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.

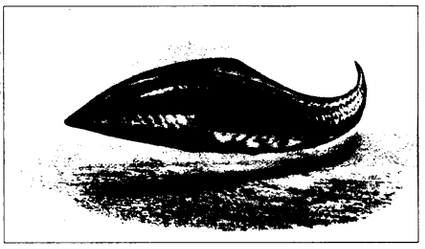
Among the tens of thousands of animals found in these two deposits, paleontologists had previously pulled up two slender creatures that fit into the chordate phylum—the broad category that includes vertebrates. But those two species lacked well-defined heads, sophisticated gills, and other features that 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.

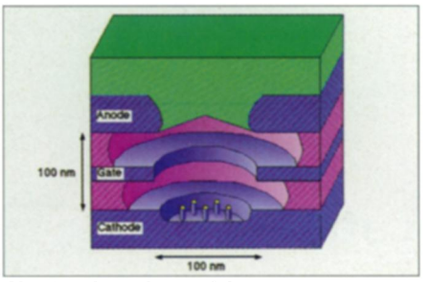
A team in England has now developed a vacuum tube whose size rivals that of transistors in today's microcircuits. The evacuated hollow in the so-called nanotriode occupies only about a billionth the volume of a grain of salt, says Haroon Ahmed, whose group describes the device in the Nov. 1 APPLIED PHYSICS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

uated cavity, thus creating a vacuum tube, but it's not as small as the Cambridge tube, Akinwande says.

For tubes of the Cambridge type to play a role in digital circuits, their traits must improve, says Ivor Brodie of SRI. The maximum current is low—about 10 nanoamperes—and too irregular, he says. Akinwande estimates that the tube's roughly 10-volt operating voltage probably can be reduced to around 2 volts, a level at which some low-voltage semiconductor devices now function.

Vacuum tubes handle high-frequency signals better than semiconductor components do. Unlike electrons in a semiconductor, which are slowed by collisions with crystal-lattice atoms, electrons in a tube fly unobstructed through the vacuum.

Consequently, arrays of nanotriodes may find use as amplifiers and oscillators for high-frequency, high-power signals, such as those in cellular phone systems or military radar, Ahmed says.

Other possible roles include pressure and acceleration sensors and satellite microthrusters, Akinwande adds. —*P. Weiss*

Each nostril smells the world differently

Much as each eye sees the world from a slightly different angle, each nostril takes a somewhat different sniff, reports a California-based research team.

Unlike the eyes, however, nostrils switch roles several times a day, seesawing peak sensitivity between two groups of odors, the researchers argue in the Nov. 4 NATURE.

The basic difference between left- and right-nostril sniffs depends on airflow, explains Noam Sobel of Stanford University. A little tissue bulge, called a nasal turbinate, dangles in each nostril. While one turbinate engorges with blood and chokes down airflow, the other shrivels to permit big sniffs.

To feel the difference, block off each nostril in turn and inhale, Sobel says. Checking again several hours later often reveals a switch. To see the turbinates, just look up somebody's nose, Sobel advises.

Researchers have known for more than 100 years that nostril airflows differ, notes Sobel. What's new, he says, is the evidence that this nasal quirk affects sensitivity to odors.

To register as a smell, molecules wafting into a nostril must cross a mucous membrane and hit a receptor. In earlier studies on bullfrogs, other researchers found that some compounds, so-called high-sorption odorants, zing through that membrane quickly, but others only creep.

To see if airflow affects perception of either odorant class, Sobel and his colleagues asked Stanford undergraduates to sniff a mix of two compounds and estimate their ratio. One component, the pepperminty L-carvone, zips across the nasal membrane, but the other, the aniselike odorant octane, dawdles.

Although they told students that proportions of the compounds would vary, the experimenters kept the mix at 50-50. For each trial, the researchers measured the flow of air as a student sniffed through one nostril.

Airflow did change the sensitivity, the team reports. Seventeen of the 20 students ranked the slow-traveling anise higher when they inhaled through their low-air nostril. When sniffing through the high-air nostril, these 17 ranked the fast peppermint at a higher proportion.

To see if some peculiarity of a nostril caused the difference, the researchers retested eight of the students after their airflow patterns had switched. Seven showed the same link between odor perception and airflow as in the earlier trial.

"It's not that one [nostril] smells oranges and the other smells apples," Sobel emphasizes. "The difference is subtle."

Richard Doty of the University of Pennsylvania in Philadelphia praised the creativity of the experiment but pointed out that Sobel used only a two-component mixture, while most smells are far more complex.

Many people don't show consistent airflow-change cycles, and the cycles dwindle with age, Doty has found. He muses that airflow response "is more akin to visual illusions that, while interesting, play little role in day-to-day visual processing."

However, study coauthor John D.E. Gabrieli of Stanford proposes that nostril shifts boost nose power by allowing two simultaneous sniffs that have their sensitivities tuned to different kinds of chemicals. As he puts it, "Two heads are better than one." Gabrieli also raises the possibility that slow- and fast-moving compounds could provide a key to understanding how olfactory processes are organized in the brain.

Brain mapping is only one aspect of the study of smell that lags behind studies of other senses, grumbles James M. Bower at California Institute of Technology in Pasadena. "There's a national eye institute, but there's not a national nose institute," he points out. He welcomes the Sobel study as a useful step. "People have known that they have two nostrils, but no one has known that it mattered," he says. —*S. Milius*

Genetic variants may ease leukemia risk

People with acute lymphocytic leukemia are more likely than healthy people to have the common version of a gene that plays a role in regulating folic acid metabolism in the body, a new study shows.

The gene encodes the enzyme methylene-tetrahydrofolate reductase (*MTHFR*), which acts on folic acid, a vitamin critical for DNA synthesis and repair. The common *MTHFR* gene produces a version of this enzyme that directs some of the folic acid toward other biological processes, reducing the amount available for proper DNA maintenance, the researchers find. Scientists have evidence that poor DNA repair triggers the growth of cancerous cells.

Folic acid deficiency may thus play a role in acute lymphocytic leukemia, a team of U.S. and British scientists report in the Oct. 26 PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES (PNAS). As many as two-thirds of people have the common form of the *MTHFR* gene.

Using blood DNA, the researchers compared the genetic makeup of 308 patients in England that have various leukemias with that of 491 healthy adults matched for sex, age, lifestyle, and geographic location. Most of the patients had acute myeloid leukemia and were no more likely to have the gene variation than healthy volunteers were.

However, the 71 patients with acute lymphocytic leukemia were significantly more likely to carry the common gene version than were 114 matched healthy people, says study coauthor Christine F. Skibola, a toxicologist at the University of California, Berkeley School of Public Health.

The healthy people were four times as likely to have a variation at a site on the gene called *MTHFR-677* than were patients with lymphocytic leukemia, also called acute lymphoblastic leukemia. The healthy participants were also three times as likely to have a change at another site, *MTHFR-1298*, as these leukemia patients, Skibola says.

The study "is very provocative and may provide some insight into the development of [acute lymphocytic leukemia]," says Joseph R. Bertino, a pharmacologist at Memorial Sloan-Kettering Cancer Center in New York.

Earlier work showed that folic acid deficiency causes breaks in chromosomes, which contain DNA, and that folic acid supplements can prevent such breaks. Also, two previous studies linked the less common *MTHFR-677* form with a reduced risk of colon cancer.

The new study reinforces the value of dietary folic acid, says Bruce N. Ames of the Department of Cell and Molecular Biology at Berkeley in the same issue of PNAS. "Chromosome breaks could contribute to the increased risk of cancer associated with [folic-acid] deficiency in humans," he says.

Bertino cautions, however, that the same variants of *MTHFR* that may help protect people against lymphocytic leukemia also seem to hike blood concentrations of homocysteine, a chemical linked to cardiovascular problems. —*N. Seppa*