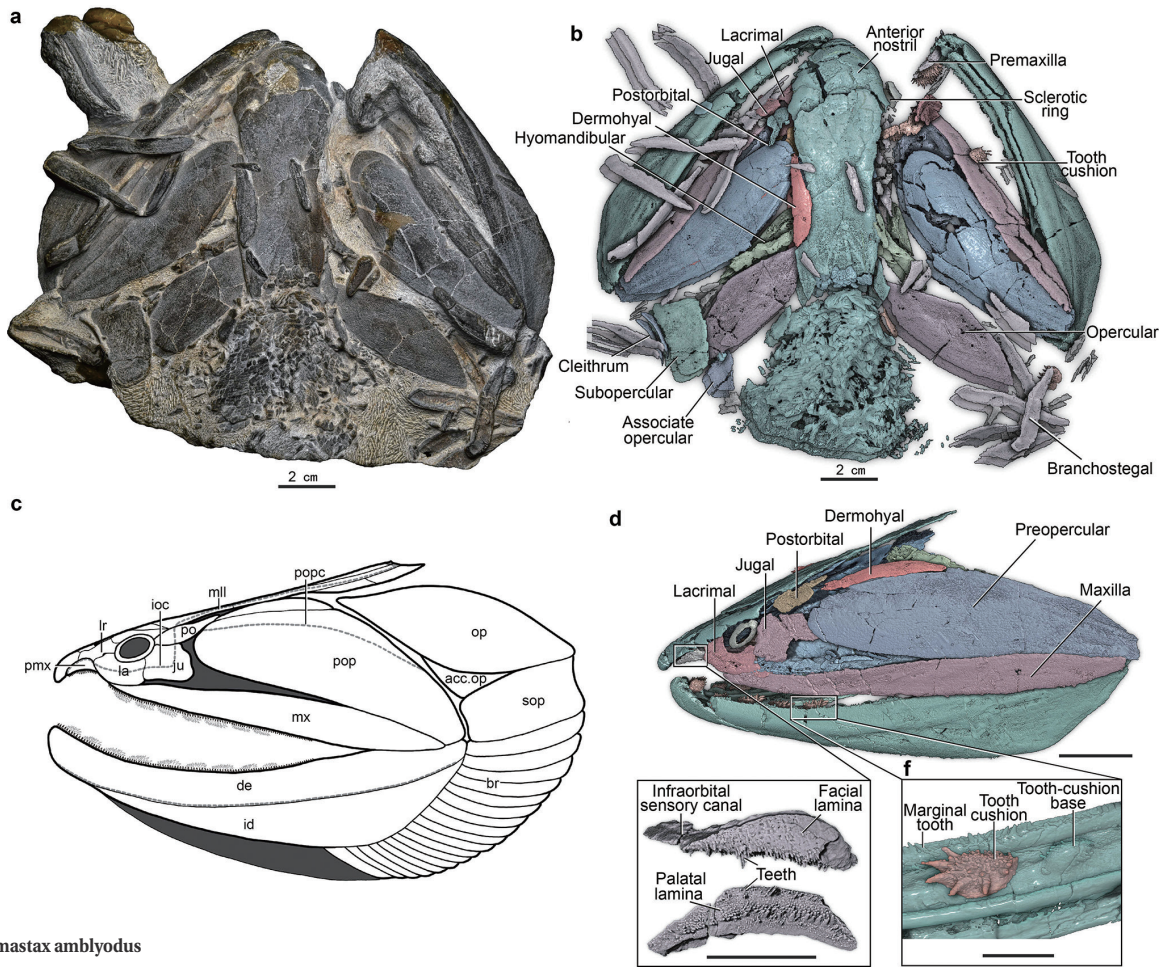
Earth Sciences

Oldest Known Bony Fish Fossils Uncover Early Vertebrate Evolution

A research team led by Profs. ZHU Min, LU Jing, and ZHU You'an from the Institute of Vertebrate Paleontology and Paleoanthropology (IVPP) of the Chinese Academy of Sciences published two back-to-back cover stories in the journal *Nature* on March 4, reporting new discoveries about the origin of bony fishes.

The team has unearthed the oldest known fossils of bony fishes, revealing the morphology and key anatomical features—including jaws, teeth, and braincases—of two primitive bony fish species. Phylogenetic analyses place both taxa within the previously little-known bony fish stem group, representing the most primitive bony fishes known to date before the evolutionary split of the two major lineages: ray finned fishes and lobe finned fishes. These findings fill a major gap in the "from fish to human" evolutionary narrative and reinforce southern China as a cradle of early vertebrate evolution.

Bony fishes form the main trunk of the vertebrate tree of life. Their two surviving lineages, ray finned fishes and lobe finned fishes, have colonized diverse niches in aquatic and terrestrial ecosystems, respectively. Ray finned fishes include more than 30,000 extant species, comprising most fish familiar to us today. The study shows that one lineage of lobe finned fishes moved onto land during the Devonian period,



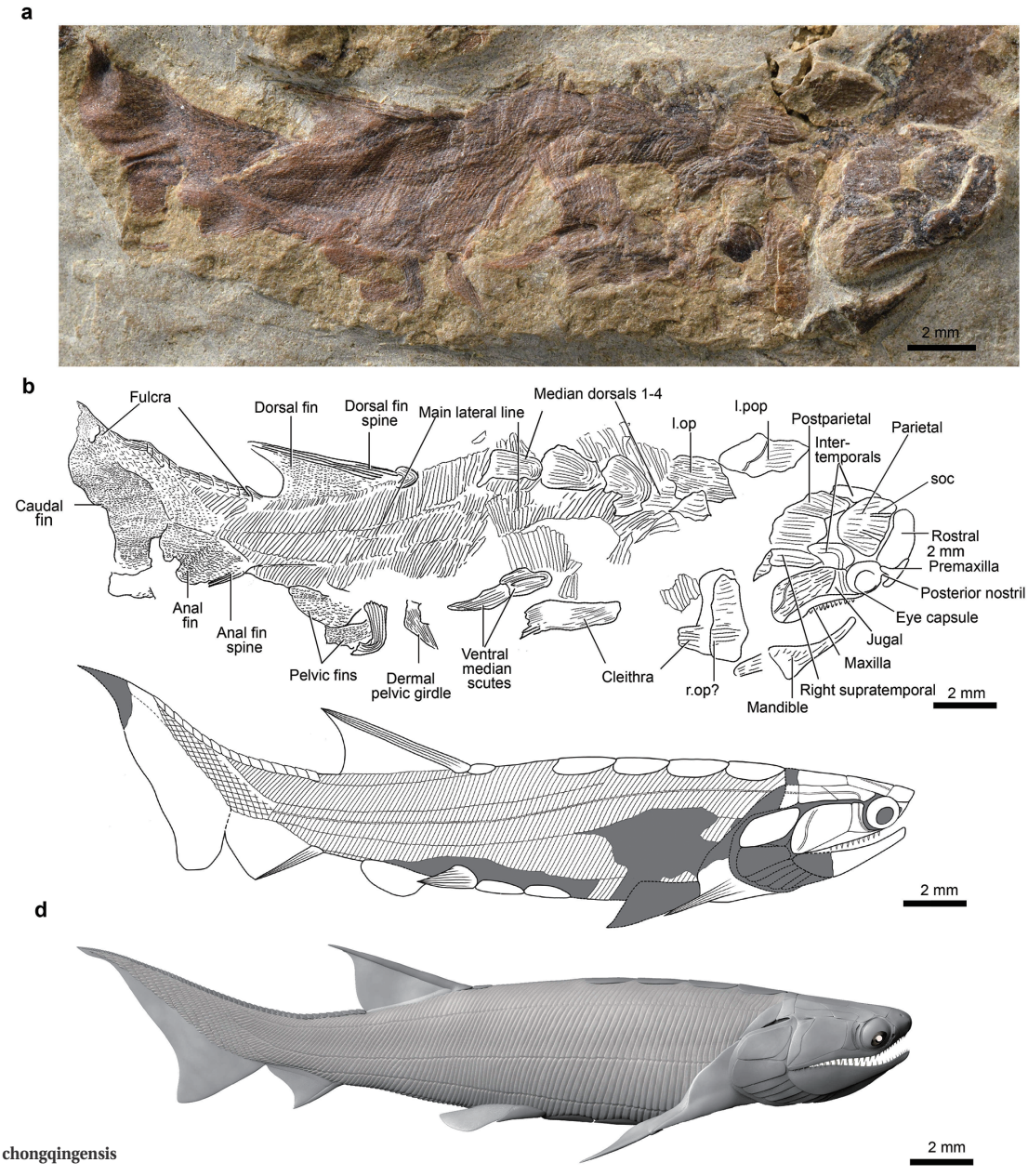
Megamastax amblyodus

eventually giving rise to all tetrapods—including humans.

However, the origin of bony fishes has long remained shrouded in mystery. A central challenge is that nearly all well-studied early bony fish fossils are already highly specialized ray finned or lobe finned forms dating back to the Devonian. Fossil evidence of primitive bony fishes, or stem osteichthyans before the divergence and prior to the Devonian, was missing, leaving the morphology of the last common ancestor of ray finned and lobe finned fishes unresolved.

After more than a decade of fieldwork and laboratory research, the team achieved two pivotal discoveries. From Early Silurian deposits in Xiushan, Chongqing, they recovered Eosteus *chongqingensis*, the oldest complete bony fish fossil ever found globally. Using high resolution computed tomography (HRCT), the researchers reconstructed the full cranial anatomy and dentition of *Megamastax amblyodus*—the largest known Silurian vertebrate—from the Late Silurian Kuanti Formation in Qujing, Yunnan. This wealth of new anatomical data has solved a half-century-old puzzle surrounding the origin of its tooth plates.

Eosteus chongqingensis lived approximately 436 million years ago and measured just 3 centimeters in total length, yet is exceptionally complete, preserving the entire body from head to tail. It predates all previously described large bony fish fossils and even the earliest known microfossils of



Eosteus chongqingensis

bony fishes. This tiny fish displays a mosaic of primitive and derived traits: Its streamlined body, single dorsal fin, and specialized scales known as caudal fulcra resemble those of early ray finned fishes, yet it lacks the lepidotrichia (bony fin rays) typical of bony fishes and bears an anal fin spine previously known only in cartilaginous fishes and placoderms. The discovery demonstrates that the suite of core bony fish characteristics evolved much earlier than previously assumed.

Megamastax amblyodus from the Late Silurian (about 423 million years ago) of Qujing, Yunnan, grew to over 1 meter in length and was the largest vertebrate of its time. After nearly a decade of work and dozens of attempts, the team used advanced imaging and three-dimensional (3D) computer reconstruction to reveal its complete cranial anatomy and internal structures. Its dentition includes inner and outer tooth rows or dental arcades; the inner row consists of tooth cushions atop blunt bases, representing a primitive condition for bony fish dentition. This structure resolves a long-running debate over the affinities of isolated tooth cushions from the Silurian of the Baltic region, clarifying their correct taxonomic placement.

Phylogenetic analyses place both fishes in the bony fish stem group, representing the ancestral condition before the split between ray finned and lobe finned fishes. They thus illuminate the ancestral morphology of all modern bony fishes—a group encompassing most living fishes and all tetrapods, including humans. These discoveries enhance our understanding of the early radiation of jawed vertebrates, refute the hypothesis that the ancestral bony fish was more similar to lobe finned fishes, and clarify the early evolutionary trajectory of jaws and teeth in bony fishes.

The researchers noted that these findings further confirm south China as the cradle for the origin of bony fishes and jawed vertebrates as a whole.

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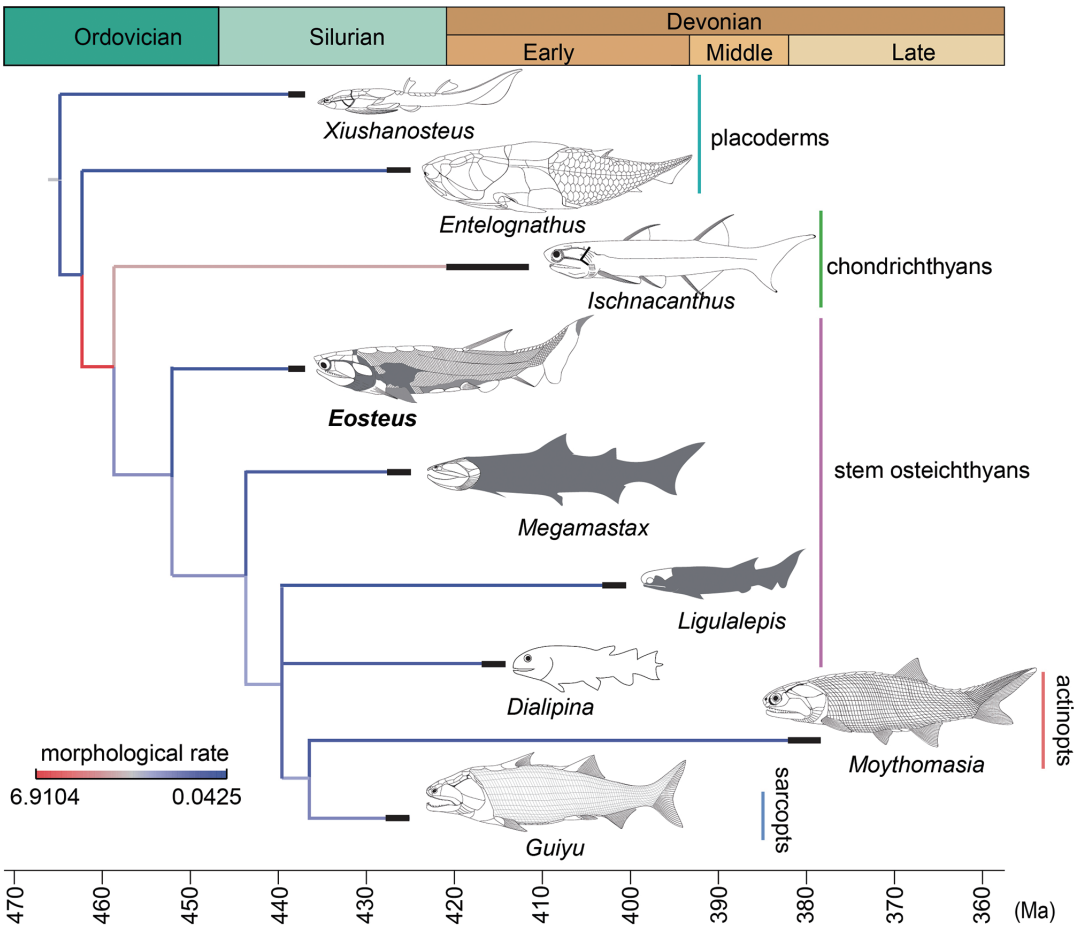
(Source: IVPP)



Evolutionary tree