test—called a uranium series—where he measured the amount of daughter elements produced by the decay of uranium in the teeth. The result was a date between 139,000 and 173,000 years ago.

But Schwarcz adds a caveat: These dates are for the hippo teeth, not the bone artifacts or the soil surrounding the artifacts. It is possible that the teeth were washed into the soils at a different time from the bone, although Schwarcz doubts this occurred. "There are risks involved with any kind of dating," says Schwarcz. "But I feel reasonably confident about the window in which we've placed these dates."

If that window through time hasn't distorted the view, the Katanda bone tools are in a class by themselves. Not only are these the oldest such tools, but they also come in a variety of shapes and sizes, including points with both rounded and flattened shafts, some with barbs, and a flat dagger. "The people who made them really had a sense of bone as a plastic medium that could be used for very different things," says Yellen. This indicates that the toolmakers were engaging in sophisticated behavior: planning ahead for activities like fishing—hence the barbs—or possibly hunting with some of the other tools.

Other aspects of the site also suggest the ability to plan. People appeared to be camping at Katanda to fish during the catfish spawning season, says Brooks. They were also using ocher pigments and grindstones made of materials that were not local and must have been deliberately carried to the site from another place. "I think we're seeing the capacity to plan ahead and to conceptualize complicated technologies," says Brooks. "We're seeing a level of sophistication in several domains of behavior—the social aspect, the aesthetic aspect, the technological and economical aspect."

Still, this is nothing compared with the sophistication seen in Europe at 35,000 to 40,000 years ago, says Robbins. At that time, modern humans were artistic—making blades, ornaments, and necklaces, and decorating the dead with ocher. "What you have at Katanda is one part of that suite of things that indicates modern human behavior—not necessarily the whole package," says Robbins.

That in itself may not be so odd—a lot can happen in 50,000 years, after all—but another aspect of the discovery troubles Stanford University paleoanthropologist Richard Klein, who is a co-author on one of the papers. "Why don't we have the same early evidence for modern human behavior at other sites in Africa?" he asks. "Why does this site stand out like a big, sore thumb?"

Yellen thinks one reason is that "people are acting in very localized ways, without vast open networks where their ideas are spread around." Brooks adds that archaeologists may have missed the earliest signs because they have been looking in the wrong places—at rock shelters, which apparently were living sites, rather than hunting venues that would contain weapons.

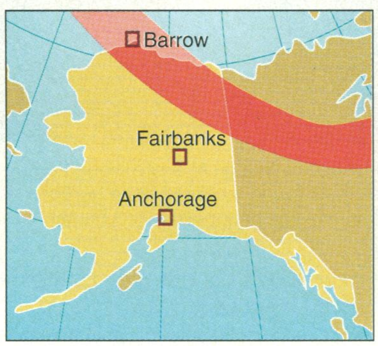
Brooks and Yellen are planning to look hard in what they consider to be the right places. For until archaeologists see signs of this sophisticated activity at other sites in the same time period, doubts will abound. Says Clark: "With something this controversial, one would have to find another site to substantiate this." If researchers pull another finely crafted bone point from such ancient ground, this time the reaction would be celebration.

–Ann Gibbons

SPACE PHYSICS

Forecasting the Northern Lights

When the aurora borealis flickered overhead, the Norse once recognized the warlike Valkyries, and medieval Europeans to the south saw ominous portents. The gods and omens faded when the aurora turned out to be the handiwork of high-energy particles bombarding the upper atmosphere, and now the northern lights may lose a little more of their mystique: Since late March, newspapers and television stations in Alaska have been presenting forecasts of the aurora along with the weather outlook, describing it in the same breath as sleet and ground fog.



SOURCE: GEOPHYSICAL INSTITUTE, UAF

PHOTO RESEARCHERS

One week's forecast. A map showing the auroral zone for late April *(left)* was posted on the World Wide Web.

But the fascination of these celestial displays is as great as ever, which is why everyone from scientists to ordinary gawkers is welcoming the forecasts, posted twice a week on the Internet's World Wide Web (http://www.gi.alaska.edu) by the Geophysical Institute of the University of Alaska, Fairbanks (UAF). For researchers who probe the notoriously erratic discharges with rockets, the forecasts of aurora location and intensity improve the chance of choosing the best launch "window." They have also been a hit with tourists and local residents who just want to know if they can catch an aurora over the weekend. "They've been right on," says Walter Munly, a television weatherman at KATN in Fairbanks who has incorporated the forecasts into his show.

UAF geophysicists Syun Akasofu and Charles Deehr produce the forecasts by combining observations of solar activity with worldwide data on Earth's magnetic field. They are more than just handy predictions. The aurora is a visible sign of turmoil in the far-flung system of charged particles and magnetic fields that emanates from the sun—turmoil that can also disrupt communications and menace satellites. By predicting aurorae, geophysicists hope to test their understanding of these particles and fields. "If you're successful time after time in making these predictions, it says you're pretty much on the right track," explains space physicist Daniel Baker of the University of Colorado, Boulder, who has his own approach to aurora prediction.

Just how the sun drives the aurora is "extremely controversial," says Roger Arnoldy, director of the Space Science Center at the University of New Hampshire in Durham, but researchers do agree on the outlines of the process. Arnoldy explains that during the quiet minima of the sun's 11-year sunspot cycle, such as the present, most auroral activity can be traced to long-lived solar features called coronal holes, areas that appear dark in soft x-ray pictures of the corona. Elsewhere on the sun, the magnetic field loops back to the surface, trapping most charged particles, but at the holes, the field lines wander into space. As a result, the holes spout streams of charged particles that spin like lawn sprinklers with the sun's 27-day rotation.

As the particles fly outward, they sweep up and intensify fluctuations in the magnetic field that travels with the slower "wind" of particles blowing steadily from the sun. When one of these bundles of intensified field runs into Earth's magnetosphere—a region of calm in the solar wind, carved out by Earth's own magnetic field—they can cause mayhem if the bundle's lines point southward, in the opposite direction from Earth's. The two sets of field lines can then splice into each other, allowing particles from the solar wind to leak into the magnetosphere. Poorly understood mechanisms roil the magnetosphere, and the spliced field lines are stretched downwind, where they can snap back, slinging lumps of plasma toward Earth.

Inside the magnetosphere, all of this action sends electrons scooting down the magnetic field lines that curl toward Earth at high latitudes. Bombarded by the electrons, oxygen and nitrogen atoms in the upper atmosphere glow, creating aurorae in oval-shaped regions ringing the magnetic poles. At the same time, the magnetic disturbances that accompany the huge electrical currents at the poles rattle the magnetic field all over the globe. Worldwide magnetometer data can thus provide a continuous, composite measure of auroral activity.

Deehr and Akasofu try to forecast this activity by searching the magnetometer data for disturbances that recur every 27 days—the time it takes the sun to rotate once, sweeping its sprinkler streams of particles past Earth. But because the coronal holes that ultimately drive the disturbances can shrink, vanish, or migrate from one solar rotation to the next, Deehr and Akasofu also keep an eye on reports from solar observatories. They then combine the observed periodicities with recent changes in the holes to predict magnetic activity 4 or 5 days in advance.

To translate the expected magnetic activity into an aurora forecast, the team searches archived satellite pictures of the auroral ovals, looking for an image that shows the brightness and extent of aurorae at a comparable level of magnetic activity. The method probably won't work well at solar maximum, when the sun's behavior is more fickle. And even now the drifting coronal holes can throw off the timing of the displays by a day or so, says Akasofu. But on the whole, he says, the agreement between the forecasts and the observations has been "quite a lovely thing."

Eugene Wescott, a UAF geophysicist who used the forecasts to help time a rocket launch on Saturday, 25 March, agrees. Without the forecast, he might have considered firing into the faint aurora that appeared earlier that week. "But the predictions were that it was going to get better for the weekend," he says. His reward for waiting? "We had a quite good aurora" for the experiment.

Deehr and Akasofu admit that their main motivation for going public with the forecasts wasn't scientific, however. They just hoped to cut down on the hundreds of phone calls they receive each year from American and Japanese tourists seeking the inside word on auroral displays. It seems the aurora hasn't lost all of its old magic.

–James Glanz

James Glanz is a science writer in Chicago.

MEETING BRIEFS

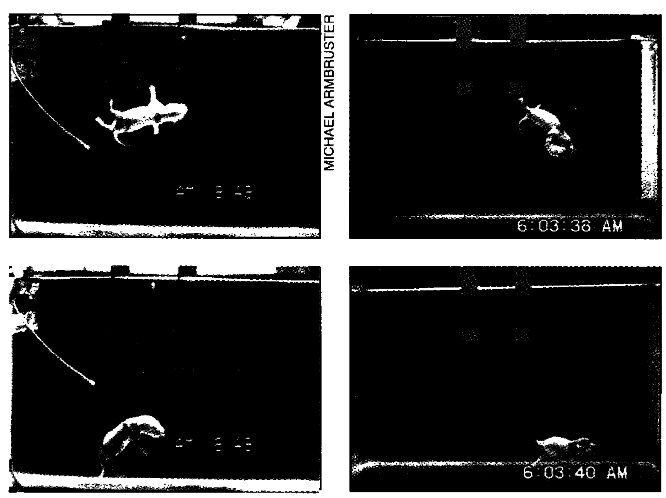
NASA's Space Biology Program Shows Signs of Life

HOUSTON—At the first Life Sciences and Space Medicine Conference, held here from 3 to 5 April, NASA Administrator Daniel Goldin made it clear that NASA's life sciences program is not exempt from his drive to reinvent the space agency. "We've got to do things differently to get to our goal" of making long-duration space travel a reality, he told the audience. He stressed "rigorous peer review," collaboration with investigators at the National Institutes of Health and in industry, and the development of commercial spin-offs. Once NASA's overhaul is complete, "life sciences will be the jewel in the crown," Goldin told *Science*. But as the meeting revealed, there are already some bright spots.

Unbalanced Rats

It's well known that for normal development of its sensory nervous system, an infant must experience the full clamor of changing sight, sound, taste, and touch stimuli available on Earth. Now it seems that a more constant stimulus—gravity—may also be crucial for sensory development.

Rat pups that spend part of their fetal development in the microgravity of space are born with a "dramatic" impairment in their sense of balance, Jeffrey Alberts, a developmental psychobiologist at Indiana University in Bloomington, told attendees. Biologist Kenneth Souza of NASA's Ames Research Center in Moffett Field, California, calls the results "convincing," but he and Alberts say further experiments are needed to show that the impairment is a permanent developmental change rather than a temporary adaptation to microgravity.



MICHAEL ARMBRUSTER WILLIAM FARRELL

Out of kilter. Rat pups that spent part of their gestation in space *(right)* are slower to right themselves in a water bath than are controls *(left)*.

In last November's experiment, 10 pregnant rats were flown aboard NASA's space shuttle Atlantis; two control groups of 10 pregnant rats each remained on Earth. After 11 days in space, Atlantis returned home; the 30 mother rats gave birth 2 days later. Alberts and April Ronca of Indiana University then ran at least one pup from each litter through tests of the vestibular system—sensors in the inner ear that keep track of gravity and body position, generating a sense of balance.

The space pups fared badly. For instance, the so-called "water-drop righting response," in which a rat placed on its back in a bath of water uses a coordinated sequence of movements to right itself, was far slower in pups that developed under microgravity than in either set of controls. "The flight rats are less responsive to the stimulus of being upside down," says Alberts.

One of the next steps will be to find out whether the absence of Earth's gravity triggers structural changes in the brain circuits that process information from the vestibular system. If it does, developmental neurobiologists won't be surprised. In the 1960s and '70s, David Hubel and Torsten Wiesel, then at Harvard Medical School, showed that if a kitten is deprived of light, the nerve cells in the brain cortex that process visual information do not make the highly organized pattern of connections that is seen in a normal cat. Since then, studies of hearing, touch, and smell have all confirmed that a sensory system needs input to develop normally. There's no reason to think balance is exempt, Alberts said, because when it comes to developmental processes, "it's a rule—almost a law—that input affects structure."

Swelled Heads in Space

Vomiting in space is both peculiarly messy and potentially dangerous because it can block the valves of a space suit. Arriving in