few other groups report that they've replicated the study, they either failed to submit their raw data or panelists found problems with the experiments. And vom Saal has destroyed his original strain of mice—so as to avoid mixing with a new type, he says—so nobody will ever be able to repeat his original bisphenol A experiment. Vom Saal's team reported at the meeting, however, that it has now gotten the same results with the new strain, CD1.

Other studies that showed an effect at low doses, though, were more straightforward, prompting the panel to conclude that low-dose effects from estrogenic compounds "have been clearly demonstrated." NIEHS researcher Retha Newbold, for example, has replicated vom Saal's inverted U curve for DES when looking at uterine changes in CD1 mice. And preliminary results from other federal studies have found alterations in brain and immune system development in rats from low doses of the plant estrogen genestein and nonylphenol, a chemical in detergents. How these results may relate to disease late in life in animals, let alone humans, is uncertain, say panel organizers. "It's not clear what the biological significance" may be, says pediatrician Lynn Goldman of Johns Hopkins University in Baltimore, Maryland, a former EPA official and a meeting organizer.

Pointing to these uncertainties, EPA's Anthony Maciorowski says it's "premature" to comment until the final report is out next spring. But he suggests that the agency may hold off on modifying its congressionally mandated screening program, which is set to begin testing commercial products in 2003. "If low-dose [effects] appear to play out, they can still be accommodated later," Maciorowski says. Lucier, for one, believes the evidence is strong enough: "I think there is reason for EPA to revisit" its testing requirements already, he says. But, he adds, the problem is not urgent. "If they're missing something [in the meantime], they're not missing anything catastrophic."

—JOCELYN KAISER

CLIMATOLOGY

Does a Climate Clock Get a Noisy Boost?

Ever-present climate noise may amplify a periodic nudging of the climate system, with dramatic past effects and uncertain future implications

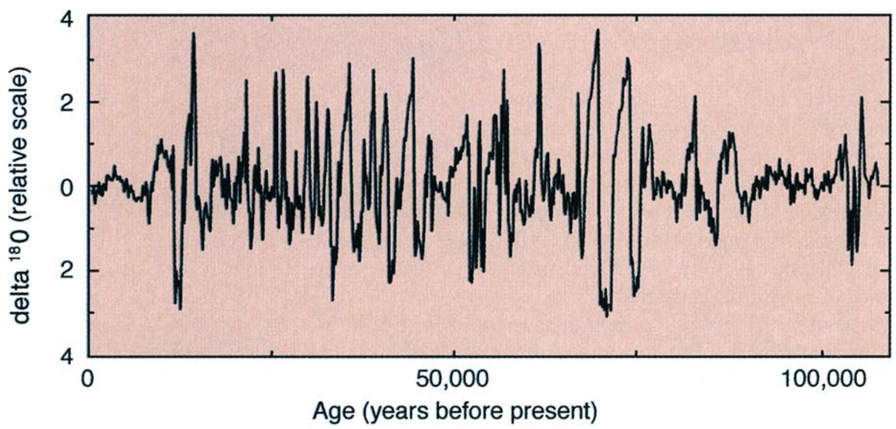
Noise has long exasperated researchers searching for signs of subtle regularity in geologic climate records. But noise may soon be viewed not just as an obstacle to understanding but also as an essential driver of climate change over the millennia. Three researchers pondering what could be behind a roughly 1500-year cycle of warming and cooling that most recently gave the world the Little Ice Age (*Science*, 25 June 1999, p. 2069) are suggesting that this millennial cycle is a combination of two climate drivers, each too weak to have a large effect on its own. When a strictly periodic cycle teams up with just the right amount of thoroughly irregular noise, the combination could achieve "stochastic resonance" and set off the dramatic climate shifts of the last ice age—or the next, possibly human-triggered, Little Ice Age.

In talks at recent gatherings, glaciologist Richard Alley of Pennsylvania State University, University Park; geophysicist Sidhar Anandakrishnan of the University of Alabama, Tuscaloosa; and physicist Peter Jung of Ohio University in Athens have presented an analysis of climate records preserved in Greenland ice cores that suggests stochastic resonance is behind the 1500-year climate cycle. If so, "noise also matters," says Alley. "What they describe is certainly consistent with stochastic resonance," says geophysicist Bruce Bills of Scripps Institution of Oceanography in La Jolla, California. "I came away feeling it was a quite plausible case." No one is claiming the case is proven, but if true it implies that "prediction is going to be really difficult," says Bills. That would complicate things as humans add in their own "climate noise" over coming centuries.

This isn't the first time researchers have invoked stochastic resonance to explain a climate cycle. In fact, the concept owes its origin to such a cycle. Now applied to everything from signal detection in electronic circuits to the neurophysiology of crayfish, stochastic resonance debuted in the early 1980s as a proposed explanation for the comings and goings of the ice ages every 100,000 years or so. If given a big enough push, the thinking went, Earth's climate system could flip between its two modes of operation, cold glacial periods and warm interglacial periods. But the only obvious means of setting the observed 100,000-year pacing—the rhythmic elongation of Earth's orbit—is too weak a driver to make the switch by itself.

Random—that is, stochastic—noise in the form of short-term climate fluctuations might help, the argument went, if it were strong enough. Increased just to the point at which noise plus the periodic signal suffice to switch the climate system from one mode to the next, noise would "resonate" with periodicity and an ice age would begin most but not every 100,000 years. Sometimes the system would skip a beat or two if by chance the noise were not strong enough when the periodic push was at its height.

Alley and his colleagues reunited stochastic resonance and climate after Alley happened to speak at Ohio University, where Jung applies stochastic resonance to neurophysiology. Alley was looking for drivers for the 1500-year cycle of moderate cooling and warming that punctuates the more dramatic 100,000-year ice age cycle. To test the 1500-year cycle for resonance, Alley, Anandakrishnan, and Jung gauged the durations of millennial climate cycles as recorded by the oxygen isotope composition of the 110,000-year Greenland Ice Core Project (GRIP) ice core from central Greenland. If the cycle were strictly peri-



SOURCE: ALLEY *ET AL.* AND GRIP

Ganging up on climate? A combination of weak climate noise and a weak periodic climate driver, such as a varying sun, may have combined to produce the climate spikes seen in this ice core record.

odic, durations would cluster around 1500 years alone.

If the ice-core isotope signal were entirely noise, there would be no preference for any particular period. But if stochastic resonance were at work, most intervals would fall near 1500 years, far fewer near two cycles or 3000 years, and fewer still near three cycles or 4500 years, with few falling at any fraction of a cycle length. That's what the researchers found in the GRIP core as well as in the nearby Greenland Ice Sheet Project 2 core. The separate peaks of decreasing amplitude with increasing interval length are there but they're very ragged, says Jung. "The problem is we only have a small number of cycles" in the record, says Jung. "You're dealing with small numbers and large fluctuations" of climate.

No one is yet claiming that stochastic resonance is the answer—it hasn't yet solved the ice age problem either—but it's being welcomed as a promising option. "It makes intuitive sense," says paleoclimatologist James White of the University of Colorado, Boulder. Biophysicist Frank Moss of the University of Missouri, St. Louis, who has demonstrated that stochastic resonance helps paddlefish find food, considers the argument "very convincing. The authors have been careful in applying the statistics."

If stochastic resonance is indeed operating, says Alley, "I really and truly don't know" what the weak periodic signal is. Suggestions have included periodic flip-flops in deep-sea circulation, solar variations, long-term tidal variations, and orbitally driven processes in the tropical Pacific. The noise may come from the largely erratic behavior of ice sheets, which have been implicated in some of the larger glacial climate oscillations (*Science*, 6 January 1995, p. 27).

What stochastic resonance would mean for the future is even less clear. When it's involved, "a really hard kick to the system will change the climate," says Alley. "The interesting question is, can humans kick it hard enough?" Greenhouse warming, ironically enough, could in theory so suppress deep-sea circulation and the warmth that it brings to the North Atlantic that another Little Ice Age could set in, at least around the North Atlantic region—a chilling punishment for making a little noise. **–RICHARD A. KERR**

NEUROSCIENCE

Neuroscience Meeting Draws Crowds, Gripes, Loyalty

Preparing for their 30th conference, neuroscientists contemplate how the field—and the annual meeting—has grown

The Society for Neuroscience (SFN) was formed in 1969 in part because people were sick of Atlantic City. The New Jersey gambling and boardwalk town was one of the only places in the United States with enough hotel rooms to accommodate the 5000 attendees of the Federation of American Societies for Experimental Biology (FASEB) meeting, and people were starting to feel crowded. "It's one of the more mundane things," says Lawrence Kruger, chair of the society's history of neuroscience committee, but such a swarm of biologists meant that it was a pain in the neck to get a hotel room, and you had to wait 2 hours to eat dinner. It was enough to make the neurophysiologists in the meeting decide to split off and look for someplace a little more private.

Today, with almost 30,000 members and an annual meeting that routinely packs in about 25,000 people, Kruger hears the same complaints. As the field of neuroscience has exploded, so has the society's meeting, and now it, too, can only be housed in a few cities. But he and other neuroscientists aren't about to fragment their annual meeting, which this year runs from 4–9 November in New Orleans. "Everybody complains about the size, and there are lots of speed bumps and glitches," concedes SFN president Dennis Choi of Washington University in St. Louis. But because of the meeting's breadth and depth, says Ron Mangun of Duke University, "it's where neuroscientists go."

Miles of aisles. Some top neuroscientists are opting to present at poster sessions.

Why do so many researchers come back every year, knowing they'll have to stand in long lines, lug around 25 kilograms of program and abstract books, and squint at slides from the back of a room that seats 4000? Some of the reasons neuroscientists cite apply to any scientific conference: the thrill of hearing about hot new research and the chance to catch up with friends.

But others say that the best reason to go to the SFN meeting every year is precisely because it's so huge and integrates the ever-growing number of subdisciplines in the field. It's a place to pick up inspiration or technical advice from people in related—or not-so-related—fields, get feedback from a wide range of perspectives, and forge interdisciplinary collaborations. "We're all linked by an interest in understanding the brain in a larger sense," says Choi, "whether at the genetic or the system level."

In 1970, 1 year after it had been founded, the society counted 1100 members. Many were neurophysiologists, experimental psychologists, or psychiatrists, says past SFN president and founding member Edward G. Jones of the University of California, Davis. It was an exciting time, he says, as new staining techniques were enabling neuroanatomists to track where axons went in the brain and to determine which neurons communicated with each other. It was also becoming technically feasible to record from electrodes in the brains of animals while they performed lab tasks. And in neurochemistry, researchers were starting to analyze how drugs interact with receptors on nerve cells.

As neuroscientists took up new tools and researchers in other fields turned their attention to neurons, new subdisciplines joined the society. Neuroscience "keeps drawing other fields into itself," explains Jones. Invertebrate neurobiologists started joining the society in large numbers a few years after it had been established, bringing tools for studying the development of the nervous system, particularly in such model organisms as

CREDIT: SOCIETY FOR NEUROSCIENCE