can be seen in venues on five continents. The Museum's website and collection of apps for mobile devices extend its collections, exhibitions, and educational programs to millions more beyond its walls. Visit amnh.org for more information.

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