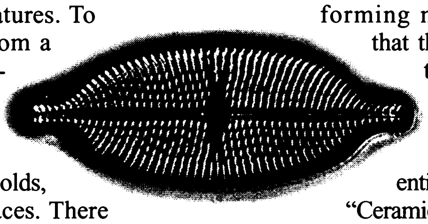
that takes hours to happen without silaffins. A scanning electron microscope showed that the precipitate had formed networks of minuscule silica spheres.

Kröger and his colleagues went on to analyze the proteins and show how their structures and chemical features could help catalyze the reaction of silicon-containing molecules into solid silica particles. The researchers "have done a great job of characterizing their proteins," says Galen Stucky of the University of California, Santa Barbara, who last year found what may be compounds with similar functions in silica-making sponges.

Besides helping to explain how diatoms transform dissolved silicon-containing molecules into sturdy solid particles, the finding is also a tantalizing clue for materials scientists who envy biology's ability to build sophisticated materials at ambient pressures and temperatures. To make any ceramic, from a dinner plate to a toughened drill bit, engineers and artisans now have to mix powders, press them into molds, and fire them in furnaces. There are no furnaces in sight when a developing child infiltrates itself with bone or a diatom drapes itself in silica lace, and materials scientists would like to know how they do it.



The Regensburg group suspected that diatoms make proteins that orchestrate the initial phase of biosilica formation—the growth of tiny silica spheres. For one thing, other researchers had already found organic molecules closely linked to diatom cell walls. After extracting the organic material from their diatom samples, the Regensburg researchers isolated three proteins that could instigate silica precipitation in a test tube—a pair of small, closely related silaffins (1A and 1B) and another larger one, silaffin 2. To begin unraveling how the proteins work, the group determined the amino acid sequence of silaffin-1B and ferreted out a gene from the DNA of the diatom *Cylindrotheca fusiformis*, which turned out to encode silaffin-1A as well. Kröger says the team also is now working to characterize silaffin 2.

The structures of these proteins harbor clues to the diatoms' silica engineering. The glasslike veil of a newborn diatom takes shape in a "silica deposition vesicle," where conditions are acidic. Both silaffins have an unusual amino acid motif, consisting of bonded pairs of lysines with a string of amine groups grafted on after the protein chain is formed. The researchers say that under acidic conditions, this motif should stimulate silicic acid molecules to form silicon-oxygen bonds, linking them together into silica particles. That might help explain how diatoms form solid silica from ingredients dissolved in their watery environs, but it doesn't explain how the algae coax the silica to form intricate patterns. Kröger conjectures that other features of the proteins could be at work.

Silaffin-1A and -1B both consist mainly of two chemically distinct components, one bearing multiple positive charges and another multiple hydroxy groups. To Kröger, the proteins resemble synthetic block copolymers—polymers in which two distinct segments, each repeated many times, alternate along the molecule. When some copolymers solidify, like segments cluster together, segregating into two separate phases that pattern the material with regions of contrasting chemical properties—somewhat the way drops of oil poured onto a saucer of vinegar form segregated droplets. Kröger wonders whether silaffins might be doing something similar within a diatom's silica deposition vesicle, forming molecular frameworks that then guide the growth of the silica.

However diatoms create their silica patterns, it's a trick materials scientists would like to emulate. "Ceramics are one of those unfulfilled materials we could use lots more of, if only we could get [them] easily," says materials researcher Paul Calvert of the University of Arizona, Tucson. Adopting biology's kinder, gentler methods could help engineers combine ceramics with other materials that can't take furnace temperatures. Quips Calvert: "You could make something with chocolate feet and a silicon carbide head." Unlikely material combinations, he says, could push forward such projects as "flexible electronics," in which silicon-based electronics are patterned onto polymer sheets. Diatom-like methods for making intricately shaped ceramics might also yield photonic materials, whose internal arrangements of solid and space could select and confine specific wavelengths of light for communication or computing.

The more scientists learn about diatoms' glassy laceworks, the more beautiful they seem. —IVAN AMATO

Ivan Amato is the author of *Stuff.*

OCEANOGRAPHY

Has a Great River in The Sea Slowed Down?

For many millions of years, two "rivers" of seawater have been flushing the deep sea clean while shuttling chemicals and heat so as to reshape climate. Now, a new analysis of oceanographic data suggests that one of the two rivers has slowed dramatically within the past century, with implications for climate and the humans who are changing it.

ScienceScope

The Long View It's way too soon for scientists to take it to the bank, but the National Science Foundation (NSF) has begun discussing new initiatives in mathematics and the social sciences.

NSF is still awaiting White House reaction to its 2001 budget request, which won't be finalized until January. But NSF director Rita Colwell says she is already thinking about highlighting mathematics in her 2002 request and the social and behavioral sciences in 2003. "Mathematics is the foundation for all the sciences," she told a 1 November symposium at the American Association for the Advancement of Science (which publishes *Science*). And scientists "need the social and behavioral sciences to interpret the huge databases" being compiled in many fields.

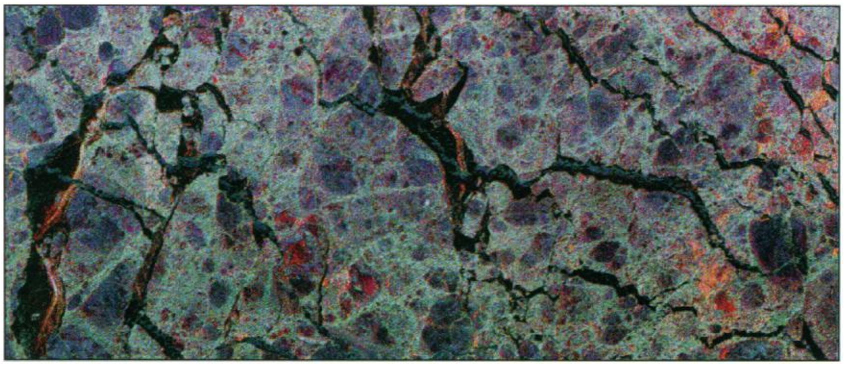
The fledgling initiatives are a response to a White House request for a 5-year plan from each agency. But the Clinton Administration will be history after next November's election, meaning that Colwell, whose 6-year term runs through 2004, must sell her ideas to the next set of political bosses.

Double or Nothing? Science groups are taking another crack at getting a cherished funding bill through the House. But few expect the bill—which would enable, but not require, the federal government to double nonbiomedical R&D spending to $68 billion by 2010—to survive a clash with Rep. James Sensenbrenner (R–WI), chair of the House Science Committee.

In a repeat of last year's unsuccessful campaign, Representative Heather Wilson (D–NM) and nine cosponsors last week introduced the doubling bill (H.R. 3161), which mirrors a companion the Senate passed earlier this year (*Science*, 28 May, p. 1452). But Sensenbrenner, whose committee must approve the measure, has derided earlier versions of the bill, calling it a "feel-good" effort that will produce little actual cash for research. Still, Sensenbrenner aides say the lawmaker hasn't yet made up his mind about the current version, which probably won't get hearings until next year.

In the meantime, doubling backers—who have made the measure a centerpiece for a high-profile campaign—are expecting the worst. But some believe the dogged effort could eventually pay off in a future Congress. Jokes one lobbyist: "We'd like a win, but a valiant defeat might be just as glorious."

In a paper on page 1132 of this issue of *Science*, marine geochemist Wallace Broecker of Columbia University's Lamont-Doherty Earth Observatory in Palisades, New York, and his colleagues argue that the renewal of deep waters by sinking surface waters near Antarctica has slowed to only one-third of its flow a century or two ago, while deep water formation in the North Atlantic—the site of the other river—remains high. "The whole concept that deep water circulation could have changed that much is mind-boggling," says Broecker, who adds that, far from being a onetime event, the slowdown may recur in a 1500-year cycle.



Less deep water? Freezing of Antarctica's Weddell Sea, seen here in a radar image (45 kilometers across), helps send water into the abyss, but the process may have slowed.

This huge, climate-altering change in the oceans—if it's real—would greatly complicate attempts to understand how the ocean and climate are responding to another influence on climate, the buildup of greenhouse gases in the atmosphere. "It's a really interesting and provocative idea," says ocean circulation modeler Jorge Sarmiento of Princeton University, "but I'm very uneasy about the calculations. I find the paper more of a stimulation to further work than what I could accept as proven fact."

Directly measuring the flow of surface waters into the deep sea is impractical. Instead, researchers examine easily measured, indestructible "tags," some natural and some manmade, that join surface water before it becomes denser and sinks into the abyss. One tracer, the sum of the phosphate and oxygen in seawater, should remain constant as water sinks into the deep sea. In data collected by other researchers, Broecker found that this tracer, called PO_4^*, is high in newly formed deep water near Antarctica and relatively low in newly formed deep water in the northern Atlantic. Throughout the deep Indian and Pacific oceans it is at intermediate levels, suggesting to Broecker that these deep ocean basins have received about equal amounts of water from each source during the past 800 years or so.

Another tag, radioactive carbon-14, also supports equal roles for the two deep-water source regions over the last millennium, according to Broecker's analysis. Surface water heading down absorbs carbon dioxide, including carbon-14 formed in the atmosphere by cosmic rays, and carries it along toward the bottom. Broecker analyzed carbon-14's distribution throughout the world ocean and concluded that about 15 million cubic meters of water per second (15 Sverdrups) has been sinking into the deep sea at each source during the past 800 years.

But tracers that gauge deep water formation over decades rather than centuries seem to show that the southern source is now much smaller than the northern one. Physical oceanographers have long believed that the principal southern source of deep water, in the Weddell Sea, now supplies no more than 5 Sverdrups, judging by heat and salt content. And Broecker finds further evidence in a new study of water in the Southern Ocean, near Antarctica, by physical oceanographer Alejandro Orsi of Texas A&M University, College Station, and his colleagues. They looked at the distribution of the pollutant chlorofluorocarbon-11 (CFC-11), which first entered the environment a few decades ago. To Broecker, the study implies that the southern source has generated only 4 Sverdrups of new deep water during the past few decades. In the north, on the other hand, other CFC-11 studies support 15 Sverdrups, says Broecker.

Why should the sinking of seawater into the deep sea have slowed recently in the south? Broecker doesn't know, but he sees a parallel between the apparent recent slowdown and more drastic variations in ocean circulation during a sharp cold snap 11,000 years ago. As recorded in Atlantic sediments, deep water formation in the north slowed or halted. Because warm water normally flows northward to replace the sinking surface water, the shutdown chilled much of the Northern Hemisphere; meanwhile water began sinking faster in the south, warming the region. Something similar might have happened in the 500-year Little Ice Age, which ended around 1880, says Broecker. Since then, deep water formation in the south would have slowed. And because some suspect that the Little Ice Age is only the latest swing in a 1500-year climate cycle (*Science*, 27 February 1998, p. 1304), further changes could be in store.

Broecker's ideas are "always interesting," says marine geochemist Richard Gammon of the University of Washington, Seattle, "and he's right often enough that people have to pay attention." Physical oceanographer Arnold Gordon of Lamont is certainly paying attention. However, he and Orsi don't think Broecker has the evidence to back up his claim. By their reckoning, true deep water formation is currently equal north and south at about 5 Sverdrups. In his accounting of deep water formation, they say, Broecker includes waters that never get very deep or are picked up by new deep water as it sinks.

Broecker isn't worried about the cautious reception. "I don't expect people to accept at face value what I say." The important thing is that "the Little Ice Age is going to get more attention," he adds. "If I'm right, it has enormous consequences." Sorting natural climate oscillations from anthropogenic greenhouse warming would become more difficult. The ocean might lose some of its ability to draw off greenhouse gases and stash them away in the depths. And future change could become even harder to predict. As Sarmiento says: "It's a very interesting speculation; it's also disconcerting. If we want to understand the next 100 years or 200 years, we really need to understand what is going on with long-term cycles."

–RICHARD A. KERR

AIDS

European Vaccine Effort Faces Chinese Puzzle

PARIS—During an international AIDS meeting here last week, a group of researchers quietly met to plan a 3-year, $9.2 million European Union–backed effort to develop an AIDS vaccine. The new initiative, called EuroVac, is expected to begin on 1 January and will mark the first time the EU has attempted to pull Europe's top AIDS researchers together into a unified vaccine drive. Yet though the contracts between the EU and the researchers are still being negotiated, the initiative has already become tangled in international AIDS vaccine politics. Some members of the EuroVac scientific team were surprised to learn last week that one of the project's potential ambitions—to test vaccine candidates in China, where the AIDS virus is spreading rapidly—may duplicate similar efforts under way by virologist David Ho, director of the Aaron Diamond AIDS Research Center in New York City.

The EuroVac project, which is co-chaired by virologists Jaap Goudsmit at the Universi-

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