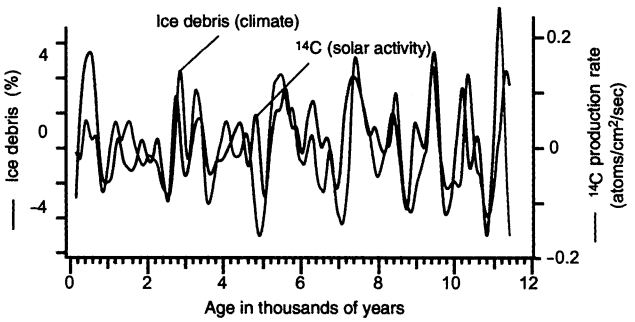
highly detailed records of both changing climate and solar activity. The climate record is a newly enhanced version of Bond's laborious accounting of microscopic rocky debris dropped on the floor of the northern North Atlantic during cold periods (*Science*, 25 June 1999, p. 2069). Ice on or around Canada, Greenland, and Iceland picked up these bits of rock and then floated into the North Atlantic, where the ice melted and dropped its load of debris. Bond and colleagues had found that the debris jumped in abundance every 1500 years (give or take half a millennium) as the ice surged farther out into a temporarily colder Atlantic. During spells of exceptional cold in the last ice age, huge amounts of ice crossed the Atlantic as far as Ireland, but even during the current warm interglacial interval a weaker millennial climate pulse continued across the Atlantic.



Well-matched wiggles. The synchroneity of fluctuations in ice-borne debris (black) and carbon-14 (blue) suggests that a varying sun can cause millennial climate change.

Records of solar activity are found in both carbon-14 in tree rings and beryllium-10 in cores of Greenland ice. Both isotopes are the products of cosmic rays striking the upper atmosphere. The solar wind of a brighter and more active sun would magnetically fend off more cosmic rays, decreasing production of carbon-14 and beryllium-10. Trees take up the carbon-14 to add new growth rings, and the beryllium-10 falls on Greenland snow that then forms annual ice layers.

The test for a sun-climate connection comes when the two types of records are put together for comparison. The more in synch the sun and climate are, the more it looks like the sun is driving climate change. "It's a strong result," says Bond. "You can do statistics on it," but what really persuades him is "what you see" in a plot of the two records: the close match between the peaks and troughs of the climate record and those of the solar record. Simple analysis gives correlation coefficients between 0.4 and 0.6. "That's a very high correlation" for separate geologic records, says geophysicist Jeffrey Park of Yale University. "It's not on the margin. It shows that the connection is real." Time series analyst David Thomson, soon to be at Queen's University in Kingston, Ontario, agrees that the statistics are good, "but their experiment may be good enough even without statistics. I think they've got a fairly convincing case."

As warm as the reception for a sun–millennial climate link may be, researchers caution that much is left to be sorted out. "It remains a little hard to figure out exactly how the sun has mattered to [recent] climate," says Alley, "and why it has mattered so much." The dimming and brightening was too small to alter the climate directly with changes as dramatic as the Little Ice Age, especially in the high-latitude North Atlantic, where the chill seems to have been greatest.

Alley points to growing evidence that solar variations can gain leverage on the atmosphere by altering the circulation in the stratosphere, which in turn changes the circulation below in the lower atmosphere (*Science*, 19 October, p. 494). Once near the surface, the solar influence might induce a change in ocean circulation. A self-sustained oscillation in the rate at which far northern North Atlantic waters sink into the deep sea had been the leading alternative to a solar influence. Given the cooling pattern they find across the Atlantic during the last few cycles, Bond and his colleagues suggest that deep-water formation does in fact oscillate, but the timing of the oscillation would be influenced by the now seemingly inconstant sun. **–RICHARD A. KERR**

CREDITS: (LEFT TO RIGHT) G. BOND *ET AL.*; ICRR/UNIVERSITY OF TOKYO

HIGH-ENERGY PHYSICS

Neutrino Oddity Sends News of the Weak

Physicists are excited, once again, about a potential conflict with the Standard Model of Particle Physics. Measurements of the behavior of neutrinos, made by a team at the Fermi National Accelerator Laboratory (Fermilab) in Batavia, Illinois, suggest that the Standard Model may misgauge the strength of one of the fundamental forces of nature. Although not conclusive, the results might signify an undiscovered particle—or an experimental fluke.

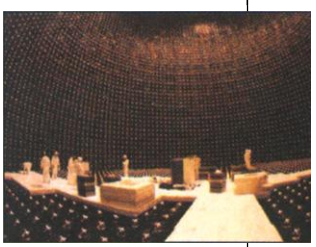
The Fermilab experiment measured θ_W ("theta-sub-w"), a quantity called the weak mixing angle. Although not an angle in the ordinary sense, θ_W smells like one to a mathematician. Roughly speaking, it measures the relation between the electromagnetic and weak forces: Different values of θ_W yield different pictures about the relative strengths of the forces at different energies.

ScienceScope

In the Dark In a major setback for neutrino observations, the Super-Kamiokande neutrino detector in central Japan has been knocked out of commission during repairs to the $100 million facility.

Buried a kilometer underground in a mine, Super-Kamiokande is a 39-meter-by-41-meter tank of water lined with 11,146 photomultiplier tubes that watch for a characteristic glow, known as Cerenkov radiation, from the statistically rare interaction of ephemeral neutrinos and atomic particles in the water. In 1998, it provided researchers with the first convincing evidence that neutrinos have mass.

The tank was emptied in August to replace 100 burned-out tubes and was being refilled on Monday when more than half of the tubes suddenly shattered in an apparent chain reaction. Yoji Totsuka, director of the University of Tokyo's Institute for Cosmic Ray Research, which heads an international collaboration operating Super-Kamiokande, says he has no idea what caused the accident or how soon the facility can be put back online. One scientist estimated that it could cost $10 million just to replace the tubes.



Deep Decision The underground science movement is still kicking. Congress last week included $10 million in a housing appropriations bill to prevent an abandoned gold mine from flooding. The money, for a skeletal crew and equipment to keep the mine dry, keeps alive scientists' hopes of transforming the Homestake gold mine in Lead, South Dakota, into the world's deepest underground laboratory (*Science*, 15 June, p. 1979). Scientists studying certain phenomena, such as neutrino signatures, need such sites to shield experiments from cosmic radiation.

Senator Tom Daschle (D–SD) and mine owners last month worked out environmental and liability issues that threatened to scuttle the plan. Ironically, Daschle aides were hammering out the final deal in the senator's Washington, D.C., office when they learned that a staffer had just opened the anthrax-bearing letter, according to *The Wall Street Journal*. While members of Daschle's staff wait to return to their shuttered building, researchers await word from the National Science Foundation on a $281 million proposal to build the underground lab.

MICROBIOLOGY

Multitasking Is This Plankton's Trademark

One of the organisms responsible for red tide, which can kill marine species and close down fisheries, is proving to be quite ingenious in how it manages its metabolism. Like many other so-called cyanobacteria, *Trichodesmium* processes nitrogen to make ammonia and also produces oxygen by means of photosynthesis. Usually these two activities are chemically incompatible, leading researchers to wonder what goes on inside this filamentous plankton. Now, after 40 years of speculation, researchers think they have figured out how *Trichodesmium* seemingly manages both processes at once.

The work "is starting to peel back how [*Trichodesmium*] gets away with what it gets away with," comments Douglas Capone, a microbial ecologist at the University of Southern California in Los Angeles. This organism is key to providing marine life with nitrogen, thereby stimulating ocean productivity, he adds.

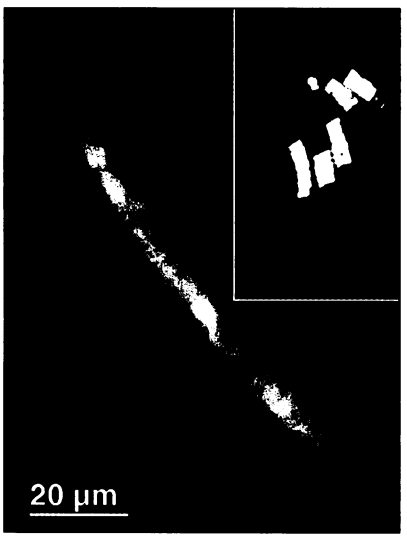
As reported on page 1534, this cyanobacterium carefully balances the amount of time it spends on photosynthesis and nitrogen fixation, shifting from one process to the other. "We're showing a decline in photosynthesis when nitrogen fixation is high," says study coauthor Ilana Berman-Frank, a phytoplankton ecologist at Rutgers University in New Brunswick, New Jersey. This prevents oxygen, a byproduct of photosynthesis, from damaging the nitrogen-fixing enzyme nitrogenase. Such damage precludes an organism from performing both processes at the same time or in the same cell.

Richard Dugdale, now at the Romberg Tiburon Center for Environmental Sciences at San Francisco State University, first discovered that *Trichodesmium* fixes nitrogen some 40 years ago. He brought a mass spectrometer on board a research ship to make field measurements of the plankton's metabolism. At the time, most microbiologists believed that nitrogen fixation occurred only at night or in specialized cells called heterocysts that don't make oxygen. Unlike other cyanobacteria, *Trichodesmium* lacks these cells, and skeptics ridiculed Dugdale's observations as "nitrogen fiction."

Over the years that fiction became fact, but still no one could figure out how this organism managed to fix both carbon (by means of photosynthesis) and nitrogen at the same time—and during the day at that.

To find out, Berman-Frank and her colleagues used a technique called fast repetition rate fluorometry to track photosynthesis as it occurs by measuring the fluorescence patterns. They monitored nitrogenase activity at the same time. The experiment showed that the oxygen-producing enzymes worked all day, except for a several-hour-long midday siesta, during which nitrogenase activity was in full swing.

Then Berman-Frank and her collaborators took an even closer look at what was going on inside individual cells. Hendrik Küppe of the Institute of Microbiology in Trebon, Czech Republic, used a customized microscope that tracked oxygen production by monitoring the changing fluorescence that occurs during photosynthesis.



Room of its own. Fluorescent antibodies light up filaments' centers, revealing localized nitrogen fixation in *Trichodesmium*.

They found that cells could shut down photosynthesis within 15 minutes to allow nitrogen fixation to occur. They also found that this shutdown often occurred only in parts of the filament, often at their centers. Thus they think the cells have exquisite control of where and when these two processes go on.

"These are very elegant experiments," notes Jonathan Zehr, a microbial ecologist at the University of California, Santa Cruz. Adds Edward Carpenter, who is also at the Romberg Tiburon Center, the study "goes a long way to explain how the organism does this."

Because *Trichodesmium* is ancient compared to other cyanobacteria, Berman-Frank and her colleagues think that its mechanism for orchestrating photosynthesis and nitrogen fixation is a primitive one and that specialized cells came later. "This may be a missing link and a precursor to how cyanobacteria evolved," agrees Capone. But Zehr isn't so sure. He thinks *Trichodesmium* species themselves could represent a highly specialized group of organisms that simply branched off early from other cyanobacteria. Nor is he convinced that this new work gets to the bottom of this paradox. "I don't think it's totally solving the riddle," he says. —ELIZABETH PENNISI

CREDITS: (LEFT TO RIGHT) I. BERMAN-FRANK *ET AL.*; P. BAGLA

ScienceScope

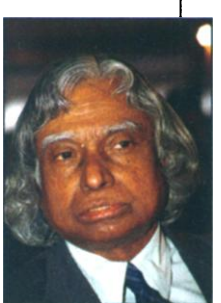
Delayed Again German researchers hoping to work with human embryonic stem cells are braced for yet another delay, while a Japanese group has won approval from its university to move ahead.

Germany has a law that forbids embryo research. But the DFG—Germany's science funding agency—was scheduled to decide on 7 December whether to fund a grant application from University of Bonn neuroscientist Oliver Brüstle to work with cell lines imported from abroad (*Science*, 8 June, p. 1811). Last week, Bundestag leaders of both the ruling and opposition parties urged DFG chief Ernst-Ludwig Winnacker to put off the decision until parliament debates the issue. If Winnacker agrees, the debate could be difficult for stem cell research backers. An ethics commission advising the Bundestag, for instance, this week voted 17–7 against allowing importation of the cells.

Brüstle, frustrated, says the nearly 2 years of discussions soon "must reach a conclusion." If the DFG delays, his application could be considered at the next meeting of the grants panel on 1 February.

In Japan, a national board must now review a stem cell research proposal approved 5 November by Kyoto University.

Indian Reshuffle A hawk has replaced a hawk as principal scientific adviser to the Indian government. A. P. J. Abdul Kalam (right), who spearheaded India's missile and nuclear program for more than 4 decades, resigned this week amid rumors that he was frustrated by bureaucratic delays in implementing a new technology policy he had crafted. He has been replaced by Rajagopala Chidambaram, until recently head of the country's atomic energy program and a major force behind the May 1998 nuclear tests.



Appointed 2 years ago, Kalam was the first chief scientist to also hold the rank of cabinet minister and report directly to the prime minister. But it was never clear what his duties entailed, and he reportedly was miffed at a lack of executive authority. Unlike Kalam, Chidambaram will not hold the rank of cabinet minister.

Kalam says he is joining the Indian Institute of Science in Bangalore to fulfill his wish to work more closely with students. Indian Science Minister M. M. Joshi says that "there were no differences between Kalam and the government."

BIOTERRORISM

Labs Tighten Security, Regardless of Need

Michael Walter does not keep anthrax in his laboratory. But since the nationwide anthrax scare began last month, the microbiologist at the University of Northern Iowa in Cedar Falls has installed new locks to safeguard strains of a harmless cousin, *Bacillus cereus*. "Everyone was giving me a hard time," he says. "So I locked up some related strains ... just to put people's minds at ease."

University researchers and administrators around the country say that the public's fear of bioterrorism has led them to increase security in labs that study anthrax—whether or not they keep bugs that could infect humans. The new precautions include police guards, security cameras, new locks, key-card identification systems, motion detectors, and remodeling that reduces the number of building entrances. Scientists say that although they don't think their labs were ever unsafe, more protection can't hurt, and the measures are good public relations.

The most extreme measures may have been taken by Iowa Governor Thomas Vilsack, who called out the National Guard in response to false reports of a direct link between the state and the anthrax strain that killed four people. (The anthrax used in the attacks has been identified as the Ames strain, which was first cultured decades ago at Iowa State University in Ames and is now widely disseminated among research labs in the United States.) After the troops arrived, Iowa State microbiologists decided that keeping anthrax spores as part of their general bacteriological collection was more trouble than it was worth. So on 12 October they autoclaved the entire anthrax collection. "We made sure nobody needed the cultures and that they weren't of value to anyone, and then we proceeded to destroy them," says Iowa State microbiologist Jim Roth.

Many researchers say that security at anthrax labs has always been excellent. Microbiologist Rodney Tweten of the Oklahoma University Health Sciences Center in Oklahoma City says that he hasn't taken any extra precautions at his lab, because the cloned anthrax DNA that he studies could not harm anyone and because existing security is high.

The costs of additional security can be sizable. Microbiologist Paul Keim of Northern Arizona University (NAU) in Flagstaff, who maintains live anthrax for his studies of the differences between strains, estimates that the university spent up to $50,000 last month on security upgrades. NAU vice provost Carl Fox says the lab is now monitored by security guards, new locks have been installed, and there's a wall where a door once stood.

> **"Barring a SWAT team or someone with bazookas, I think we actually have a pretty safe situation for the cultures."**
>
> —Paul Keim

CREDIT: GARY FOX/NAU

But the fallout from underestimating public fears also can be significant. Detroit television station WXYZ-TV this month aired a report questioning the security in the laboratory of pathologist James R. Baker, a so-called anthrax researcher at the University of Michigan, Ann Arbor, who has used the harmless *Bacillus cereus* in the past. When the TV crew members attempted to enter Baker's laboratory, they were rebuffed by a locked door and, later, challenged by lab personnel. But scenes of the reporter freely entering an adjacent laboratory, even though it is used to study hearing, left the impression that university labs were vulnerable. The video, which aired several times over 2 days, forced university public relations officials to work frantically to calm fears about campus security.

Researchers who question the value of additional security point out that anthrax is widespread in soils. They also note that a potential terrorist breaking into an anthrax lab might not know what to look for. "It would take me at least a couple of hours to find anything, and I'm the dean," says Michael Groves, who heads the Louisiana State University School of Veterinary Medicine in Baton Rouge, where police guard a building that houses anthrax cultures pending the installation of a new key-card identification system.

Still, researchers say precautions are worthwhile if they reassure a jittery public. "The business of allaying fears is very important," says Northern Iowa's Walter. And al-

ScienceScope

Call to Arms The Swiss Science and Technology Council (SSTC) has issued a "manifesto" calling on the government to take science more seriously. Signed by many leading Swiss scientists, last week's appeal follows a strongly worded September warning from council president Gottfried Schatz that a decade of stagnant spending has caused Swiss science to lag behind that of other nations. The SSTC advises the Swiss Federal Council, which is currently setting science policy for 2004–07.

Among the council's complaints: an "abominable" Swiss training and tenure system that it says shortchanges young scientists and favors hiring foreign professors. The manifesto demands a "minimum" science spending increase of nearly $1 billion per year, new training grants for young researchers, and a more transparent, U.S.-style tenure-track system. Researchers are aware of the problems but the public is not, Schatz told the Swiss newspaper *Der Bund*. He says researchers "need a lobby."

Scientist Sanctioned A Johns Hopkins University scientist charged with improperly testing an anticancer drug in India has been barred from leading future trials.

Hopkins came under fire last July after the Indian media reported problems in an oral cancer study involving Ru Chih C. Huang, a biologist in Hopkins's School of Arts and Sciences. This week, a Hopkins faculty committee found that the trial hadn't received required approvals from a university Institutional Review Board (IRB) and the Food and Drug Administration (FDA), involved insufficient animal tests, and used inadequate consent forms. The three panelists found no evidence that patients were harmed, nor financial conflicts, says a Hopkins spokesperson. In response, Hopkins's arts and sciences dean—who didn't identify Huang by name—said that any future human studies she participates in must be supervised by a Hopkins clinical researcher.

Huang has said Hopkins administrators led her to believe she needed approval only from an IRB in India (*Science*, 10 August, p. 1024). She told *Science* that she "totally agree[s]" that she should not oversee trials: An Indian doctor headed the trial in India, she says. Huang added that she is now requesting approval to conduct a second trial, which would be led by a physician from the Hopkins Singapore campus.

Contributors: Dennis Normile, Charles Seife, Gretchen Vogel, Pallava Bagla, Giselle Weiss, Jocelyn Kaiser