Waking Up to the Dawn of Vertebrates

Paleontologists have long regarded vertebrates as latecomers who straggled into evolutionary history after much of the initial sound and fury had fizzled. Chinese paleontologists, however, have discovered fossils of two fish that push the origin of vertebrates back to the riotous biological bash when almost all other animal groups emerged in the geologic record.

Preserved in 530-million-year-old rocks from Yunnan province, the paper clip–size impressions record the earliest known fish, which predate the next-oldest vertebrates by at least 30 million years.

The fossil finds, while not totally unexpected, thrill paleontologists who despaired of ever uncovering such evidence from Earth's dim past. "It's important because up to now the vertebrates were absent from the big bang of life, as we call it—that is, the great early Cambrian explosion, where all the major animal groups appeared suddenly in the fossil record," comments Philippe Janvier, a paleontologist at the National Museum of Natural History in Paris.

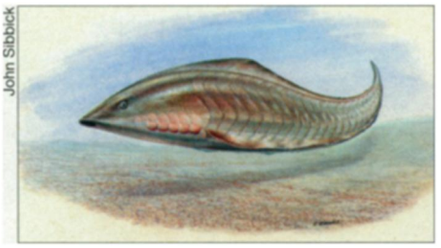
The Chinese fish come from a site near the town of Chengjiang, the world's richest locale for documenting the early part of the Cambrian period. Together with the middle-Cambrian animals found in Canada's famous Burgess Shale, the Chengjiang fossil fauna reveals the diversity of life in the seas following the Cambrian explosion.

Among the tens of thousands of animals found in these two deposits, paleontologists had previously pulled up two slender creatures that fit into the chordate phylum—the broad category that includes vertebrates. But those two species lacked well-defined heads, sophisticated gills, and other features that would provide them entrée into the vertebrate subphylum. Instead, they resemble the living invertebrate called amphioxus, a passive filter-feeding marine animal.

The new Chengjiang species have a number of features not seen in amphioxus or other invertebrate chordates. "It is practically certain that these are vertebrates," says Janvier.

Both the Chinese specimens have a zigzag arrangement of segmented muscles—the same type of pattern seen in fish today, reports Degan Shu of Northwest University in Xi'an, China, and his colleagues. The fossils, named *Myllokunmingia* and *Haikouichthys*, also have a more complex arrangement of gills than the simple slits used by amphioxus, according to the team's report in the Nov. 4 NATURE.

Although the ancient Chinese animals qualify as vertebrates, they lack the bony skeleton and teeth seen in most, but not all, members of this subphylum today. Instead, these early jawless fish appear to have had skulls and other skeletal structures made of cartilage, says Simon Conway Morris of the University of Cambridge in England, who collaborated with the Chinese team.


John Sibbick

First fish: An artist's conception of the Myllokunmingia.

The researchers propose that vertebrates evolved during the explosive period of animal evolution at the start of the Cambrian and only some 30 million years later developed the ability to accumulate minerals in their bodies to form bones, teeth, and scales.

"It is interesting that the gap is so big between the first [jawless vertebrates] and the first evidence of biomineralization," says M. Paul Smith of the University of Birmingham in England, who studies early fish.

The appearance of the first vertebrates marked a profound transition in the lifestyle of our ancestors, says Smith. The earliest chordates presumably resembled amphioxus in being nearly brainless animals that lacked paired eyes and fed by filtering food from the water. Evolution formed the vertebrate body by fashioning fish with distinct heads, paired eyes, and other features for hunting.

The new discoveries indicate that these swift progenitors of sharks were darting around the seas with the other animals that attended the Cambrian carnival. The festivities may have begun far earlier. Genetic evidence hints that most animal phyla evolved hundreds of millions of years before they began leaving fossil evidence, a point debated by paleontologists. *—R. Monastersky*

Vacuum tubes' new image: Too small to see

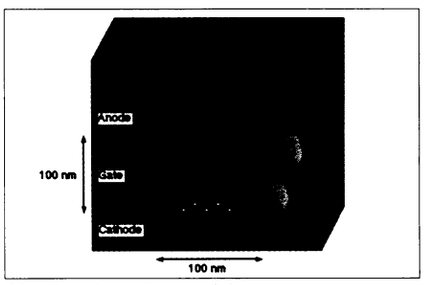
In the lilliputian realm of modern electronics, old-style vacuum tubes have all the charm of hulking Gullivers. However, researchers have recently been reducing these components to daintier proportions (SN: 4/20/96, p. 249). They hope to exploit ways in which vacuum tubes outperform semiconductor devices.

A team in England has now developed a vacuum tube whose size rivals that of transistors in today's microcircuits. The evacuated hollow in the so-called nanotriode occupies only about a billionth the volume of a grain of salt, says Haroon Ahmed, whose group describes the device in the Nov. 1 APPLIED PHYSICS LETTERS.

Capp Spindt of SRI International in Menlo Park, Calif., hails the article as "the first credible report of an operating vacuum diode or triode on this scale." Diodes act as one-way valves for current between two electrodes; triodes control current via a third electrode.

Akintunde I. Akinwande of the Massachusetts Institute of Technology calls the results "really spectacular."

Alexander A.G. Driskill-Smith, David G. Hasko, and Ahmed, all of the University of Cambridge, fabricated the prototype device from alternating layers of metals and insulators. The inventors expect the triode to operate under conditions of radiation or heat that would make standard semiconductor components fail.



Driskill-Smith *et al./APL*

Varying the voltage of the gate, an electrode in the ultrasmall vacuum tube shown in this diagram, adjusts the current zipping from a cathode pillar to the anode. Insulating material appears in magenta.

"It looked pretty exciting from that point of view," says Ahmed.

Old-fashioned vacuum tubes initiate a current by boiling electrons off heated electrodes. By contrast, in the microscopic vacuum tubes, devices called field emitters shoot electrons from the most prominent tip of an array of tiny, unheated posts or pyramids. The electrons are torn from the tip by an enormous voltage produced when an external electric field becomes concentrated there. Field-emission research has intensified in the past decade because emitters can be used in flat displays for computers and other items.

Another research team in 1991 reported sealing minuscule emitters inside an evac-