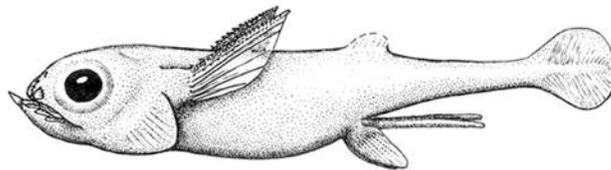




## OLDEST FOSSIL BRAIN FOUND IN KANSAS

### SHARK RELATIVE THAT LIVED 300 MILLION YEARS AGO YIELDS VERY RARE SPECIMEN

When Alan Pradel of the Muséum National d'Histoire Naturelle in Paris CAT scanned a 300-million-year-old fossilized iniopterygian from Kansas, he and his colleagues saw a symmetrical blob nestled within the braincase. This turned out to be the oldest brain found in fossil form, a wholly unexpected and rare discovery. Additional scanning on the synchrotron at the European Synchrotron Radiation Facility in Grenoble, France (and using a new X-Ray approach) yielded detailed information about the structure of brain, the shape of the braincase, and the nerves running between the two features. The new discovery is described with several other intact braincases—the first three-dimensional fossils from this group of extinct marine fishes—in the early online edition of the *Proceedings of the National Academy of Sciences*.



Reconstruction of large iniopterygian *Sibyrrhynchus denisoni*. Credit P. Janvier AMNH (courtesy of A. Pradel) has access to additional images of fossil as well as video detailing the fossil, braincase and brain.

“For a long time, paleontologists have used the shape of the cranial cavity to research the general morphology of the brain—because soft tissue was not available until today,” says Pradel.

“Soft tissue has fossilized in the past, but it is usually muscle and organs like kidneys because of phosphate bacteria from the gut that permeates into tissue and preserves its features,” says John Maisey, Curator in the Division of Paleontology at the American Museum of Natural History and a co-author of the report. “Fossilized brains are unusual, and this is by far the oldest known example.”

Iniopterygians are extinct relatives of modern ratfishes, also known as “ghost sharks” or chimaeras. Chimaeras are obscure relatives of sharks and rays that were extensively described by Museum Curator Bashford Dean in 1906 and number about 40 species. But in the late Paleozoic, relatives of chimaeras were relatively common in the oceans of the world with a huge diversity of shapes and sizes, and iniopterygians were a bizarre part of this radiation. Known at first only from completely flattened fossils (which is partially why the complete braincases described now are so stunning), these fishes had several unusual features: massive skulls with huge eye sockets, shark-like teeth in rows, tails with clubs, enormous pectoral fins that were dorsalized or placed almost on their backs, and bone-like spikes or hooks on the tips of their fins. Most iniopterygians were fairly small, averaging about 6 inches in length.

The new research looked at four 3-dimensional braincases of iniopterygians found in shales from Kansas and Oklahoma. The specimens share several features with living ratfishes, which means that these skull features have been conserved in the group for the last 300 million years. Complete reconstructions of these skulls were made with a CAT scan and X-ray synchrotron microtomography, and the imaging of one skull showed a dense, symmetrical object sitting within the large braincase. This was the mineralized brain.

The specimen that included the brain was imaged as a holtomography by Paul Tafforeau and colleagues at the European Synchrotron Radiation Facility. This more powerful scan brought the brain to light in great detail. It is a tiny (about 1.5mm by 7 mm in size), symmetrical shape that sits within a large braincase; as in many lower vertebrates, the brains of these fish ceased to grow as their skulls continued to expand. The brain has a large lobe for vision and an optic nerve that stretches to the correct place on the braincase; both of these features correlate well with the large eye sockets. The auditory section of the brain is reduced, and this information reflects observations of the inner ear in iniopterygians. Unlike typical ear canals that regulate orientation and balance with three big loops, the ear canals in this extinct group are all pulled into a horizontal plane. This means that the fish could detect side to side movements, but not up and down.

“There is nothing like this known today; it is really bizarre,” says Maisey. “But now that we know that brains might be preserved in such ancient fossils, we can start looking for others. We are limited in information about early vertebrate brains, and the evolution of the brain lies at the core of vertebrate history.”

Pradel agrees and will next look for possible brains of spiny rayed fish found in the same fossil beds from Kansas, Oklahoma, and Texas. “This fossilized brain allows for real paleo-neuroanatomical studies of fossil vertebrates,” he says. “Now that we have fossilized soft tissue in addition to bone, we can see that there is no general correspondence between the morphology of the brain and that of the endocranial cavity and that past paleo-neuroanatomical studies must be taken with caution.”

In addition to Pradel, Maisey, and Tafforeau, coauthors on this paper include Philippe Janvier and Didier Geffard-Kuriyama of the Muséum National d’Histoire Naturelle in Paris, and Max Langer and Peter Cloetens of the European Synchrotron Radiation Facility in Grenoble. Research was funded by Pradel and Janvier.

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No. 26