that whoever selects the projects that go on the teraflop computer picks the wrong ones."

In view of these problems, many computational biologists think it's best to wait and let computing power get a lot cheaper before the field leaps in and commits itself to one big machine. "It would be possible now to put together something that could compute that fast, but it wouldn't be a balanced machine," says Ten Eyck. This year industry might be capable of building a teraflop computer, he says, but it's likely that some of such a machine's components wouldn't be technically advanced enough to keep it running at peak speed for more than a fraction of the time. By 1995, however, several firms are expected to offer well-balanced teraflop computers and the price should be much less than current estimates, says Rick Stevens, director of math and computer science at Argonne National Laboratory. According to Ten Eyck, the San Diego Supercomputing Center is looking at several supercomputers that might be expandable to teraflop speed by 1995.

Concerns over the hardware's cost and quality apply to software, too, says Peter Wolynes, a theoretical biophysicist at the University of Illinois. "A lot of thinking will have to go into how to utilize all the masses of data that will come out of [a teraflop computer]," he says. Scientists in computational fields already have begun developing such software, adds Stevens. For example, he says, atmospheric scientists "are spending enormous energy getting retooled to take advantage of teraflop machines" in order to do computationally intense climate modeling, he says. Computational chemistry, automotive design, and high-energy physics are among the fields that "aren't standing still either," Stevens says.

With computational biologists at odds over nearly every issue engendered by a teraflop computer, it should come as no surprise that they don't all think Florida State is the logical place to put one. "It's not obvious to me that one should start a separate center from the National Science Foundation centers," says Wolynes. Another concern raised by some computational biologists is Bash himself. "A number of individuals have raised a concern about Paul's experience," one computational biologist told *Science*.

But some prominent scientists think that location and track record may not be the key things. "What I think is important is to have [a teraflop machine] in a place where people are hungry, interested in the problems, and ready to get on with the job," says Frederic Richards, a structural biologist at Yale University. Zerner agrees: "Location isn't crucial—I flip a switch and I can log onto Florida State." And some scientists outside computational biology think Bash could be just the person for the job. "As much as there's the technological problems to solve, there's the sociological problems—people used to workstations are constrained by that mindset," says Stevens. "Paul's trying to expand that mindset, get people thinking about what sort of problems can be solved on a teraflop."

Whether or not Bash persuades funding officials—not to mention other computational biologists—that his proposal will lead the field down the right path, computational biology already is beating a trail toward a teraflop computer. It's just a question of when—and how—the teraflop revolution takes place.

–**Richard Stone**

Model of Computing's Future?

Behind the veneer of yellow and green lights that flash when data is transferred between its 528 microprocessors, the 16-foot-long Touchstone Delta supercomputer looks like *2001's* monolith tipped on its side. But poised behind the computer's physical setup is another structure that, although it's not visible, is just as crucial to the machine's success: the Concurrent Supercomputing Consortium (CSC), which owns the Delta. The CSC is a group of 10 universities and national laboratories, as well as Intel Corp., which made the machine. And that organization could provide a model for computational biologists who might want to merge their funds and buy a teraflop computer (see main story).

"We all hoped that by forming this consortium we'd be getting a computational resource we couldn't individually get," says Paul Messina, a Caltech computer scientist and executive director of CSC. The consortium formed in November 1990; by last May, the Delta, capable of a record-breaking speed of 32 gigaflops, was up and running at Caltech.

Not only have computational scientists got the machine they wanted, but "big chunks of time are getting allocated to individual projects," says Messina, who sits on the machine's time-allocation committee. The reason is that there are relatively few users, and the result is that consortium members (who get time in proportion to their financial contribution to the purchase of the $15 million supercomputer) are pleased. "If you open it up to everyone, it's no longer a supercomputer," says Hans Kaper, a senior mathematician at Argonne National Laboratory, one of the consortium members. And that same tune—purposeful organization in the service of efficiency—is a tune computational biologists hope to be singing if they get their teraflop machine.

–R.S.

MEETING BRIEFS

Chemists Storm San Francisco

This year's Spring meeting of the American Chemical Society (ACS), held 5 through 10 April in San Francisco, was so huge that it took three sizable volumes–a total of 5 pounds, 1.5 ounces of paper–to hold the 6200 abstracts. Like a city within a city, 15,943 attendees scurried to and from social gatherings and sessions that offered something for every taste, from nuclear waste disposal to the birth of the solar system.

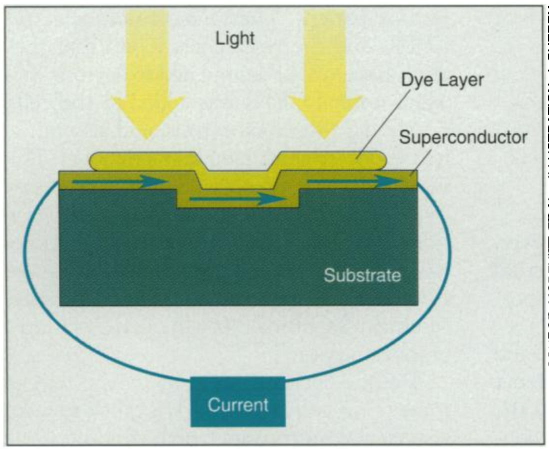
Superconductors That See Red, Green, and Blue

What do you get when you mix a high-temperature ceramic superconductor with biochemicals that capture light of specific wavelengths? Most chemical novices will get an ugly pile of grit, but in the hands of chemist John T. McDevitt and his colleagues at the University of Texas at Austin, the combo becomes a color-sensitive optical detector. The researchers' aim is to come up with new optoelectronic devices for, say, detecting faint light signals in astronomy or defense or even sophisticated data-storage devices.

McDevitt and his colleagues are following a trail laid in the late-1980s by workers who used thin films of high-temperature superconducting ceramic as sensitive, rapid-response light detectors. The detectors work like this: Light warms up the superconductor and degrades its ability to conduct electricity without resistance. Light thus causes a change in conductivity, which is easy to monitor. But these devices respond indiscriminately to any wavelength from ultraviolet through visible into the infrared. "We wanted to make devices that respond more selectively," says McDevitt.

That's where the light-sensitive biochemicals come in. McDevitt and his colleagues liked the idea of using porphyrins—a family of molecules whose most famous derivative is chlorophyll, the light harvesting pigment of photosynthesis. Because of their ability to capture photons of specific wavelengths, McDevitt thought porphyrins would be just the thing for making the superconducting light detectors more choosy.

Atop a thin film of ceramic superconductor such as yttrium barium copper oxide, the Austin researchers fashioned small superconducting junctions and then coated them with porphyrin-based dyes and other organic pig-



SOURCE: MCDEVITT ET AL. ILLUSTRATION: J. CHERRY

Cool eye. For color-sensitive detectors, top a film of ceramic superconductor with a biochemical-based dye.

ments. The researchers find that the devices have conductivity changes when they are exposed to light, and the changes are most pronounced at the bluish, greenish, or reddish wavelengths absorbed by the dye films.

"We've demonstrated the concept," McDevitt says. But before dye-coated superconducting light sensors find themselves in telescopes and spectrometers, the Austin researchers need to understand more precisely the physical pathways by which absorbed energy interferes with the superconductivity. They also would like to broaden their now restricted palette of sensitizing dyes, so that they can detect the world in full color.

High Flying Chemistry

Cosmochemist Robert N. Clayton of the University of Chicago may have won this year's ACS award in nuclear chemistry and proudly participated in a symposium in his honor at the San Francisco meeting. But that didn't keep a former student of his—the organizer of the symposium, no less—from presenting new evidence against one of his mentor's biggest ideas, which links the chemical composition of meteorites to the origin of the solar system.

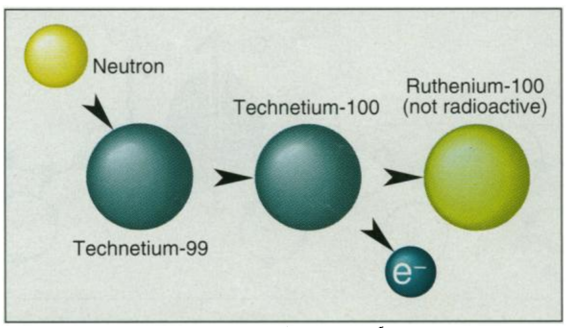
For nearly a decade, chemist Mark H. Thiemens of the University of California, San Diego, has been arguing that Clayton got it wrong in his 1973 proposal about an unusual enhancement of oxygen-16 over heavier oxygen isotopes—oxygen-17 and oxygen-18—found in the famous Allende meteorite, recovered 4 years earlier in Mexico. Clayton argues that the isotopic ratio is a clue to the solar system's formation; the ratio originated, he says, in the debris of a supernova that exploded near the presolar nebula, jolting it and triggering its collapse into the sun and planets. Light oxygen, Clayton says, was favored over heavier isotopes by the star's nuclear processes, and the oxygen ratio was left as a kind of birthmark on the part of the nebula nearest the supernova.

Thiemens has an alternative explanation for the isotopic imbalance, calling on chemical rather than nuclear processes in the early solar system. In 1983, he showed that ozone (O_3) made in the lab by electrically zapping oxygen molecules (O_2) has an isotopic ratio that is the mirror image of the one found in the Allende meteorite. Ozone molecules containing an atom of oxygen-17 or oxygen-18 formed 10% more often than would be expected from the normal abundance of the heavy isotopes relative to oxygen-16, the majority isotope. Thiemens can't yet explain the chemical boosting of isotopically diverse ozone. But perhaps something similar went on in the cool gas of the primordial nebula, he says. In that case pockets of gas enriched in heavy oxygen might have formed, leaving enrichments of light oxygen elsewhere that were preserved in meteorites.

Critics, including Clayton, weren't convinced that the laboratory reactions actually took place in nature. So Thiemens looked to the ozone layer in the stratosphere, obtaining air samples from high-altitude balloons launched over New Mexico and Texas. As he told his ACS audience, the ozone in these samples showed the same unusual ratio of oxygen isotopes he had seen in the laboratory.

Clayton now agrees that isotope-enriching oxygen chemistry can take place in nature—in the stratosphere, at least. But he still thinks that a supernova is a better explanation of the meteorite anomaly, pointing out that meteorites hold unusual isotopic ratios of many other elements besides oxygen. Thiemens is far from showing that his poorly understood chemistry could occur in the early solar system, Clayton contends.

Even if Thiemens' idea never gets beyond the atmosphere, it might have some far-reaching implications. Besides bearing out the laboratory work, Thiemens said, the stratospheric air samples also suggested that ozone exchanges oxygen atoms with carbon dioxide molecules, whose oxygen atoms end up displaying a similarly odd isotopic ratio. By tracking isotope distributions, Thiemens thinks, chemists might gain "a new probe of atmospheric chemistry." He also speculates that the exchange "could even have some bearing on the ozone depletion question." If so, a study that started with the earliest moments of the solar system will have had an up-to-the-minute payoff.



SOURCE: LANL ILLUSTRATION: J. CHERRY

Nuclear billiards. Neutrons could help transmute radioactive waste into more benign material.

Aid to Alchemy

Modern-day alchemists have found a way to convert long-lived nuclear waste into less nasty nuclei. But the last thing an alchemist wants is to waste his artistry on nuclei that don't need it. So Kent Abney and colleagues at the Los Alamos National Laboratory have been working on a way to cull "radiodeactivated" nuclei from the radioactive waste as fast as they are produced.

Abney's separation technique is part of a broader plan he and his colleagues have proposed, known as Accelerator Transmutation of Waste (ATW), for turning highly radioactive nuclei into more benign ones. Proposed last year as an alternative to related plans involving nuclear reactors (*Science*, 22 June 1991, p. 1613), ATW harnesses neutrons generated by slamming protons from a particle accelerator into metal targets. Slowed by a mass of water, the neutrons then shower the waste and are captured by radioactive nuclei. Neutron absorption transmutes the nuclei into nonradioactive isotopes or shorter-lived radioactive ones, which decay into harmless forms.

One key target of this alchemy is the nuclear reactor by-product technetium-99, a radioactive isotope with a half-life of 250,000 years. The Department of Energy's Hanford Nuclear Reservation in Washington state has tons of this stuff that somehow have to be cleared out; ATW would transform it into harmless ruthenium-100 atoms, said Abney. Similar fates could await other radioactive isotopes as well.

But alchemy has never been easy. One difficulty is that no existing accelerator can produce the required flux of neutrons, Abney noted. More to the point for chemists, how do you extract the ruthenium atoms as they are produced, so that neutrons don't go to waste on harmless nuclei? Abney's tack, which he described at the ACS meeting, is to blow ozone through the waste as it is exposed to the neutrons. The ozone reacts with ruthenium to form gaseous ruthenium tetroxide, which can be removed, leaving the technetium-99 behind in the path of the neutrons.

Signs of success have encouraged Abney and his Los Alamos colleagues to include the separation method in their ATW proposal for the Hanford cleanup. With the help of the ozone process, their admittedly long-shot scheme would transform 2.2 tons of pure radioactive waste into benign or more easily contained isotopes each year—perhaps enough to complete the Hanford cleanup in 30 years. That's alchemy on a grand scale.

–Ivan Amato