BIRD EVOLUTION

Surprise Hummingbird Fossil Sets Experts Abuzz

If it's hummingbirds you're after, the New World is the only place to be. Of the 300-plus species of the hovering, nectar-sipping birds, almost all live in Central and South America. Experts agree that all species of modern hummingbirds evolved there and later spread to North America, but it appeared they had never set wing in Eurasia.

Now, fragile bones in 30-million-year-old rocks from southern Germany show that hummingbirds were much farther-flung than anyone expected. "The amazing thing about this fossil is that it's essentially a modern hummingbird," says Margaret Rubega of the University of Connecticut, Storrs. "My mind is a little blown." The discovery, which ornithologist Gerald Mayr of the Forschungsinstitut Senckenberg in Frankfurt, Germany, describes on page 861, raises questions about where early hummingbirds evolved and why the European ones became extinct.

Hummingbird history has long been shrouded in mystery, chiefly because the delicate-boned creatures have left so few fossils. None at all have been found in the Western Hemisphere. Hints of Old World origins appeared when a possible primitive insect-eating hummingbird, *Parargornis messelensis*, turned up in 49-million-year-old rocks in Messel, Germany. The only other fossil hummingbirds are the 30-million-year-old *Argornis caucasicus* and *Jungornis tesselatus*, both incomplete, from the Caucasus. They appear to have been able to hover, but it's not clear whether they had modern-style beaks. Last year Mayr classified all three as "stem taxa," extinct relatives that share a common ancestor with modern hummingbirds, but not all experts were convinced. ▶

Wider range. Hummingbirds, such as *Amazilia rutila*, live only in the Americas today, but they once inhabited Europe.

UNDERGRADUATE SCIENCE

Harvard Joins Reform Movement

BOSTON—Harvard University has joined a growing number of elite schools attempting to revamp undergraduate science education. The effort, which is part of a larger rethinking of Harvard's entire undergraduate program, could double the number of science courses required of nonscience majors, provide a more interdisciplinary approach to life and physical sciences, and encourage students to conduct research abroad.

Last week, a panel of students, faculty, and administrators delivered a 69-page report* that proposes new introductory science courses and urges the university to give its undergraduates "a genuine view of the excitement of research science." Scientists across the country say that changes at Harvard College, to be spelled out over the next year, are sure to spark increased interest among other universities in overhauling undergraduate science courses.

The reform movement is driven by concern that many undergraduates are turned off by their science courses and leave school without an appreciation for research. To address that problem, this fall Columbia University in New York City will require that all undergraduates take a general course called "Frontiers in Science" (*Science*, 18 October 2002, p. 531). Taught by star professors, the course will include small weekly seminars. Other schools, such as the University of Michigan, Ann Arbor, are experimenting with greater undergraduate involvement in research projects. And the University of Wisconsin, Madison, has restructured its tenure and merit-pay criteria to encourage better science teaching.

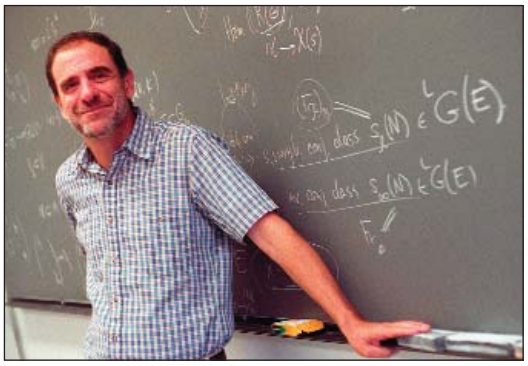
The Harvard report examined the needs of undergraduates in three categories—science majors, those preparing for medical school, and those whose interests lie outside science. It recommends that all undergraduates take one interdisciplinary course in life sciences and one in physical sciences, rather than the current system of choosing an introductory course in one of the two fields. "This is a significant new emphasis on educating all students," says Harvard biologist Richard Losick, who was involved in the study. "This will be real science teaching, not the history of science or science for poets."

Those majoring in science, says the report, should be given more opportunity to experience how science is conducted by working in a research lab. The report's emphasis on international experience, says Losick, should be extended to opportunities for doing lab science around the globe.

Benedict Gross, a mathematician and dean of Harvard College who co-chaired the study, says Harvard this summer will appoint a science working group to come up with a detailed science curriculum. The details could be ready for discussion by the entire Harvard community by the end of the next academic year, he adds. The last major change to Harvard's undergraduate curriculum took place in 1978.

Harvard's freshman class of 1650 is tiny compared to the enrollments of many state universities. But outside scientists and administrators say having Harvard on board should further their reform campaigns. "This is terrific," says Peter Bruns, vice president for grants and special projects at the Howard Hughes Medical Institute in Chevy Chase, Maryland, which has funded efforts to improve undergraduate education. "And it is about time, since we live in an increasingly scientific world." **–ANDREW LAWLER**

* *A Report on the Harvard College Curricular Review*, April 2004, at www.fas.harvard.edu/curriculum-review/HCCR_Report.pdf



Problem solver. Mathematician Benedict Gross is counting on his colleagues to help improve Harvard's curriculum.

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The new fossil, called *Eurotrochilus inexpectatus*, is the first fossil of a modern-looking hummingbird and the closest to modern ones. When Mayr came across two partially prepared specimens of the creature in a museum drawer in Stuttgart, "I didn't have a real idea what it was," he says. But closer inspection revealed evidence that the specimens were hummingbirds. One of them sports a long, slender beak adapted for feeding on nectar. The clincher was the short, stocky humerus with a bony knob that probably allows the wing to rotate during hovering flight. Although the tip of the beak is not preserved, Mayr estimates that the bird measured 4 to 5 cm from head to tail, as big as a medium-sized modern hummingbird.

Not everyone accepts the identification. "The similarities with modern hummingbirds are pretty superficial," says Joel Cracraft of the American Museum of Natural History in New York City. Other experts, however, say they are convinced.

Eurotrochilus demonstrates that in the Old World, hummingbird ancestors had evolved the main features of living hummingbirds by 30 million years ago, Mayr says. That might explain why a handful of European flowers appear adapted for hovering birds, he adds. It could be that these plants first evolved with hummingbirds and were pollinated by them. This conclusion makes sense to Ethan Temeles, an ecologist at Amherst College in Massachusetts who studies the coevolution of plants and pollinators. Finding a fossil pollinator, as Mayr has done, can help explain the evolutionary history of both the plant and pollinator, he says.

Why did Old World hummingbirds become extinct? One possibility, Mayr says, is that songbirds outcompeted them. Where the whole hovering tribe came from, meanwhile, remains up in the air. The four European fossils could suggest that stem taxa first appeared in the Old World and spread to the Americas across the Bering Strait, but the fossil record is so sparse that it's just speculation. Answering those questions will take more discoveries. For paleontologists scouting for clues to hummingbird history, the Old World may become the new place to be. **–ERIK STOKSTAD**

NEUROSCIENCE

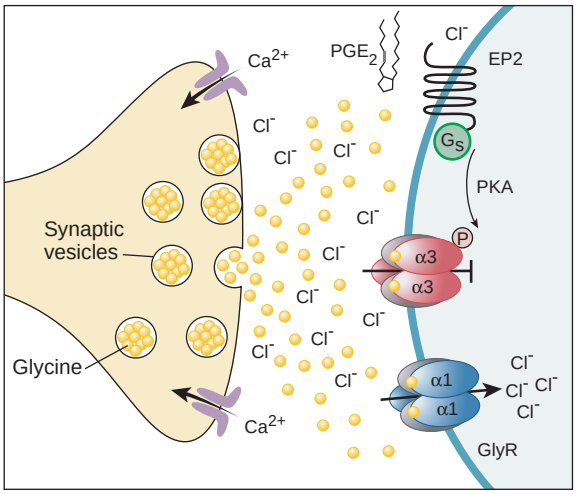
Locating a New Step in Pain's Pathway

As pain sufferers can attest, there's room for improvement in painkilling medications. Many of the current ones can cause side effects, such as stomach ulcers, particularly in people who have to take them over long periods of time for conditions such as arthritis. Work described in this issue now points to what may be a good new target for analgesic drugs; it also sheds light on an inflammatory pain sensitization, which causes patients to feel intense pain even in response to normally innocuous stimuli such as a light touch.

On page 884, an international team led by Ulrike Müller of the Max Planck Institute (MPI) for Brain Research in Frankfurt, Germany, reports having identified the α3 form of the receptor for the neurotransmitter glycine as a key intermediate in transmitting pain signals from the spinal cord to the brain. The work shows that the receptor is needed for pain sensitization—the first time a function has been identified for this particular receptor.

Previously, pain sensitization, or hyperalgesia, was thought to be due predominantly to changes at the inflamed sites themselves, but recent evidence suggests that alterations in the spinal cord are even more important. The new findings now confirm that; they show that the glycine receptor is the target of prostaglandin E_2 (PGE_2), a pain-sensitizing signaling molecule. "They identified a specific component that shows how this [pain sensitization] system works," says Anthony Yaksh, whose group at the University of California, San Diego, also has evidence that PGE_2 acts in the spinal cord.

When Müller began her work several years ago, her goal was to identify a function for the α3 type of glycine receptor. Robert Harvey, a former MPI colleague now at the School of Pharmacy in London, U.K., produced antibodies that enabled the team to locate the receptor in the spinal cord. In contrast to other glycine receptors, which are found throughout the cord, the α3 receptor occurs only in a particular layer where pain neurons from the peripheral tissues terminate. That suggested it might somehow be involved in transmitting pain signals.



Giving pain a boost. Glycine binding to the α3 receptor normally triggers chloride ion movement into the target neuron, inhibiting its action. But PGE_2 binding to its receptor causes phosphate addition to the α3 receptor, blocking the chloride influx and thus boosting neuronal activity.

At that point, the Frankfurt team joined forces with Hanns Ulrich Zeilhofer and his colleagues at the University of Erlangen-Nürnberg, whose earlier work had hinted at a possible role in pain for a glycine receptor. It showed that PGE_2 inhibits glycine receptor activity in the same spinal cord layer where the MPI group had found the α3 receptor. Because glycine receptors suppress neuronal firing, inhibiting them with PGE_2 could facilitate transmission of pain signals to the brain. At the time, however, there were no tools with which to prove that. But now Müller and Harvey wondered whether the Zeilhofer group had encountered the α3 receptor. Further studies by the Zeilhofer group confirmed that hypothesis. Recordings of electrical signals from spinal cord neurons showed that PGE_2 inhibition was totally absent in tissue from mice in which the α3 receptor gene had been knocked out.

To pin down the receptor's role, the researchers compared pain responses in the knockout mice with those in normal animals. The two groups responded the same way to acute pain stimuli. But when the researchers first induced inflammation in the animals' paws by injecting an irritant, they found that the prolonged sensitization to further pain stimuli seen in normal animals did not occur in the knockouts. "Central prostaglandins work only through this one receptor" to promote pain sensitization, says pain expert Clifford Woolf of Harvard's Massachusetts General Hospital in Boston.

That also means that aspirin and other so-called nonsteroidal anti-inflammatory drugs, which produce analgesia by blocking prostaglandin production, exert their effects in the spinal cord, and not just in peripheral tissues as was once thought. And as Yaksh points out, the α3 glycine receptor itself "potentially represents an important target for drugs in chronic pain states." If researchers find drugs that stimulate the receptor, they may be able to expand the arsenal of analgesics. **–JEAN MARX**

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