Primitive fish fossils reveal developmental origins of teeth

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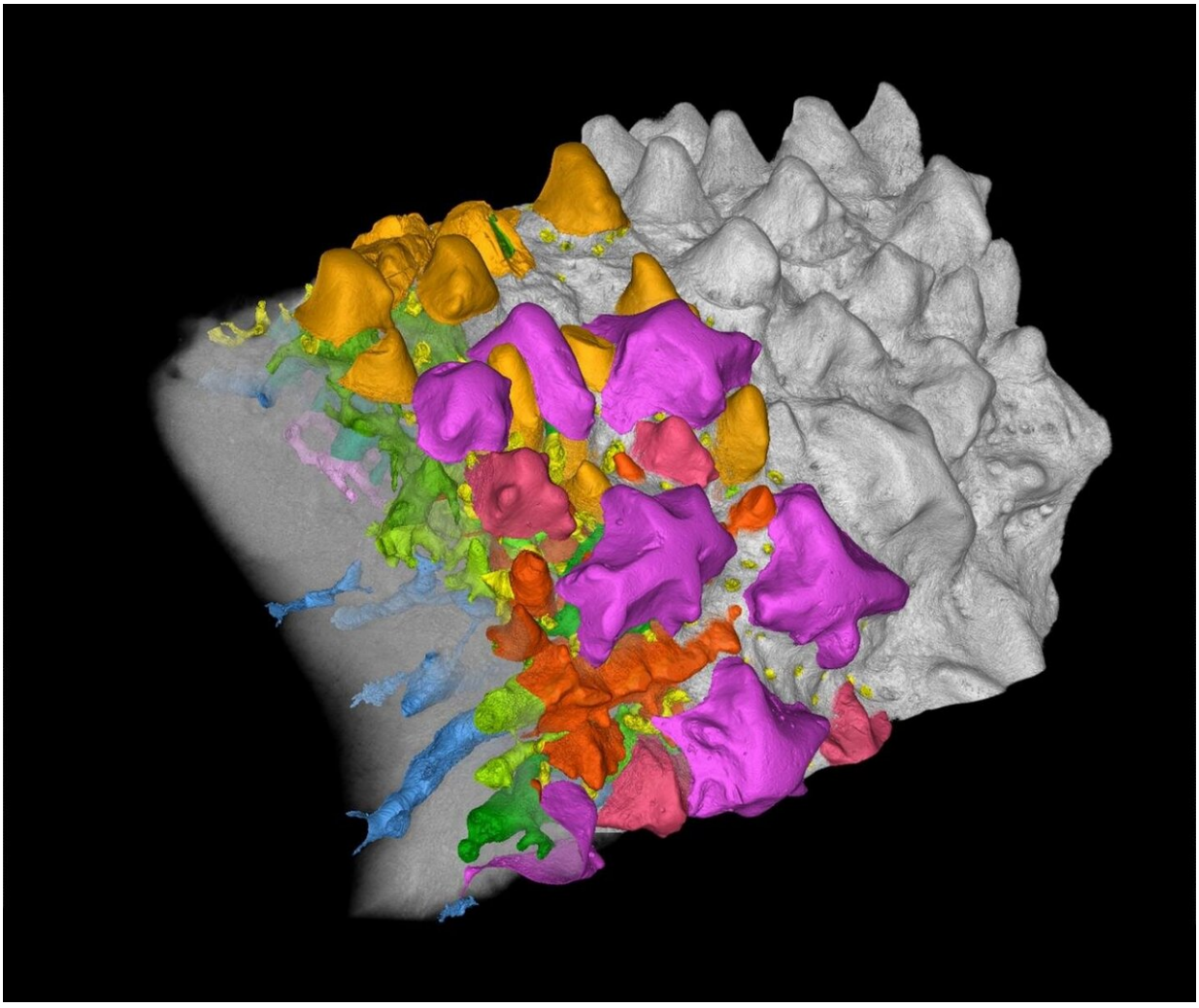

Part of a jawbone of the 422-million-year-old fossil bony fish Lophosteus, visualized with a high-resolution X-ray technique. On the right, the surface of the jawbone is shown in gray. In the middle, exposed teeth are highlighted in gold and dermal odontodes in shades of purple, pink and red. On the left, the

bone itself is made transparent, revealing internal blood vessels and pulp cavities, shown in blue and green, as well as the embedded teeth and dermal odontodes. Credit: Chen et al. (CC BY 4.0)

Teeth and hard structures called dermal odontodes are evolutionarily related, arising from the same developmental system, a new study published today in *eLife* shows.

These findings in ancient fish fossils contradict established claims about the difference between the two structures based on modern sharks, and provide potential new insights into the origins and development of teeth.

Odontodes are hard structures made of dentine, the main substance in ivory, and are found on the outside surfaces of animals with backbones (vertebrates). Teeth are an example of odontodes but some animals also have them on their skin, such as the tooth-like 'scales' of sharks. These are known as dermal odontodes.

"Teeth and dermal odontodes are thought to have evolved separately because they seem to develop in different ways," says lead author Donglei Chen, a researcher at the Department of Organismal Biology, Uppsala University, Sweden. "However, most of what we know is limited to modern sharks in which the difference between these structures has become very distinct. To understand the relationship between the two more clearly, we needed to turn to the fossil record."

The team looked at fossils of one of the earliest bony fishes called Lophosteus which lived more than 400 million years ago. They chose this fish because it represents an early stage of tooth evolution, bringing them closer to the time when teeth and dermal odontodes could have separated in the hopes that any developmental similarities between the

two would be more obvious.

The researchers used high-resolution X-ray imaging to look at the three-dimensional structure of odontodes in Lophosteus at different stages of development. They found that the appearance of odontodes were similar at the early stages of development but would change depending on whether they grew into the mouth or the face. This suggests there were different chemical signals in each area directing their development. At the later stages, some dermal odontodes would move from the face to the mouth and begin to look like teeth.

These findings suggest that both types of odontodes are able to respond to the same signals controlling each other's development and are made by the same developmental system—not separate systems as previously thought.

"In addition to casting light on the early evolution of our own teeth, our results point to a previously unrecognized evolutionary-developmental relationship between teeth and dermal odontodes," says senior author Per Ahlberg, Ph.D., Professor at the Department of Organismal Biology, Uppsala University. "This has potential implications for understanding the signaling that occurs during development and could inspire new lines of developmental research in other organisms."

More information: Donglei Chen et al, The developmental relationship between teeth and dermal odontodes in the most primitive bony fish Lophosteus, *eLife* (2020). DOI: 10.7554/eLife.60985

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