PALEONTOLOGY

Fossil Opens Window On Early Animal History

A fossil site in southern China that has held paleontologists captivated for a decade keeps relinquishing new treasures. Only 4 weeks ago, a Chinese-British team reported the oldest known vertebrates at the site, two fishlike creatures that lived 530 million years ago (*Science*, 5 November, p. 1064). Now, a rival team presents hundreds of astonishingly well-preserved fossils from the same site, which may represent some of the earliest chordates—a broad group that comprises not only vertebrates but also more primitive invertebrates such as sea squirts and lancelets.

The researchers, led by Junyuan Chen from the Nanjing Institute of Paleontology and Geology, think this animal, too, may have been an early vertebrate—it has a relatively large brain and perhaps eyes—but there's still some doubt, because they didn't find anything resembling a skull. Either way, however, the new fossils give researchers another eagerly awaited peek at the animals that set the stage for the evolution of the backbone, an important transition in the animal body plan. And other researchers add that the sheer quality of the specimens, reported in this week's issue of *Nature*, may eclipse last month's findings. "I think this is going to be an icon that we'll see in the textbooks for many years," says zoologist Nicholas Holland of the University of California, San Diego. "They're almost like a photograph of the anatomy of the animals," adds paleontologist Philippe Janvier of the Muséum National d'Histoire Naturelle in Paris.

Animal icon. *Haikouella*'s preserved internal organs and bulging back offer a rare glimpse of a primitive animal.

Both discoveries were made at a site called Chengjiang near the city of Kunming, where 530-million-year-old fine-grained rocks have preserved even soft animal tissue in exquisite detail. After finding a few intriguing specimens in April, Chen's group stepped up excavations. "We knew we had found something very important," says Chen, "and we started working really hard." A month later, the group had collected and described 305 specimens, 30 of them complete, of what they have christened *Haikouella lanceolata,* after the nearby town of Haikou.

Thanks to the stunning preservation, the researchers could not only discern a heart and a circulatory system in these 3-centimeter fossils, but also some of the hallmarks of chordates, such as a nerve cord and a notochord, a rod of stiff tissue that provides support along the back of the body and is present today in most embryonic vertebrates and adult chordates. *Haikouella* also has a puffed-up back that seems to contain segmented muscles—another key chordate feature. What's more, the animal seems to have a relatively large brain, and what appear to be two eyes, suggesting that it may be a very early member of the vertebrates—which would put it somewhere on the first steps of the long road to humans. *Haikouella* also clearly resembles a specimen Chen and colleagues found 4 years ago at the same site, called *Yunnanozoon lividum*, which also seemed to have a notochord and a nerve cord. Chen considered *Yunnanozoon* to be an ancient chordate, too, and says that the much better preserved *Haikouella* now confirms this.

But others contested *Yunnanozoon*'s right to a place within the chordates and seem likely to be skeptical about *Haikouella*, too. "I think they're trying to force too much advanced morphology into the animal," says paleontologist Simon Conway Morris of Cambridge University in the United Kingdom, a coauthor of the early vertebrate paper published last month. For one, Conway Morris isn't convinced that the bulging back does indeed contain chordatelike muscles. In his view, *Haikouella* may be even further down the evolutionary tree than *Yunnanozoon*—a progenitor to chordates and to other invertebrates such as the echinoderms, which include starfish and sea urchins. If so, the species might have been a kind of living fossil in its own time, offering a glimpse into an earlier phase of animal evolution about which even less is known. "In a paradoxical way it could be more interesting than [Chen's team] indicated," Conway Morris says.

But Chen and other researchers reject that idea. "There's no question that these things are chordates," says Holland. Janvier agrees. "This puts an end to the discussion about *Yunnanozoon*," he says. Everyone agrees, however, that more fossils from the Chengjiang site will likely be the key to the definitive history of the chordates. "It's quite astonishing how many new things we find there," says Conway Morris. "It's inevitable that there's going to be a whole lot of surprises." —MARTIN ENSERINK

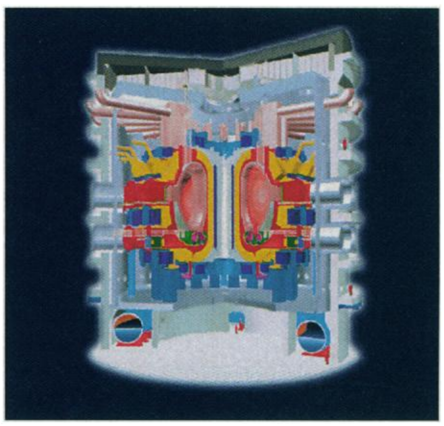
NUCLEAR FUSION

Europe, Japan Finalizing Reduced ITER Design

MUNICH, GERMANY—European and Japanese fusion researchers have drawn up what they hope will be a winning design for a scaled-down version of the International Thermonuclear Experimental Reactor (ITER). Last week ITER scientists described key elements of the smaller and cheaper design at a seminar here for policy-makers, industrialists, and journalists. Details will be revealed next month, in time to influence political decisions to be made starting next summer in Europe and Japan, the two major ITER partners. "We have been preparing for a long time and we are ready," ITER director Robert Aymar told the meeting attendees.

ITER began in 1986 as a joint project of Europe, Japan, the United States, and the Soviet Union. But its future was thrown into doubt in July 1998 when concerns about the $6.8 billion price tag led the partners to extend the design phase to July 2001 and to investigate smaller, cheaper alternatives. The United States later withdrew its support, and Russia's economy precludes it from providing more than intellectual and political support.

Despite those setbacks, a special working group was set up to look for cheaper ways of achieving a "next step" toward a prototype fusion reactor. It considered a series of smaller, cheaper experiments rather than one large one before coming down in favor of a single machine, similar to the original ITER, but with reduced technical objectives. Teams in Garching, Germany, and Nara, Japan, are now putting the finishing touches on the



Reactor redux. The old ITER design will shrink by up to 25% in new plans.

CREDITS: (LEFT TO RIGHT) NANJING INSTITUTE OF PALEONTOLOGY AND GEOLOGY; ITER new design, which would have a radius of 6 to 6.5 meters instead of the original 8 meters and a price tag of about $3 billion.

The reduction in size and cost was achieved largely by compromising on the machine's main scientific objective, ignition in a burning plasma. Fusion reactors such as ITER use magnetic fields to confine a deuterium or deuterium-tritium plasma within a toroidal vessel called a tokamak. When the plasma is heated to temperatures of about 100 million degrees Celsius, nuclei fuse and give off neutrons (whose energy is harvested) and alpha particles, which reheat the plasma. Ignition occurs when alpha particle heating is sufficient to sustain the fusion reaction indefinitely without further input of energy.

Rather than achieving ignition, the new design will aim for a burning plasma, in which alpha particles provide at least 50% of the plasma heating. The new design will produce at least 10 times as much energy as it consumes, generating 400 megawatts of power in bursts of 400 seconds rather than the originally specified 1.5 gigawatts in 1000-second bursts. In a burning plasma, "alpha particles become the dominant source of plasma heating and the determinant of plasma behavior," says Aymar. "These conditions cannot be reached by present machines or by upgrades, nor satisfactorily simulated."

Now that the design is in place, the ITER team must work quickly to convince the politicians. European funding comes from the European Union's Framework research program, a 5-year cycle that begins a sixth term in 2003. "The first strategy paper on the contents of the sixth Framework program will be issued in about June 2000," Klaus Pinkau, co-chair of the special working group, told the Munich meeting. Hiroshi Kishimoto, executive director of the Japan Atomic Energy Research Institute (JAERI), says the agency has a similar timeframe to secure funding but details of the financial package must be resolved before any final agreement.

The other big decision concerns choosing a site for the reactor. "JAERI has a strong interest in [bringing] ITER to Japan," says Kishimoto, adding that Japan might be willing to pay "more than 50%" of the total project costs. While such an arrangement would ease the financial burden on Europe, several European officials suggested that they are more likely to back a bid by Canada, an associate ITER member. One big reason is that a North American site would appeal to the United States, should it wish to rejoin the project. Nuclear engineer Charles Baker of the University of California, San Diego, who led a U.S. ITER planning team, doesn't see that happening "anytime in the near term." But he says that a formal decision by Japan or Europe to build the device "might create an opportunity for the U.S. to play a limited and modest role."

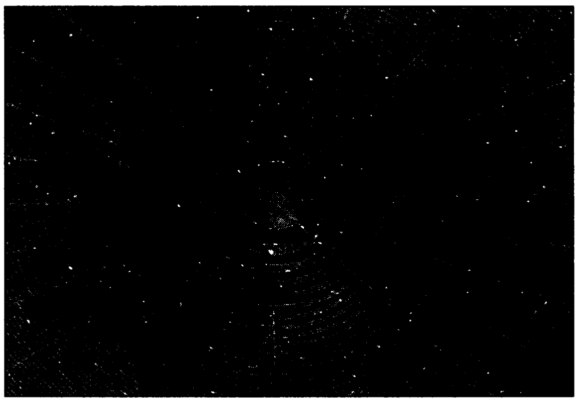
Taking an optimistic view, Aymar hopes that a site will be chosen in 2001 and a construction agreement signed in 2002. Adding in 2 years to prepare the site and sign licensing agreements, ITER could come on line around 2013. —**JUDY REDFEARN**

Judy Redfearn writes from Bristol, U.K. With reporting by Dennis Normile and David Malakoff.

MICROSCOPY

Helium Beam Shows the Gentle, Sensitive Touch

A microscope with unprecedented sensitivity, based on a beam of atoms rather than light or electrons, is a step closer to reality thanks to a German collaboration that has coaxed helium atoms into an intense, needle-fine beam. Atoms can play the role of light in a microscope because according to quantum mechanics, they too exist as waves, albeit thousands of times shorter than light waves. Because the crispness of a microscope image is governed by wavelength, matter, or de Broglie, waves could offer a very high resolution. And in contrast to energetic probes such as x-rays or electrons, helium atoms bounce lightly off the target surface without damaging it, explains Peter Toennies of the Max Planck Institute for Fluid Dynamics in Göttingen, Germany. "With helium atoms you see the flesh, whereas with all other probe particles you see the bones," he says.



Atom lens. This Fresnel zone plate can focus a helium beam to a 2-micrometer spot.

CREDIT: R. B. DOAK *ET AL*, *PHYS. REV. LETT*, 22 NOVEMBER 1999

An atom-beam microscope would be a unique instrument for examining surface structures nonintrusively, such as watching the buzzing vibrations on the surface of the minute crystals in metals, says Toennies. "Neutral atoms interact with matter in fundamentally different ways from other microscopic agents," says Jabez McClelland of the National Institute of Standards and Technology in Gaithersburg, Maryland. The Göttingen work "is really significant" as a demonstration of how to manipulate these truly inert atoms, says Jürgen Mlynek of the University of Konstanz in Germany, who led an earlier atom-focusing effort.

The starting point in the Göttingen experiment is a jet of helium atoms, spurting out of a fine nozzle. To trim down the spread of this jet to a fine pencil beam, the researchers pass the helium atoms through a "skimmer," a drawn-out glass micropipette with a tip just 1 micrometer across. "Think of it as a funnel, and we shoot the beam in through the narrow end," says Toennies. Atoms too far off the beam axis are guided away by the curving outer wall of the funnel.

A meter farther on, a type of lens called a Fresnel zone plate focuses the beam. Whereas conventional lenses bend light to a focus using refraction (the deflection that occurs on entering or leaving a denser material), zone plates rely on diffraction (the spreading of waves emerging from tiny apertures). Beams pass through a set of concentric opaque and clear rings, sized so that light diffracting from neighboring clear rings combines. Wave-peak adds to wave-peak to reinforce the light along the beam axis, focusing the beam, while peaks and troughs meet to cancel out the light just off-axis.

For the ultrashort wavelength of helium atoms, Günter Schmahl of Göttingen University's Institute of X-ray Physics, who co-leads the collaboration with Toennies, used electron beam lithography to create a zone plate in which the finest rings are just 50 nanometers wide and the entire zone plate is just a half a millimeter across. Without a zone plate, the atoms would illuminate an area 400 micrometers across. Using a zone plate, the researchers managed to create a spot just 2 micrometers wide (*Physical Review Letters*, 22 November, p. 4229)—10 times smaller and 100 million times brighter than in earlier atom-focusing efforts, says Toennies. What's more, unlike earlier efforts, the Göttingen group's atoms are in their lowest energy state, which is crucial for an atom microscope because they scatter from the surface more predictably. "What's new here is the use of ground-state helium atoms, which really have a pure 'billiard-ball' interaction with the surface," says McClelland.

Now the Göttingen group is trying to turn its beam into a full-fledged microscope. "The next step now is to detect the particles which have struck the surface within this narrow spot and then been deflected from the surface," says Toennies. "And that is what we are tooling up to do." —**ANDREW WATSON**

Andrew Watson writes from Norwich, U.K.