Ottawa noticed a region similar to the modern basal complex as they examined a well-preserved, 8-centimeter dragonfly from La Rioja, Argentina. When Wootton, an expert on the mechanics of insect wings, made a three-dimensional paper copy of the wing region, it responded to a force on the underside of the wing—similar to the force of air as a dragonfly flaps its wings downward—in the same way as the modern dragonfly's. The authors propose that the structure played a similar role in the ancient insects, allowing them to get more efficient lift from a downstroke. Thomas agrees. "I made the cardboard models" from their diagrams, he says, "and they work in exactly the same way" as the modern basal complex.

Despite the similarity in function, it seems that the two designs arose independently. They use different sets of veins, and the modern basal complex forms a triangle while the fossil one is a parallelogram. In addition, the wings are attached to the body of the fossil insect differently than those of modern dragonflies, and the researchers believe it was a cousin to, not a direct ancestor of, insects alive today.

Dating from only 10 million years after the oldest known flying insect, the specimen shows how quickly insects evolved sophisticated aerodynamic engineering, says insect flight physiologist Robert Dudley of the University of Texas, Austin. Still, there has been some improvement over the eons. The Argentine fossil is missing another aerodynamic feature present in modern dragonflies—a stabilizing structure called the node, which helps the wings withstand stresses from the twisting required for hovering in place. That may have evolved, Wootton says, as dragonfly prey itself became more aerodynamically adept—adaptations that anyone who has chased a mosquito can appreciate.

—GRETCHEN VOGEL

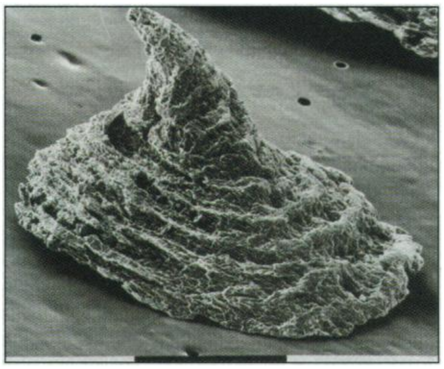
PALEONTOLOGY

Fossils Challenge Age of Billion-Year-Old Animals

Three weeks ago in the pages of *Science*, paleontologists pushed back the origins of multicellular life by 400 million years to a startling 1.1 billion years ago, based on ancient fossilized tracks found in central India. But a paper published about the same time in the *Journal of the Geological Society of India* may now yank those dates forward again to a more mundane figure of perhaps 600 million years old. The Indian paper, by paleontologist R. J. Azmi of the Wadia Institute of Himalayan Geology in Dehra Dun, presents tiny shelled fossils—unarguably about 540 million years old—from rocks that Azmi claims were laid down shortly after those holding the animal tracks. If so, the spectacularly old tracks would be transformed into simply another example of early animals.

Although other paleontologists confirm that Azmi's fossils are indeed relatively young, the authors of the original paper on the tracks, Adolf Seilacher of Yale University and his colleagues, are standing by their discovery. "I have strong doubts this one paper will blow us out of the water," says coauthor Friedrich Pflüger of Yale, noting that work by many other researchers supports the billion-year-plus age. To reduce the age, "you have probably 50 papers against you; you need to convince a lot of people."

The rocks in question, in the Vindhyan basin of central India, were repeatedly dated in recent decades using radiometric techniques, which rely on the slow decay of radioactive elements such as potassium, uranium, or rubidium. Done properly, this method is considered the gold standard for dating rocks. In dozens of studies, the sandstone holding the trace fossils yielded the age of about 1.1 billion years that is cited in the *Science* paper (2 October, p. 80). "Nobody expected the ages to be questioned," says Pflüger. "All the ages seemed to be consistent."



Tiny timekeeper. This millimeter-scale shell implies a younger age for Indian rocks.

CREDIT: R. J. AZMI

But Azmi argues that in this case, the ages estimated from distinctive fossil species known to have lived at certain times in the geologic past are more accurate. In layers of limestone and shale just above the sandstone, Azmi found millimeter-scale "small, shelly fossils," the remains of unique shelled animals whose appearance marks the explosion of new animal forms in the early Cambrian period 540 million years ago. He says the fossils hadn't turned up in the Vindhyan before because "people have not looked from this point of view." The rocks were believed to be very old, so no one macerated them in the way that allows small shelly fossils to be extracted, he says.

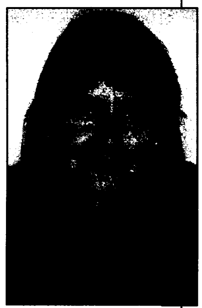
Other paleontologists accept the identity

ScienceScope

GERMANY'S NEW MINISTER STEPS OUT OF SHADOW

Germany's new research and education minister says she will support bigger budgets for the nation's scientists and universities.

This week, the newly elected ruling coalition of Social Democrats and Greens announced that Edelgard Bulmahn—the Social Democrat's parliamentary spokesperson for science—will replace Jürgen Rüttgers when the new government assumes control on 27 October. In making the announcement, the "Red-Green" coalition resisted calls from rival ministries to split the portfolio, which includes basic and applied research. Leading German scientists had opposed the idea. However, the coalition moved several small business-related research programs to the economics ministry.



Bulmahn

Although Bulmahn, 47, is a political scientist by training, she is no stranger to science policy. She recently served as "shadow minister" for science while the Social Democrats were in the opposition and since 1995 has served on the Bundestag's science and education committee. Bulmahn has a good grasp of the issues facing German science, says biochemist Ernst-Ludwig Winnacker, who heads the Deutsche Forschungsgemeinschaft, Germany's basic-research granting agency.

Bulmahn says that the new ruling partners, led by chancellor-designate and longtime ally Gerhard Schröder, "agree on the importance of scientific research for Germany's future." In a new position paper, the coalition promises a "significant strengthening" of science budgets next year and moves to bolster German universities.

Bulmahn told *Science* that she opposes "major changes" in biotechnology policies, despite a push by some Greens for stricter controls on research involving genetically engineered plants. However, she expressed support for studies into the potential risks of certain biotechnology methods. It is not yet clear, however, how her ministry will respond to the research implications of the coalition's plans to phase out Germany's nuclear industry. The move could pinch fusion research and possibly delay the FRM-II neutron source now under construction in Garching.

of the fossils. "Everybody would say yes, these are small shellies," agrees paleontologist Douglas Erwin of the National Museum of Natural History in Washington, D.C., who has seen Azmi's paper. The question is what they mean for the age of the tracks.

In the early 1980s, Azmi found similar fossils in another Indian basin, boosting its accepted age by 400 million years into the Cambrian. He thinks the new fossils hold a similar message about the sandstone layer they overlie. As he argues in a letter on page 627, there's not much rock separating the 540-million-year-old fossils from Seilacher's trace fossils—implying that the tracks must be about 600 million, not 1.1 billion, years old. That would make them no older than other known traces of early animals.

Azmi and others add that the radiometric dates aren't as impressive as they might seem. As geochronologist Samuel Bowring of the Massachusetts Institute of Technology notes, the dates might accurately reflect the age of individual mineral grains, but those grains may have formed long before they eroded from parent rock and washed into the sea to become part of the Vindhyan sedimentary rocks. Indeed, the radiometric dates of grains from the formation containing the Cambrian fossils are also about 1.1 billion years old, suggesting that the dates may not reflect the age of the rock layer itself.

Seilacher, Pflüger, and their colleague Pradip Bose of Jadavpur University in Calcutta are just now seeing the details of Azmi's paper, but they already have some reservations. Pflüger speculates that perhaps Azmi's Cambrian fossils are not close in time to the trace fossils after all. Thick layers of sediment may be laid down in one place but not in another, and rocks can be eroded away before the next layer is laid down, making it look as if little time has passed when in fact hundreds of millions of years have gone by. Pflüger also notes that Azmi's fossils come from a part of the basin different from the one that contained the tracks, increasing the chances that fracturing and jumbling of rock layers could confuse interpretations.

And Indian researchers, including paleontologists Anshu Sinha of the Birbal Sahni Institute of Paleobotany in Lucknow and B. S. Venkatachala of the Wadia Institute, say that they are reluctant to adopt a young age for Vindhyan rocks, given the radiometric dates. They also report signs of pre-Cambrian single-celled algae and other fossils in the rocks. To prove the age of the Vindhyan, geologists may have to find and date rocks such as volcanic ash layers, which offer secure dates because they are deposited as soon as they're formed. Until then, the age of the first animals remains in question. –RICHARD A. KERR

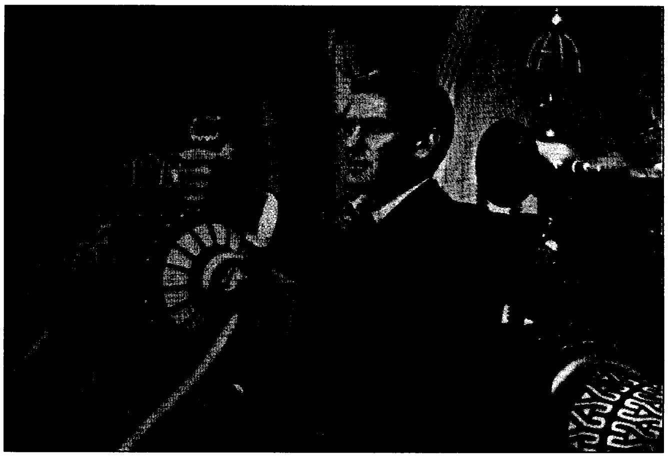
With reporting from India by Pallava Bagla.

PHYSICS

Particle Decays Reveal Arrow of Time

In the everyday world, time is a one-way street. Unlike characters in Martin Amis's novel *Time's Arrow*, we never exit a taxi and salute while it retreats down the street or awake in the evening and see our clothes come flying from the corners of the room. The microscopic level where particles collide and decay, however, has seemed indifferent to the direction of time. But two groups of researchers, at Fermi National Accelerator Laboratory (Fermilab) in Illinois and CERN in Switzerland, have now directly detected the forward march of time in the decays of subatomic particles.

Physicists once thought that the equations of the subatomic world would look the same if time were reversed. A movie of an atom decaying into bits, when run in reverse, would show a process that—although unlikely—still obeys the laws of physics: the bits converging to form a full atom. But they also knew that this time-reversal symmetry was part of a larger, more powerful package known as CPT (for charge, parity, and time reversal) symmetry, which sits at the heart of modern physics: Swap antimatter for matter, view the universe (essentially) in a mirror, and reverse the direction of time, and all the experiments should come out the same way they do in the real world. The CPT theorem (which has now been tested to an impressive 18 decimal places) meant that time-reversal symmetry could hold only if charge-parity (CP) symmetry holds as well.



Only in the movies. New findings would leave H. G. Wells's time machine (here, in a 1960 version) with nowhere to go.

In 1964, physicists found that it doesn't. They noted that neutral particles called kaons occasionally decayed in a way that blatantly violated CP symmetry. The CPT theorem could be saved only if making time flow backward changed things in a way that canceled out the CP asymmetry. No one could gather enough data to isolate the rare decays that would show this directly, however.

Now two groups have finally managed this feat, by measuring the rate of a particular decay and showing that it differs from the rate of the same process done in reverse. "I think it's truly spectacular work," says Alan Kostelecky of Indiana University, Bloomington. "This is the most important experimental advance since" 1964 for testing time symmetry.

One of the groups, the CPLEAR collaboration at CERN, collided antiprotons and hydrogen atoms to make kaons and their antimatter counterparts, antikaons. As they travel, antikaons can transform into kaons and vice versa. In results to appear in an upcoming issue of *Physics Letters B*, the team used a large tracking chamber to count the kaons and antikaons as they decayed—each to an electron, a pion, and a neutrino. The charge of the electron revealed which type of kaon had decayed. The team found that the rate for antikaons transforming into kaons was a fraction of a percent higher than for what would be the time-reversed process—kaons becoming antikaons. "This shows that you can't turn the clock backward" and always get the same results, says CPLEAR spokesperson Panagiotis Pavlopoulos.

The other group, the KTeV collaboration at Fermilab, also studied kaons, but watched for much rarer events—the 1-in-10-million decay of a single kaon into pairs of electrons and pions. The team, which presented its results at a Fermilab workshop earlier this month, mapped out the directions of the electrons and pions. Here, time asymmetry revealed itself in a subtler way. Because reversing time also reverses a particle's momentum, the team looked for time asymmetries by comparing the rates of some decays to others where the direction of the emerging particles looked as they would if time had been reversed. The rates differed by about 13%. "It's a huge effect," says Fermilab physicist and KTeV collaborator Vivian O'Dell.

Both experiments observe time asymmetry at about the level that would compensate for the CP asymmetry first observed over 3 decades ago. "I don't think anyone is sur-

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