waveguide focuses 80% of the light on the laser's active region, compared to about 50% for a traditional waveguide, making the laser much more efficient. The plasmon version is also half the thickness of the traditional 8-micrometer waveguide and still within the capabilities of existing deposition processes.

Best of all, the new technique permits longer wavelength infrared beams. These allow the emitted light to be tuned to make molecules bend, revealing them to a detector as surely as fingerprints pinpoint a criminal. The surface plasmon laser emitted beams of 19-micrometer infrared light—the longest wavelength emitted by a semiconductor laser so far. And Capasso hopes to go even further: "We think we'll be able to do 60 to 80 microns."

Zare hopes that the prototype device might lead to many new applications. "This was a gap where we now have neat light sources," he says. For instance, a laser in that region of the spectrum might be tunable to detect the vibratory motion of various molecules, allowing a robot to detect the molecules' presence. "The applications [include] detecting explosives and chemical and biological agents, looking at disease states, and medical diagnosis," says Zare. Although the lasers still must be kept at temperatures too cold to be widely used, Zare thinks that room-temperature lasers are possible: "I've got lots of hope." –CHARLES SEIFE

PALEONTOLOGY

## First Upright Vertebrate Lived Fast, Died Young

Early land vertebrates were a cloddish crew. When amphibians first sloshed ashore, some 360 million years ago, they waddled like soldiers crawling under barbed wire. Even after reptiles began to spread into drier landscapes and diversified, these landlubbers still plodded on all fours using the same sprawled stance. Paleontologists thought that the pace didn't pick up until fleet-footed bipedal dinosaurs appeared in the Late Triassic, about 210 million years ago.

Now a fossil discovery shows that at least one reptile was dashing around on two legs in the Early Permian, as much as 80 million years before the first dinosaur. On page 969, Robert Reisz of the University of Toronto in Mississauga, Ontario, Canada, and David Berman of the Carnegie Museum of Natural History in Pittsburgh and their colleagues describe *Eudibamus cursoris*, a 25-centimeter-long herbivore that is the earliest known vertebrate able to run on its hindlimbs. "When I first heard about this fossil, I was just amazed," says Hans-Dieter Sues of the Royal Ontario Museum in Toronto. "I didn't expect a bipedal creature that far back in time." The find suggests that bipedalism may be more common than previously thought—but not necessarily a sure route to evolutionary success.

The 290-million-year-old fossil was discovered by Stuart Sumida of California State University, San Bernardino, in 1993 in a quarry near Gotha, Germany. For about a decade, scientists working with Thomas Martens, a paleontologist at the Museum der Natur Gotha, have been uncovering relatively complete, well-preserved specimens from the quarry. The spot represents an upland environment quite different from the lowland deltas and floodplains in which most Paleozoic fossils have turned up. It took 2 years to prepare the small, delicate specimen. Once the bones were revealed, the group realized that the fossil was unique, too.

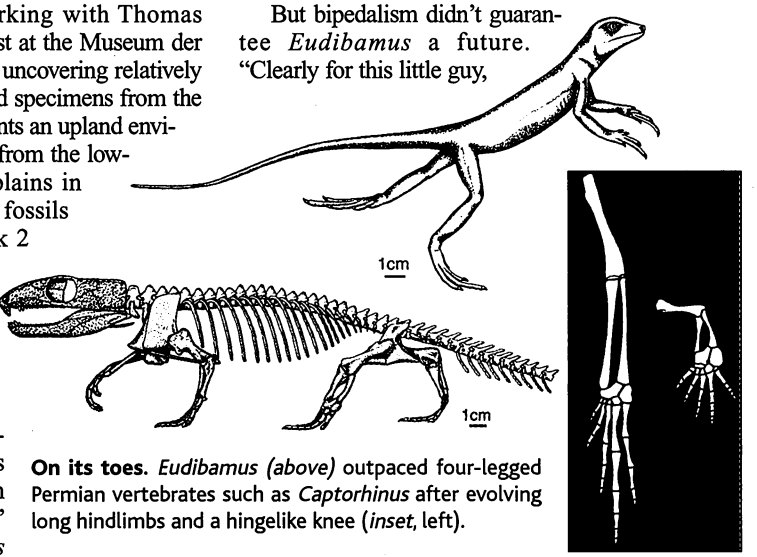
"What's really exciting is that this fossil is the first instance of an animal built for speed," Reisz says. *Eudibamus* had hindlimbs that were 64% longer than its forelimbs and 34% longer than its trunk, proportions comparable to those of modern lizards that run on two legs. Feet sporting long digits would have given the animal a substantial stride. "It ran on its toes, especially when it got going," Berman says. "That's what all fast animals do."

Its tail also helped it move quickly, Berman says. Like the tails of modern bipedal lizards (and unlike those of its fellow Permian vertebrates), the tail of *Eudibamus* makes up more than half the length of the creature's body. Muscles attached to such a hefty appendage could have made *Eudibamus*'s hindlimbs powerful enough for two-legged sprinting. The arrangement also kept the animal's center of gravity close to its hip, a necessary feature for balancing a two-legged gait.

*Eudibamus* had also evolved a new kind of knee joint—one that allowed it to run with its feet directly underneath its body. In other vertebrates of the time, the legs jutted outward from the body. That's because one of the paired shinbones (tibia) connected with the underside of the mostly horizontal thigh bone (femur), while the other shinbone (fibula) attached to the end of the femur. By contrast, both shinbones in *Eudibamus* fit onto the end of the femur, forming a hingelike joint that puts all of the leg in one plane, just as in humans and dinosaurs. The result is an energy-efficient posture that allows the bones, not just muscles, to help support the animal's weight.

*Eudibamus* probably wasn't an ideal biped; its limbs might have tended to splay out to the side when it wasn't running. Even so, Reisz and his colleagues speculate, its two-legged posture could have given the animal a crucial edge over four-legged predators. That evolutionary advantage may explain the widespread dispersal of *Eudibamus*—inferred from fragmentary fossils of its relatives—across the northern continent of Laurasia.

But bipedalism didn't guarantee *Eudibamus* a future. "Clearly for this little guy, it didn't make much of a difference," Sues says. "This was a very short-lived evolutionary lineage, as far as we know." Michael Caldwell of the University of Alberta in Edmonton suspects that bipedalism may have evolved many times in vertebrate history before dinosaurs, birds, and primates made the innovation an evolutionary success. In giving lug-necked predators a run for their money, *Eudibamus* may have been just one of any number of creatures darting briefly ahead of their time. –ERIK STOKSTAD




**On its toes.** *Eudibamus (above)* outpaced four-legged Permian vertebrates such as *Captorhinus* after evolving long hindlimbs and a hingelike knee (*inset*, left).

CREDITS: (*EUDIBAMUS* AND FEET) D. BERMAN *ET AL.*; (*CAPTORHINUS*) M. J. HEATON AND R. R. REISZ/*JOURNAL OF PALEONTOLOGY* 54, 136 (1980)

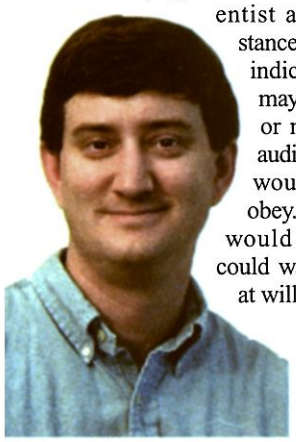
SCIENCE AND COMMERCE

## Digital Music Safeguard May Need Retuning

A hacker-professor says he and his graduate students have cracked the four leading methods proposed for thwarting audio pirates. Ed Felten, a computer scientist at Princeton University, says his achievement shows that so-called digital watermarks—identifying signals hidden inside streams of digital data—cannot protect music from illegal copying. But the music industry begs to disagree.

The charges and countercharges center on a competition sponsored by the Secure Digital Music Initiative (SDMI), a forum of music, technology, and electronics companies that is designing a method to thwart illegal copying of audio files. SDMI champions a protection scheme analogous to the ghostly image of Andrew Jackson that appears next to the Treasury department seal when you hold a new $20 bill up to the light. "A device

can scan for a watermark, detect the watermark, and make a decision based upon whether the watermark is there," says Scott Craver, a graduate student and computer scientist at Princeton. For instance, the watermark might indicate that an audio file may be copied only once, or not at all—orders that audio players and recorders would be constructed to obey. But such instructions would be moot if hackers could wash off the watermark at will.



**Skeptic.** Ed Felten says audio watermarks will fail.

SDMI's quest for a secure digital watermark went public in September, when the consortium posted four proposed watermarking schemes and two supplementary technologies on one of its Web sites (www.hacksdmi.org). An accompanying letter offered $10,000 to anyone who could hack any of the security schemes within 3 weeks. "Attack the proposed technologies," read the letter. "Crack them."

Many computer-security experts flatly refused. Don Marti, the technology editor of *Linux Journal*, arguing that SDMI's scheme is a unilateral attempt by the music industry to recast intellectual property rights in its favor, called for a boycott of the HackSDMI effort. "I wanted to call people's attention to the legal rights SDMI is planning to take away," Marti says. Others dismissed the competition as a waste of time. "Challenges and contests are stupid ways of assessing security," says Bruce Schneier, chief technology officer of Counterpane Internet Security in San Jose, California. "If I challenge people to break into my house and it's not robbed in a week, can I conclude that my house is secure? It's bizarre." Craver agrees: "A 3-week challenge could not be taken seriously in the cryptographic community." Nevertheless, Felten, Craver, and others ignored the boycott and attacked the watermarks.

Last week, Felten and Craver's team declared that it had defeated all four watermarking schemes. "Basically, for each of the technologies, we figured out where in the signal each watermark was put and then washed it out," Felten says. "For instance, if it's all stored in a narrow frequency band, you can add a bit of noise in that frequency band." Felten claims that removing the watermarks didn't damage the quality of the music. The SDMI consortium agreed that Felten's sample had no watermark and sounded just fine, at least in a preliminary inspection.

The result proves that "watermarking technology is not mature enough to do what SDMI wants it to do," Felten says. But SDMI isn't convinced. "The word we received was that all 153 attacks have failed to meet the criteria," says David Leibowitz, chair of San Diego–based Verance, which provided one of the four watermarking schemes. SDMI officials say the Princeton team did not submit technical information showing that it had devised a general strategy for defeating watermarks. As Leonardo Chiariglione, SDMI's executive director, explains, "If every bit of new music is a new challenge, if repeatability is not guaranteed, it is not considered a successful attack."

Some experts, though, see Felten's attack as a confirmation that copy-protection schemes will never deter any but the most inept would-be pirate. "Digital bits can be copied; it's the natural way, and any procedure that tries to go against the tide will fail," Schneier says. "Watermarks can't possibly work. Copy protection can't possibly work. Get over it. Accept the inevitable, and figure out how to make money anyway."

—CHARLES SEIFE

CREDITS: (TOP TO BOTTOM) FELTEN CONSULTING INC.; P. BAGLA

INDIA

## New Guidelines Promise Stronger Bioethics

**NEW DELHI**—The Indian government has issued new guidelines for conducting medical research on humans that would raise standards and tighten oversight at most institutions. The voluntary guidelines, released on 18 October, are also expected to bolster international collaborations by putting Indian practices on a par with standards in the West.

Although the guidelines will mean more paperwork for an already clogged bureaucracy, most scientists say that they are an important step toward ensuring ethical research. "It is expected that all institutions that carry out any form of biomedical research involving human beings should follow these guidelines," says Nirmal Kumar Ganguly, director-general of the Indian Council of Medical Research (ICMR) in New Delhi.

Four years in the making, the new guidelines would create a network of institutional review boards. That in itself would be a major change: An ICMR survey last year of 30 leading research institutions found that most had no ethical committees overseeing experiments involving humans. The few committees that did exist were generally moribund, meeting rarely and having little influence on major research decisions.

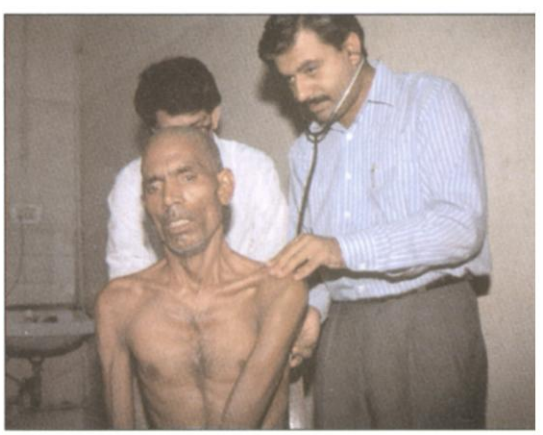
The new guidelines, titled "Ethical Guidelines for Biomedical Research on Human Subjects," stipulate that each research proposal that involves human testing will be vetted by an institutional ethics committee. Its five to seven members must include a legal expert, a social scientist, a philosopher, and a community representative in addition to researchers. All committee decisions will be made at a "formal meeting" and not "through the circulation of a proposal." Once cleared, the protocols would receive no further ethical review.

In addition to enshrining the principles of informed consent and confidentiality, the guidelines specify the nonexploitation of vulnerable groups such as the poor and mentally challenged people. It also says that anyone in a trial who has an adverse reaction should receive the "best possible nationally available care."

The guidelines were unveiled at a meeting here of the Indo–U.S. Biomedical Research Policy Forum, which seeks to resolve obstacles to collaborative biomedical research between the two countries. Gerald Keusch, director of the Fogarty International Center of the U.S. National Institutes of Health, who attended the meeting, called the guidelines "comprehensive." He said they "have the same philosophic context" as those that federally funded researchers and their U.S. institutions must follow.

Absent binding legislation and additional resources, the success of the voluntary guidelines will depend on the response of the scientific community. "There is no way the ICMR can be the policing agency," says Vasantha Muthuswamy, chief of basic biomedical research at ICMR and secretary of the Central Ethics Committee on Human Research, which formulated the guidelines. And that puts the burden on those who fund the research, as well as those who carry it out. "Now that a strong ethical framework has been put in place, it is up to the grant-giving agencies to ensure that funding is not given in instances where ethical violations are noticed," says Prakash Narain Tandon, a neurosurgeon and professor emeritus at the All Indian Institute of Medical Sciences in New Delhi.

—PALLAVA BAGLA



**Standard of care.** Indian doctors examine a tuberculosis patient being recruited for a drug trial.