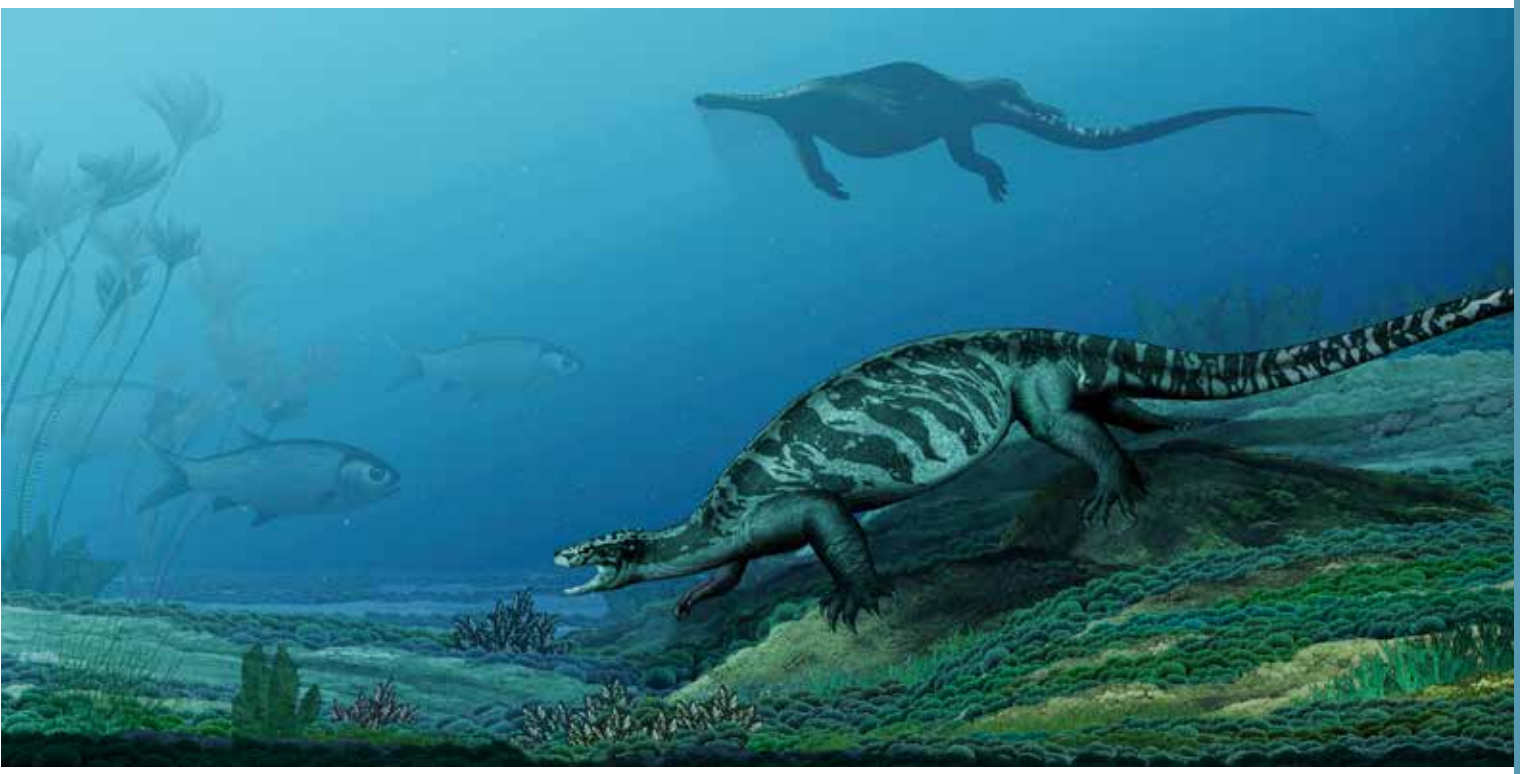
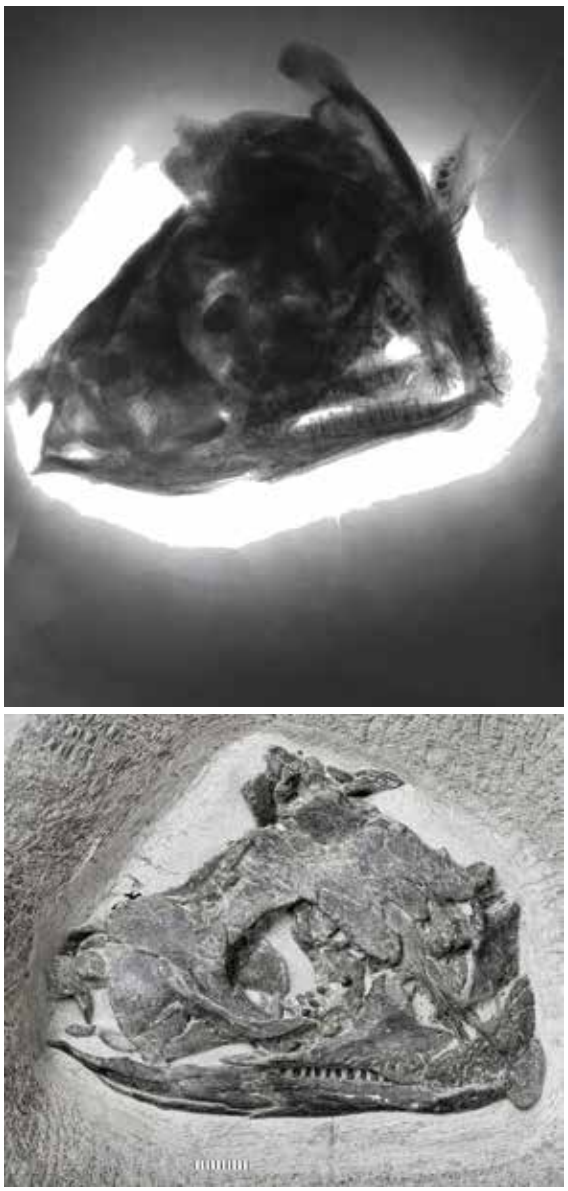
Turtle before Turtles

People are familiar with modern turtles, but the evolution of turtles remains one of the biggest mysteries in paleontology. The turtle has a unique body form of tetrapods (four-leg vertebrates, or vertebrates except fishes, such as lizards/crocodiles, birds, and mammals). It has a shell composed of carapace and plastron, and most of the skeleton, including the vertebrae, ribs and some limb girdles is fused with the shell inside. It is the only extant reptile without temporal fenestrae (openings behind the orbits on the skull), and like birds, it has a toothless beak.

How turtles acquired these unusual characters from their evolution has long baffling paleontologists. On the other hand, their phylogenetic position has also long puzzled researchers: is the turtle a lineage derived from a separate reptile group called Anapsid, which has no fenestra on the skull behind the orbit either, or one that shares with other reptiles such as lizards, crocodiles and dinosaurs (including birds) a common ancestor called Diapsid? This common ancestor has double fenestrae behind its orbits, but the openings in turtles could have closed in their evolution, therefore no post-orbit opening



A reconstruction of *Eorhynchochelys*, a "turtle before turtles" without a shell, together with its ambient environment. Strikingly, it has a primitive beak with teeth and enclosed temporal fenestrae – openings behind the orbits of its skull. (Image by courtesy of IVPP)



The skull of the *Eorhynchochelys sinensis* shows a primitive beak with teeth and enclosed temporal. (Upper: Structure in the specimen; Bottom: Reconstruction of the skull. Images by courtesy of LI Chun's group)

The specimen of *Eorhynchochelys sinensis*. (Image by courtesy of LI Chun's group)

is visible on an extant turtle skull.

For quite a long time, the oldest and most primitive turtle documented was *Proganochelys*, dated back around 200 million years. However, it already had the same body structure as turtles today. It had a complete shell and a beak. Therefore, the question has become how turtles evolved before *Proganochelys*. Unfortunately, no such fossil record was discovered until 2008.

In the year 2008, a turtle specimen named *Odontochelys*, meaning "turtle with teeth and semi-shell," dated back about 220 million years was found from Guanling of Guizhou. This work was led by LI Chun of the Institute of Vertebrate Paleontology and Paleoanthropology (IVPP), Chinese Academy of Sciences (CAS). For the first time, people saw a creature one step earlier in the evolution of turtles.

Later in 2015, another primitive turtle, *Pappochelys*, dating back about 240 million years, was discovered in Germany. Although very scattered,

scientists from German and US gave a reconstruction of this primitive turtle: it did not have a shell, but did have small openings – temporal fenestrae on the skull.

Again, on Aug 23, 2018, the same research team led by LI Chun published in *Nature* a new early turtle from Guizhou. It was discovered from the marine Triassic of Guanling, shedding new light on the earliest evolution of turtles. Dating back about 228 million years, this fossil represents the oldest turtle ever discovered with a toothless beak, and thus named as *Eorhynchochelys*, meaning "the first turtle with a beak." The fossil turtle is more than 2 meters long, with a short trunk and enclosed temporal fenestrae, but no shell on its back and abdomen. Although the beak was developed, there are teeth on the posterior part of the jaws. "It showed not only primitive, but also derived and transitional features, indicating a complexity in the early stage of turtle's evolution. The evolutionary position of *Eorhynchochelys* is between *Odontochelys* and *Pappochelys*, filling another missing link in turtle's natural history," said LI Chun, leader of the work.

"Its skeleton suggests the turtle might have lived an amphibious life near the estuary, and had a habit of digging holes," LI said.

"With the discovery of recent early turtles, more and more evidence suggests that turtles evolved gradually. I think our new discovery supports Darwin's theory that biological evolution went on step by step, and gave us the idea that what a turtle before turtles looks like."

Reviewers of *Nature* commented that the finding was extremely important as it closed a major gap in the evolution of the turtle, and indicated the development was more complex than previously assumed.

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