peer-reviewed. But major universities are already excited by the advent of the system; a group of senior university officials met earlier this month in San Francisco to discuss the subject. "It's going to be a hit; it could trigger a whole new level of activity," says Wolff. The system is slated to be operating by 1 April. "The current NSFnet system is just not going to support the kinds of high speeds needed," says Lawrence Rowe, a computer scientist at the University of California, Berkeley. "For videoconferencing and sharing documents, we need a lot more bandwidth."

Fear of higher fees

Although the future is bright, the present is clouded with worry about costs. Universities and colleges pay from $10,000 to $60,000 a year for access that regional networks provide to the backbone subsidized by NSF. Now those regional networks will have to pay commercial providers for access to the backbone, and the cost of using the networks inevitably will be passed on to the users. How much, however, is hard to forecast.

Marjory Blumenthal, a National Research Council staffer who directed a study last year on the future of information systems, says costs could go up on average from 10% to 100%, depending in part on one's distance from an access point. The study, *Realizing the Information Future*, warns that small colleges, public libraries, and schools with small budgets will feel the pain more sharply than wealthier institutions will.

At the same time, individual researchers likely will not be billed directly for the higher costs, say university and NSF officials. Instead, the charges will be added to university overhead rates. And NSF intends to cushion the blow by subsidizing the regional nets, in diminishing amounts, over the next 4 years. "The change in NSFnet is causing more apprehension than circumstances appear to warrant," the study notes.

All in all, most observers see the changes in a positive light. "The scientific community will be better off in the new environment because the net will be operated more efficiently by the private sector—and therefore at a lower cost," says Representative Rick Boucher (D–VA), who helped frame the issue in a bill to privatize NSFnet that was introduced in 1992 but was never enacted. And Educom's Roberts thinks the changes will be taken in stride by most scientists and universities. "The research community is pretty comfortable with this," says Roberts. "After all, it's been involved with this technology now for 10 years."

Despite the lingering uncertainty about the Internet's future, everyone agrees on one point: Researchers will find new uses for networks. And those uses will increase traffic and run up the tab for their institutions.

–Andrew Lawler

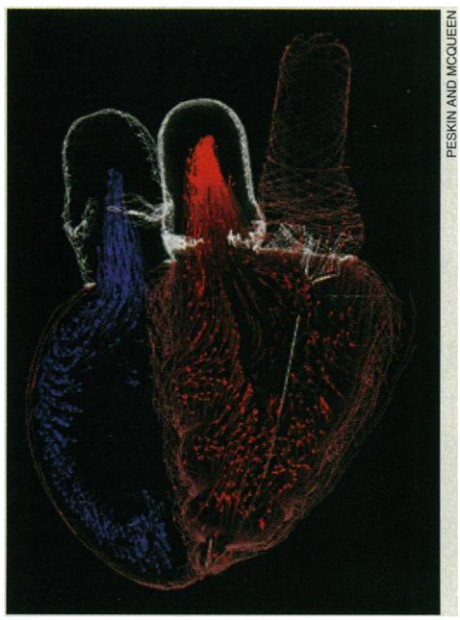
U.S. SUPERCOMPUTING

... Weighs Future of Computer Centers

Charles Peskin isn't a medical doctor, but for the past 25 years he's been operating on the human heart. An applied mathematician at the Courant Institute of Mathematical Sciences at New York University, Peskin does his "surgery" via computer, using a three-dimensional model to describe blood flow through this vital organ. The model, developed with colleague David McQueen, is so complex that a single heartbeat takes 150 hours to run on a Cray Research C90 supercomputer. And the machine isn't even located in the Big Apple—it's nearly 400 miles away at the Pittsburgh Supercomputing Center.

Peskin's work, which won two national computing awards last year, is helping scientists to understand heart disease and companies to design better valves. It's made possible by a program at the National Science Foundation (NSF) that has provided 15,000 researchers at 200 universities with access to supercomputers over the past decade. In 1985, when supercomputing was in its infancy, NSF established five centers, equipped them with state-of-the-art machines, and linked them together with a high-speed network that later formed the basis of the Internet. The centers make computing time available to researchers like Peskin, free of charge, on the basis of a peer review of proposals. This year NSF will spend almost $60 million on cooperative agreements with Pittsburgh and the three remaining centers—the Cornell Theory Center, the National Center for Supercomputing Applications (NCSA) at the University of Illinois, and the San Diego Supercomputing Center. (In 1989 NSF decided to end support for a center at Princeton University.)

But that arrangement could be changing. Last fall the National Science Board, NSF's governing body, turned down an NSF-backed proposal to renew the centers' contracts for 5 years. Instead, the board extended the existing agreements for 2 years and directed NSF officials to conduct a thorough review of the centers' operations. One is needed, they say, because scientists can satisfy their supercomputing needs at other sites and because a tight NSF budget compels them to scrutinize every large program. These moves have sent a tremor through the centers and their growing band of users, who fear that researchers' access to supercomputers may be reduced.



PESKIN AND MCQUEEN

In the flow. A cross section of Peskin and McQueen's three-dimensional heart model shows computed blood flow during ventricular ejection.

A task force,* chaired by Edward Hayes, vice president for research at Ohio State University, convened in January in the hope of delivering its report to the board next November. The eight-member panel will analyze "all possible alternatives," says Paul Young, head of NSF's computer and information science and engineering directorate—including giving vouchers to scientists to spend on supercomputing as they choose, requiring them to obtain outside funding for computing, holding an open competition for future center sites, or terminating the program.

Whatever the panel decides, its recommendations are likely to alter an arrangement that, in the words of board member Thomas Day, president of San Diego State University, has been "incredibly successful" for a decade. Set up to provide U.S. academic scientists with access to supercomputers, the centers have moved beyond what are known as "flop shops"—sources of raw computing power—to becoming service centers that offer technical support, programs like Mosaic (developed at the Illinois center), digital libraries, visualization, communications, and education.

* The task force members are: Arden L. Bement, Purdue University; John Hennessy, Stanford University; John Ingram, Schlumberger Research Laboratories, Austin, Texas; Peter A. Kollman, University of California, San Francisco; Mary K. Vernon, University of Wisconsin; Andrew B. White Jr., Los Alamos National Laboratory; and William A. Wulf, University of Virginia.

"People focus very narrowly on the megaflop rate of the processor," says Massachusetts Institute of Technology chemical engineer Gregory McRae, who heads an NSF-funded Grand Challenge project that models pollution in cities. "What's missing is how you go about reducing the elapsed time to solve a problem, which requires software, access, training, and the support structures that go with that." That combination of factors, says Princeton cosmologist Jeremiah Ostriker, who models galaxy formation, another Grand Challenge, provides an attractive bottom line for scientists. "You can solve problems at these places that you couldn't solve any other way," he says.

NSF'S STABLE OF SUPERCOMPUTING CENTERS

Center	Budget (in millions)	(% from NSF)	# staff	Main Hardware	Highlights
Cornell Theory Center	$29.1	50	110	512-processor IBM SP2	Focus on massively parallel computing
Nat'l Center for Supercomputing Applications (Univ. of Illinois)	$30.6	55	215	Thinking Machines CM-5, Convex Exemplar, SGI Challenge	Created MOSAIC, Telnet, and other Internet software
Pittsburgh Supercomputing Center	$36.1	50	132	Cray T3D parallel linked to Cray C90	First high-speed link of massively parallel and vector machines
San Diego Supercomputing Center	$24.1	71	100	Cray C90 vector, 400-node parallel Intel Paragon	Graphics and computational biosciences

Budget numbers are for FY 1994
SOURCES: NSF, INDIVIDUAL SUPERCOMPUTING CENTERS

But even staunch supporters concede the evolution of high-performance computing raises serious questions about the centers' purpose. "The technical case [for the centers] is less clear," says theoretical biophysicist Peter Wolynes of the University of Illinois, who helped start the Illinois center. With the growth of state supercomputer centers, the centers are no longer the only places to do high-performance computing. The growing power of workstations, linked over high-speed networks, is approaching the capabilities of mainframe supercomputers. And the need for software to operate newer, parallel-processing supercomputers has led some scientists to suggest that NSF should spend its money in other aspects of computing.

At the same time, backers take heart from a succession of positive reviews of the centers. Most recently, a 1993 advisory panel on high-performance computing headed by Harvard University physicist Lewis Branscomb concluded that even an open competition among the supercomputing centers would be disruptive. Instead, it recommended that their contracts be renewed. An advisory panel to the computing directorate agreed, as did an internal review by NSF officials.

But science board members say the political climate in Washington has changed since then. The report "was written when there was still a feeling there would be growth in the NSF budget," says John Hopcroft, dean of engineering at Cornell University, citing the Branscomb panel's recommendation for a doubling of funding for workstations. "Given the new budget realities," says Hopcroft, the board is now asking itself, 'What are the choices that we should make?' "

One idea before the task force is to give researchers "green stamps," or vouchers, that could be exchanged for time on any supercomputer. NSF would still foot the bill, but the money would come out of individual programs, not the supercomputing budget.

Last month NSF was encouraged to consider the idea in a report by a National Research Council panel reviewing the federal High-Performance Computing and Communications initiative, a $1 billion program of which the NSF centers are a part. That panel was chaired by Frederick Brooks, a computer scientist at the University of North Carolina, who advocated the use of such green stamps in the 1980s while a member of the science board.

Not everyone loves the idea, however. "These researchers shouldn't have to go around begging and making local deals," one center administrator told *Science*. "These are world-class scientists who have every right to command the resources that they need." And some scientists worry that the new arrangement would inevitably reduce NSF's total investment in high-performance computing: "It would be disastrous to reduce the amount of supercomputing time available to scientists," says Peskin, "and I think it's likely that any reorganization will have that effect."

The task force's first step will be to gather information from users, vendors, and the centers themselves; some will probably testify at future public meetings. But Hayes predicts that most of the debate will take place in private. "People don't talk a lot about these various kinds of scenarios because they're threatening to the status quo," he says. And change is precisely what the science board has in mind.

–Jocelyn Kaiser

Jocelyn Kaiser writes for Science News.

HUMAN EMBRYOLOGY

Japanese Panel OKs IVF Screening

OSAKA—A researcher affiliated with Kagoshima University, in western Japan, has received preliminary approval from a university committee to carry out the country's first genetic screening of in vitro–fertilized human embryos. Kazuhiro Takeuchi, who developed a technique to remove individual cells from a four- to eight-cell embryo to identify its sex, hopes to screen embryos before implantation in cases where mothers are known carriers of X-linked genetic diseases. The parents would then have the option of implanting only unaffected female embryos.

This screening method has been used in the West for several years. Takeuchi himself trained with scientists at the East Virginia Medical School in Norfolk, Virginia, which runs one of the largest IVF centers in the country, the Jones Institute for Reproductive Medicine. Although the U.S. government hasn't supported the development of screening techniques because it has had a de facto moratorium on funding IVF research, the technology is available privately, says Susan Black, senior clinical geneticist at the Genetics and IVF Institute of Fairfax, Virginia.

At Kagoshima, the seven professors and one lawyer on the university committee gave unanimous approval for the screening last week after an 8-month review of Takeuchi's application. (The absence of one member prevented final approval, which is expected to occur at another meeting next week.) The university committee did, however, restrict screening to three X-linked diseases—Duchenne type muscular dystrophy, hemophilia, and fragile X syndrome. The committee also required Takeuchi to obtain informed consent from the would-be parents.

Once the committee's vote is final, Takeuchi will be free to go ahead, for although two Japanese panels oversee applications for gene therapy, there is no national body that regulates genetic screening. Takeuchi welcomed last week's vote, noting that "we have worked for so long to develop these techniques, and now we will be able to help parents who are carriers of these diseases."

–Marc Lamphier

Marc Lamphier is a scientist working at Osaka University.