Researchers discover surprising connection between prehistoric dinosaurs and mammals in their teeth

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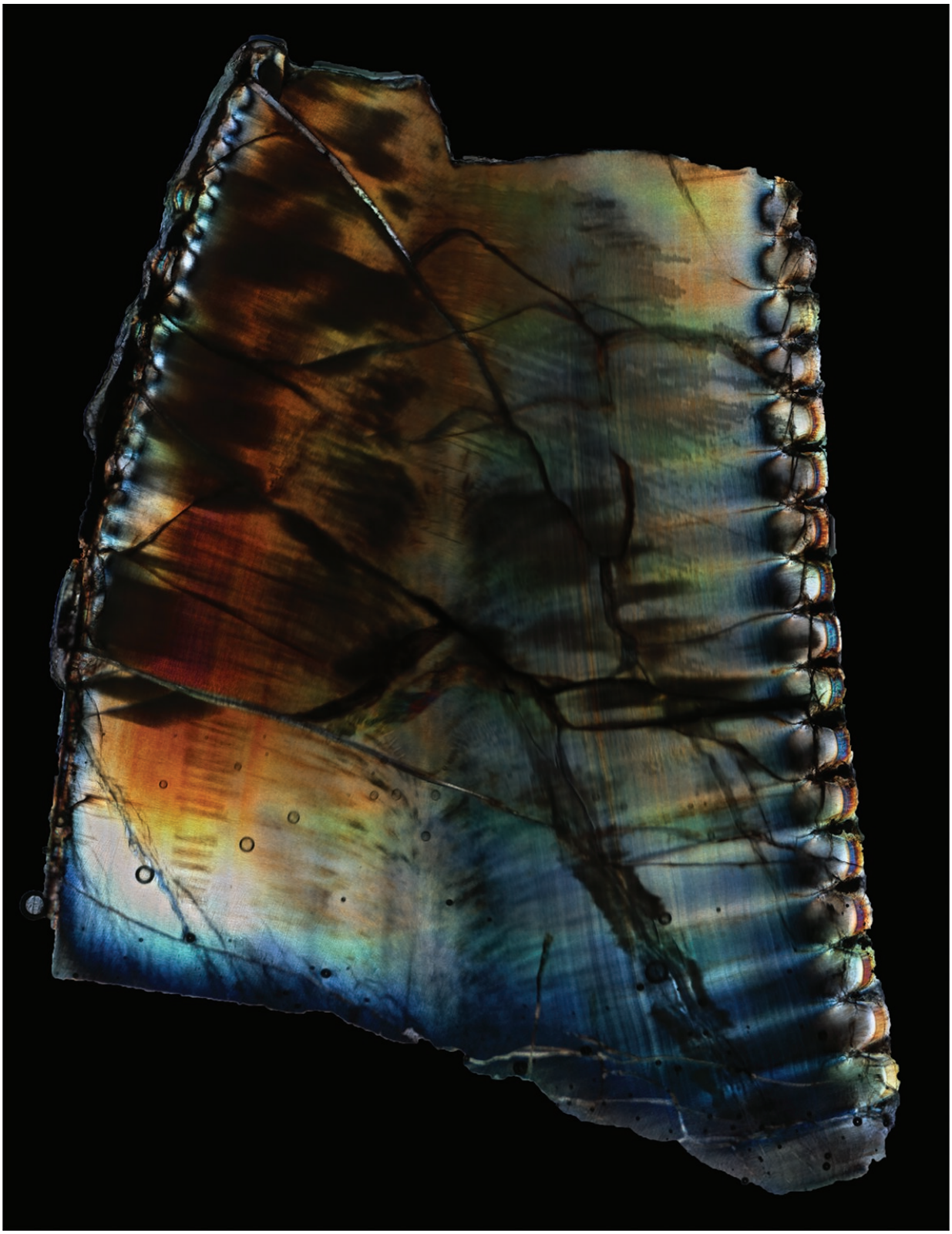


Thin section of a partial gorgonopsian canine under polarized light. Serrations

are evident on the right side of this specimen. Credit: Megan Whitney

When most people think of ferocious, blade-like teeth on prehistoric creatures they picture *Smilodon*, better known as the saber-toothed tiger. But in the world of dinosaurs, theropods are well known for having blade-like teeth with serrated cutting edges used for biting and ripping their prey. And until recently, the complex arrangement of tissues that gave rise to these terrifying teeth was considered unique to these meat-eating dinosaurs.

In a paper published December 16 in *Biology Letters*, lead author Megan Whitney, postdoctoral fellow in the Department of Organismic and Evolutionary Biology, Harvard University, examined thin fossil slices of gorgonopsian's teeth and discovered similar complex arrangement of tissues that made the steak-knife-like serrations in theropods.

Gorgonopsians are a group of synapsids from the middle-late Permian 270-252 million years ago. These animals, like other synapsids, are considered to be the forerunners of mammals and fall within the lineage that eventually gave rise to mammals. "These animals were the apex predators of their day and are characterized by their sabre-like canine that could extend up to 13 cm long," said Whitney.

Previous studies of theropod dinosaurs uncovered a complex arrangement of tissues made of both enamel and dentine that formed the serrations on their teeth. This complex arrangement was considered unique to theropod dinosaurs. But no one had ever made a thin section of a gorgonopsian tooth before to examine the serrations.


1 cm

A complete sabre-toothed canine from a gorgonopsian from Zambia. This specimen includes both the crown (top) and root (bottom) of the tooth. Credit: Megan Whitney

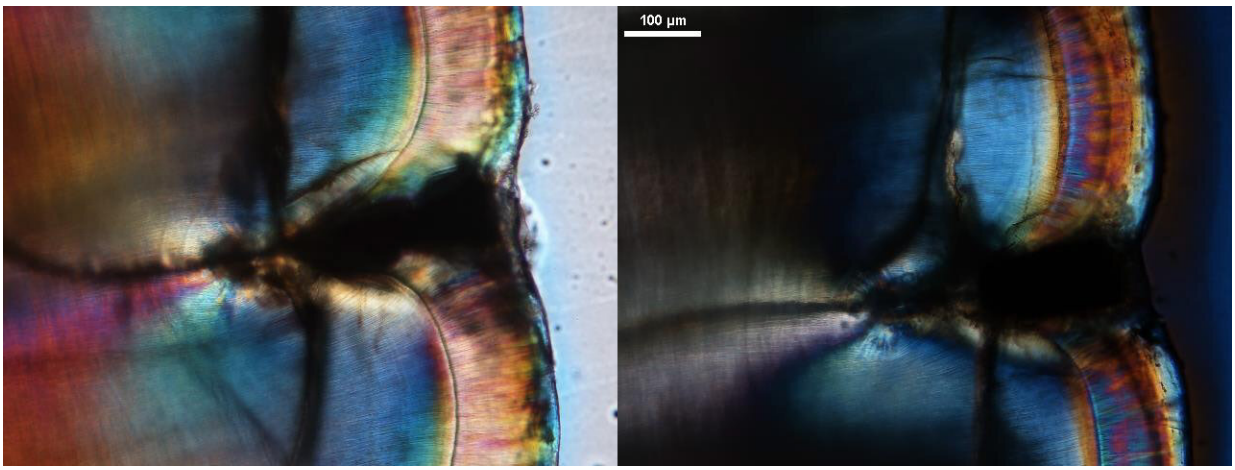
Inspired, Whitney and co-authors combined their expertise in paleohistology (the study of the microstructure of fossilized skeletal tissues) and examined thin sections of fossils from three synapsids from three different time periods to test a theory of the structure of the serrations in this group. "We were surprised to find theropod-like serrations in gorgonopsians," said Whitney. "We wanted to see how other carnivorous synapsids had made their serrations, so we looked at an older synapsid [*Dimetrodon*] and a younger, mammalian synapsid [*Smilodon*]."

Gorgonopsian, *Dimetrodon*, and *Smilodon* are all synapsids and like theropods were apex predators of their day and had serrated, knife-like teeth (i.e. ziphodonty). *Dimetrodon* is one of the earliest synapsids during the Cisuralian period around 295 to 272 million years ago; *Dimetrodon* is often mistakenly described as a dinosaur. *Smilodon* lived in the Americas during the Pleistocene epoch 250 million years ago to 10,000 years ago. "All of these animals fall along the mammal-line which is divergent from the reptile line with dinosaurs," said Whitney. "In fact, these three animals are more closely related to humans than to dinosaurs."

Whitney's Ph.D. focused on the teeth of gorgonopsians and other forerunners of mammals so she examined the gorgonopsian specimens that were collected from ongoing, extensive fieldwork in Zambia where many of these animals are found. Co-authors Aaron LeBlanc, postdoctoral fellow in the Department of Biological Sciences, University

of Alberta, Ashley Reynolds, Ph.D. candidate in the Department of Ecology and Evolutionary Biology, University of Toronto, and Kirsten Brink, assistant professor in the Department of Geological Sciences, University of Manitoba, contributed expertise in dental histology and the animals included in this study.

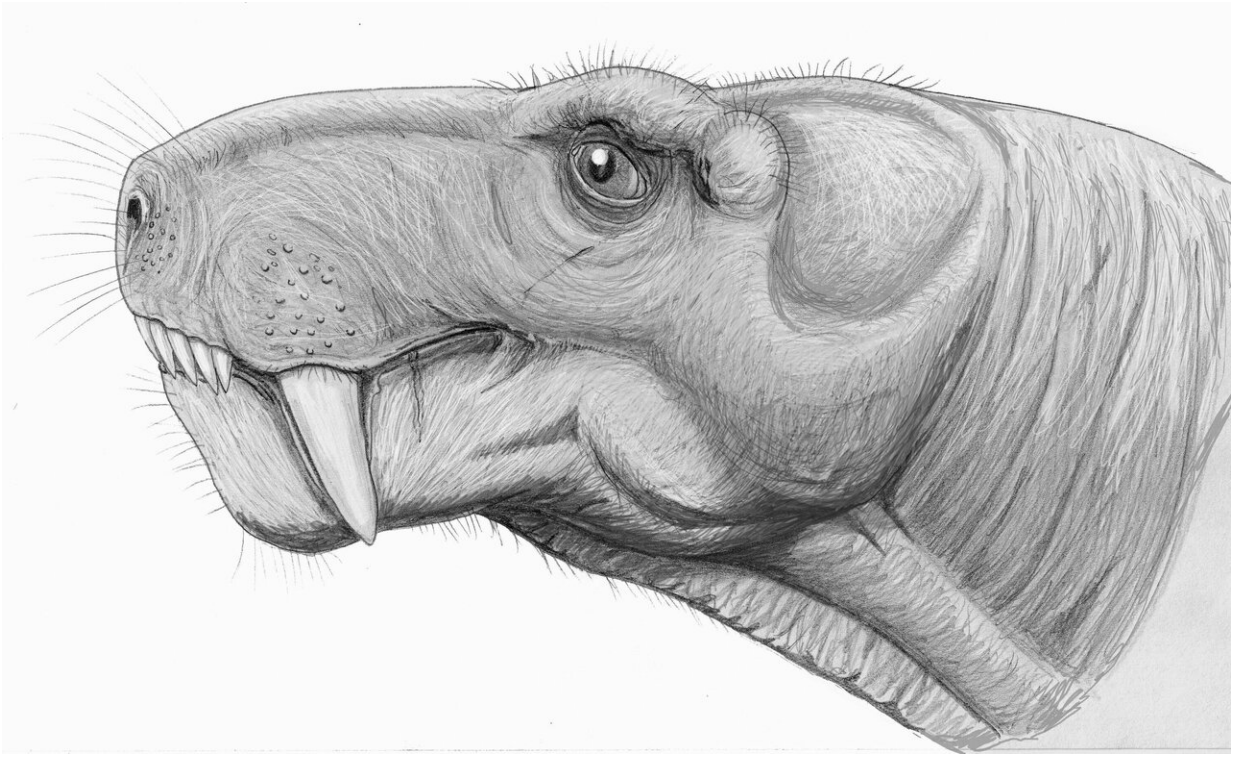
The thin sections revealed that the gorgonopsian serrations are composed of tightly-packed serrations made of both enamel and dentine, the same complex arrangement of tissues that had previously been attributed to theropod dinosaurs and considered unique to them. "What's surprising is that the type of serrations in gorgonopsians are more like those of the meat-eating dinosaurs from the Mesozoic era," said LeBlanc. "It means that this unique type of cutting tooth evolved first in the lineage leading to mammals, only to later evolve independently in dinosaurs."



Both are magnified images of the serrations under polarized light. Gorgonopsian serrations are made from both enamel (thinner, lighter tissue to the right) and dentine (thicker tissue to the left) and an interdental fold (black central structure that is a fold in between the serrations). This particular arrangement allows for more serrations to be tightly packed along the tooth and makes each serration more resistant to wear. Credit: Megan Whitney

"The fact that we only see this type of serration evolve in meat-eating animals is significant," said Brink. "The tiny microstructures hidden inside the teeth offer a significant advantage to the tooth, strengthening the serrations and helping them last longer in the mouth, which in turn helps the animal eat efficiently."

Though gorgonopsians share this trait with theropod dinosaurs, they actually share more characteristics with other synapsids like *Dimetrodon* and humans. "These animals converged on a similar tooth serration morphology because of the functional benefits, not because they're close relatives to one another," said Whitney. "In this case, it probably has something to do with the fact that animals were really putting a lot of wear and tear on their teeth. And so independently they've been able to form a serration that is going to withstand the repeated forces needed to eat because eating is important. So, there's a lot of selection acting on teeth."



Gorgonopsian were the first saber-toothed animals. Their canines extended up to 13 centimeters. Credit: CCA 3.0/Dmitry Dogdanov

Gorgonopsians were a diverse group with body sizes that ranged from the size of a medium-sized dog to a bear and Whitney notes that although the specimens sampled had this type of morphology, it remains possible that there is a diversity of serration types that would match the diversity of gorgonopsians.

More information: Convergent dental adaptations in the serrations of hypercarnivorous synapsids and dinosaurs, *Biology Letters*, royalsocietypublishing.org/doi … .1098/rsbl.2020.0750

Provided by Harvard University

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