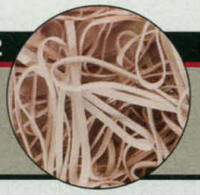
508
Move to sequence malaria mosquito

LEAD STORY 512
Stringing the universe along



518
Why mammals have seven neck vertebrae

Michigan leaders hope their plan for a "life sciences corridor" centered around the state's research universities will put the area on the map as a powerhouse comparable to, say, Research Triangle Park in North Carolina. The plan makes use of $8.5 billion Michigan will receive from the settlement last November with tobacco companies, under which 46 states will recover the costs of treating tobacco-related illnesses. The only comparable program is a 10-year-old research fund in California financed by cigarette taxes that allocates about $20 million a year to state scientists. Some other states have modest research programs on the drawing board.

The Michigan Health and Aging Research and Development Initiative—its official name—was proposed by the presidents of Michigan State University, the University of Michigan, and Wayne State University, as well as the Van Andel Institute for Medical Research and Education in Grand Rapids, founded by the family that owns the Amway company. The governor will appoint members of those institutions to serve on the steering committee, and awards will be made on a competitive basis to scientists in Michigan. Although the budget for 2000 has already been set at $50 million, subsequent budgets will be approved by the legislature.

The specific agenda has not yet been decided but is governed by legislation that calls for spending 40% on basic research, 50% on applied collaborative projects, and up to 10% on commercial development. Robert Huggett, research vice president at Michigan State, says "we want to focus at the molecular genetic level" on topics that might range from neuroscience to diabetes. The initiative's planners have talked about using some money "to bring in world-class scientists in a few critical areas" and build infrastructure such as nuclear magnetic resonance facilities shared among universities, says James B. Wyngaarden, former director of the National Institutes of Health and a member of the Washington Advisory Group, a consulting group in Washington, D.C., that helped design the initiative. But "there's an awful lot of planning to be done," he adds.

Not everyone is happy with Michigan's plan, which would spend most of the rest of its settlement on college scholarships. Antitobacco advocates are disappointed that none of the money will go for smoking prevention programs. Michigan "doesn't have anything approaching a comprehensive tobacco prevention program," asserts Joel Spivak of the Campaign for Tobacco-Free Kids.

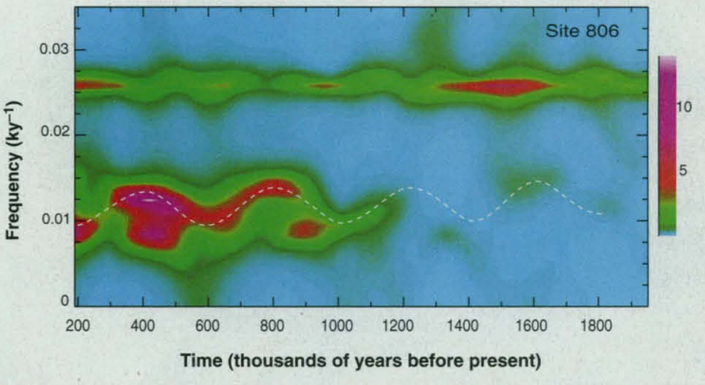
But scientists in Michigan are giddy with anticipation. "This is a great story and an exciting day for Michigan," says George Van de Woude of the National Cancer Institute, who as of October will be the new research director of the Van Andel Institute.

–JOCELYN KAISER

PALEOCLIMATE

Why the Ice Ages Don't Keep Time

According to the textbook theory, the ice ages and much other climate change should unfold with clocklike precision. In this astronomical or Milankovitch theory, the pacemaker for climate cycles over tens to hundreds of thousands of years is the rhythmic nodding and gyroscope-like wobbling of Earth's spin axis and the periodic stretching of its orbit, all of which change climate by redistributing sunlight across the planet. These cycles can be calculated millions of years into the past, and ice cores and other climate records do reveal climate swinging from one extreme to another with pendulum-like precision in time with some orbital forcings. But other climate changes, including the ice ages themselves, don't quite keep time, raising doubts about how much the astronomical theory can explain (*Science*, 8 May 1998, pp. 828 and 874). In this issue of *Science*, two studies attempt to tidy up some of these loose ends and reassert the power of the astronomical climate clock.



Climatic pitch. The frequency of the ice ages varies in time with a 413,000-year orbital cycle (dotted line), while a shorter cycle (top) goes unmodulated.

On page 564, geophysicist José Rial of the University of North Carolina, Chapel Hill, explains why the timing of the ice ages seems to be off by invoking an interaction between orbital forcings that resembles the way FM radio signals are generated. The work "show[s] that the Milankovitch frequencies really are deep in the [climate] data set," says geophysicist Jeffrey Park of Yale University. And on page 568, geographer–plant ecologist Katherine Willis of Oxford University and her University of Cambridge colleagues present a new record of the start of the ice ages 2.75 million years ago suggesting that an intensification of one orbital cycle may have triggered a surprisingly abrupt drop into northern glaciation.

Although cycles of 23,000 and 41,000 years in the climate record do match up precisely with Earth's wobbling and nodding, the ice ages don't keep to the 100,000-year schedule that should be set by the periodic elongation of Earth's orbit. Some ice ages have come as much as 120,000 years apart; other cycles have been as short as 80,000 years, Rial says. But he noticed an underlying regularity: A complete cycle from quicker, higher frequency cycles to slower, lower frequency cycles took about 400,000 years, suggesting that yet another astronomical cycle—a second, 413,000-year cycle in orbital elongation superimposed on the shorter cycle—might be modulating the frequency of the 100,000-year cycle the way broadcasters "frequency modulate" a carrier signal to produce FM radio broadcasts.

To test his idea, Rial calculated how a 413,000-year signal should modulate a 100,000-year one and checked the climate record to see how it matched the simulation. He found that the frequency of the 100,000-year cycle has risen and fallen in time with the longer modulating cycle, matching the calculation. As in an FM broadcast, the modulating signal itself failed to show up in the climate record but left its fingerprints in pairs of "sideband" signals that have frequencies just above and below the carrier frequency. Rial found exactly the predicted

SOURCE: J. RIAL/UNC CHAPEL HILL

pattern of sidebands in the climate record, including a prominent 107,000-year oscillation. Frequency modulation "changes periodically the duration of the ice ages," says Rial. "It's a pretty idea."

He can't point to a particular physical mechanism that would translate the 413,000-year cycle into a lengthening and shortening of the 100,000-year cycle, although he says that the longer cycle of sunlight changes may interact with an oscillating part of the climate system, such as ice sheets. Even so, other climate specialists are taken with the frequency-modulation idea. "I like very much the ideas of Rial," says paleoclimatologist André Berger of the Catholic University of Louvain in Belgium. "Orbital forcing is certainly the pacemaker." The fit between the predicted pattern of oscillations and the climate record is "intriguing," says geodynamicist Bruce Bills of the Scripps Institution of Oceanography in La Jolla, California, but "it would be even better if you could point to an obvious physical mechanism that would explain why the system works that way."

How the glaciation in the north got started in the first place 2.75 million years ago is another enigma. Earth had been cooling for 50 million years, perhaps because waning carbon dioxide was reducing the atmosphere's greenhouse effect—although that idea has recently been questioned (*Science*, 11 June, p. 1743). Another push toward glaciation could have come when the Isthmus of Panama closed about 4.5 million years ago, shutting the passageway between the Atlantic and Pacific oceans and redirecting warm ocean currents into the North Atlantic. That would have increased the supply of moisture to high latitudes and hence fostered the snowfalls that built the ice sheets. But sizable ice sheets still failed to form in the north for another 2 million years, suggesting that at least one more factor was still missing. Candidates have included a surge in North Pacific volcanism (*Science*, 10 January 1997, p. 161), whose airborne debris would have further cooled climate, and a change in Earth's nodding.

Now a hint of an astronomical trigger for Northern Hemisphere glaciation has turned up beneath a field of sunflowers in central Hungary: a high-frequency climatic "buzz" apparently excited by Earth's orbital wobbling. The sunflowers grow over the bottom sediments of a now-vanished lake, where Willis and her colleagues retrieved a 320,000-year climate record spanning the onset of glaciation. It is largely made up of annual layers created by minerals that precipitated out of the lake in summer, alternating with wintertime algal blooms. So far, the researchers have sampled the core at 2500-year intervals, extracting pollen whose species composition varies as the climate changes. They found an abrupt increase in pollen from plants of the cold, boreal forest that began 2.75 million years ago, the same time that marine sediment isotope records show ice sheet formation accelerating.

The pollen also shows short warmings and coolings lasting just 5000 to 15,000 years. Such cycles, also known from other records, are shorter than any astronomical cycle, and climate researchers think some may be overtones of Milankovitch oscillations created in the climate system, like the squeaking of an overblown clarinet (*Science*, 14 January 1994, p. 174). In the lake record, the buzz intensifies 2.75 million years ago, when the orbital wobbling intensified. That's just when the boreal forest raced southward and the ice sheets swelled; Willis thinks the intensified buzz could have been the trigger. She suggests that the quick bursts of cold could have fostered ice buildup, while the intervening warm periods would have been too short to melt all the ice.

Berger and others are impressed with the detailed view of climate afforded by the Hungarian lake core. "They clearly see sub-Milankovitch [climate] periodicities," says Berger, but he says the connection between Milankovitch forcing, the climate buzz, and the onset of glaciation is not yet so clear. The answer may still lie in a closer look beneath the sunflowers. **–RICHARD A. KERR**

CREDIT: (TOP) GRANT HEILMAN

PHYSICS

DOE to Review Nuclear Grant

Cold shoulder. DOE is taking a second look at a grant to George Miley that critics say involves cold fusion.

The U.S. Department of Energy (DOE) is reconsidering a grant that critics say will fund "cold fusion" experiments. DOE officials this week announced that a special review panel will take a fresh look at the science underpinning the $100,000 project, which proposes to test a new method of transforming radioactive waste into harmless byproducts. The restudy represents a potentially embarrassing stumble for DOE's new $19 million Nuclear Energy Research Initiative (NERI), which DOE officials pledged would use top-notch external reviewers to pick the best projects (*Science*, 11 December 1998, p. 1980).

The grant, to George Miley, a nuclear engineer at the University of Illinois, Urbana-

ScienceScope

To GM or Not? Scientists from around the globe are planning a joint statement on the potential risks and benefits of genetically modified (GM) agriculture. Representatives from seven scientific academies last week attended a London conclave organized by the U.S. National Academy of Sciences (NAS) and the U.K.'s Royal Society to ponder the issues surrounding GM foods, which have sparked controversy in many nations. The delegates—from the U.S., the U.K., China, Brazil, India, Mexico, and the 76-nation Third World Academy of Sciences—agreed that each academy will focus on a topic, such as environmental concerns, then report back. The full group hopes to issue a statement by November. Developing nations should "take the lead" in writing the document, urged NAS head Bruce Alberts, saying it is a chance "for their voices to be heard."

Meanwhile, in the wake of reports that corn engineered to carry pesticides might harm butterflies and other wildlife, U.S. Agriculture Secretary Dan Glickman last week announced plans for "an independent scientific review" of the U.S. Department of Agriculture's process for reviewing the safety of GM organisms. The department also plans to launch eight to 12 research centers to do long-term studies of biotech farm products.

Disaster Scenario? Physicists want to dispel worries that a new particle collider will destroy Earth. This week, the *Sunday Times of London* published an 18 July story suggesting that experiments at the soon-to-be-completed Relativistic Heavy Ion Collider (RHIC) at the Brookhaven National Laboratory in New York could create rare particles or mini–black holes that would devour the planet. Lab director John Marburger quickly took to the Internet to respond (www.pubaf.bnl.gov/pr/bnlpr071999.html). "There is no chance that any phenomenon produced by RHIC will lead to disaster," he wrote. Still, just to be sure, he has asked "experts in the relevant fields" to prepare a report on the disaster scenario, which was first aired in a letter in this month's *Scientific American*.

Contributors: Erik Stokstad and Jocelyn Kaiser, David Malakoff