Hughes-Fulford, a biochemist at San Francisco's Veterans Administration Medical Center, who has focused on gene expression in microgravity—and is one of the few scientists to have done a whole series of experiments. "People like me are saying, 'Maybe I should do NIH [National Institutes of Health] [grants] instead.'"

Silver lining?

Such fatalism will be difficult for the Silver panel to counter. But researchers say the task force has the power to define the coming debate over station science. The hardest part will be to lay out priorities. Kicza's office has traditionally tried to slice its disciplinary pie in an equitable manner. But that makes little sense now, given budget and flight constraints. Says Vernikos: "We're not NIH or NSF [National Science Foundation]—and we never will be. We should focus on very specific problems."

But there may be ways to do more with less. Automation may ease the problem of crew time. The European Space Agency already has taken a lead in developing equipment that requires minimal attention in orbit. Hughes-Fulford's latest experiment, for example, will make use of the European Biopack, a largely automated centrifuge, slated to fly in July on the shuttle. Ames's Sarver says NASA is pushing automation to reduce the need for scarce crew time. For example, a $35 million cell-culture unit slated to fly by 2006 will take samples and preserve and refrigerate them without astronaut help, and a built-in microscope will enable researchers on the ground to have more control over the experiment. But automation can create more costs and problems—for instance, by greatly increasing the need for space-consuming freezers to store samples, notes Tim Hammond, a biologist at Tulane University in New Orleans.

If an independent research organization, perhaps modeled on the Space Telescope Science Institute in Baltimore, Maryland, were established, it might also provide better direction with less bureaucracy for station science. An NRC panel already has suggested that course, but the proposal has bogged down at NASA. Some congressional members who support Houston's Johnson Space Center fear it could usurp that organization's control over station operations, and others worry that an independent institute would have less political pull in winning an annual budget. Kicza has a team studying whether the agency should back the idea.

Increasing the amount of crew and research time in orbit would obviously be the best solution for station users. One proposal is to attach the space shuttle to the station for long periods, providing room for a much larger station crew. The shuttle could also be flown on an annual mission dedicated wholly to science, as in the one slated for July. Both ideas would require much more money than O'Keefe has on the books. And Congress, despite its concern over the health of station research, may prove extremely reluctant to fork out more money for an effort already mired in red ink.

That reality is what makes researchers such as Fettman skeptical that NASA will accept Silver's recommendations any more readily than it has her predecessors'. The problem, he says, is not with the research program. "What needs changing," he says, "is NASA's response. If they listened, wouldn't that be too cool?"

Still, many researchers say the panel can get the ball rolling by carefully spelling out what needs doing immediately and what can wait. Recommendations for more automation, greater use of the shuttle for crew and experiments, and a limited research repertoire—along with more money—will help, they add. That will involve pain for those researchers left behind at the launch pad, but it might give the program with an unhappy childhood a shot at maturity.

–ANDREW LAWLER

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MATHEMATICS

NSF Moves With VIGRE to Force Changes in Academia

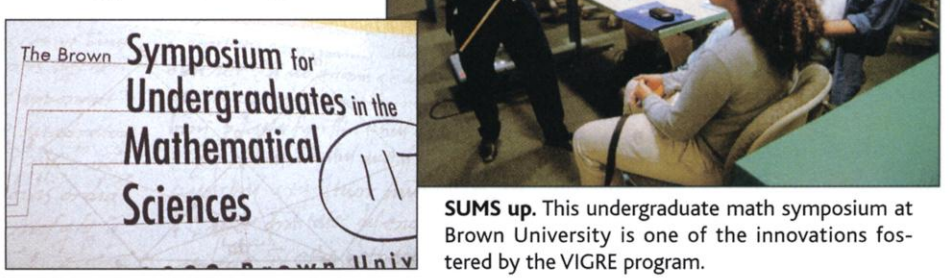
A new NSF program aims to make mathematics more user friendly for students—but it's not for every university department

Three years ago, the National Science Foundation (NSF) set out to change how the United States trains its mathematicians. This spring, it sent a handful of universities their first report cards. The verdict: The culture of math departments is changing, but even the most prestigious departments will find themselves out in the cold if they don't do it NSF's way.

The vehicle for change is an ambitious system of grants designed to fix a badly leaking educational pipeline. From 1992 to 1999, the number of U.S. mathematics majors dropped by 23%, and the number of math graduate students fell by 20%. When those students emerged with diplomas, many could not find jobs. In 1995 and 1996, the unemployment rate among new math Ph.D.s topped 10%, rivaling that of Michigan steelworkers. Many graduate students postponed entering the job market, causing the median "time-to-degree" to rise to nearly 7 years—two more than most math departments consider optimal.

In 1998, a blue-ribbon panel chaired by retired General William Odom concluded that the talent drain was threatening not only the nation's leading position in mathematics worldwide but also its ability to innovate in related disciplines. In response, NSF launched its Grants for Vertical Integration of Research and Education (VIGRE) program. The program has become a showpiece in NSF's most rapidly growing division, which hopes to boost VIGRE's budget next year by 62%, to $26 million.

VIGRE is based on the assumption that declining enrollments were caused by a lack of mentoring, according to Don Lewis, who as head of the math division created the VIGRE program. "Students viewed mathematics courses only as training for mathematics teaching," he says. Fields such as genomics, cryptology, and image processing were awash in jobs ideal for trained mathematicians, he adds, but students and postdocs didn't know about them. The answer, to Lewis, was obvious: Help universities do a better job of training and informing students about nontraditional careers. Or, as Bill



SUMS up. This undergraduate math symposium at Brown University is one of the innovations fostered by the VIGRE program.

Rundell of Texas A&M University in College Station puts it: "VIGRE makes us do what we should have been doing all along."

To make that happen, Lewis proposed a complete reform in the culture of mathematics, a shift away from the subject's traditional sink-or-swim individualism. VIGRE would encourage departments to transform themselves into mathematical villages, blurring the distinction between traditional boundaries separating research and instruction, pure and applied math, and advanced and beginning students. The goal was to help students at every level prepare for the next step in their careers.

"I wanted to have the mathematical research environment be more like the environments in other sciences," Lewis says, in which undergrads, graduate students, and postdocs all rub shoulders in the laboratory. "Biology does this much more effectively than mathematics" does, adds Philippe Tondeur, who succeeded Lewis as division director. "Students know [their subject] is exciting. They know where it leads."

A dozen universities received the first round of VIGRE grants in 1999, and 19 more have been added in two subsequent rounds. By mathematical standards, the new grants are lavish, ranging up to $1 million a year. The great majority of the money goes to graduate traineeships and postdoctoral fellowships, for which only U.S. citizens qualify. In return, departments must demonstrate progress in a variety of ways: increased enrollments, research papers, or posters by undergraduates; decreased "time-to-degree" for graduate students; improved outreach to other sciences and to nonacademic employers; and effective mentoring.

The grants have been a godsend for middle-tier universities, and not merely because of the money. For math professor Loyce Adams of the University of Washington, Seattle, the biggest difference is that the department can now afford to have postdocs. "They give seminars on topics not covered in the normal curriculum," she says.

Skip Garibaldi, a VIGRE-supported postdoc at the University of California, Los Angeles, has both a teaching and a research mentor. The latter is helping him write a book with Jean-Pierre Serre, a former winner of the Fields Medal (the mathematical equivalent of a Nobel Prize). "You can't get much above Serre, and you can't get much below me," says Garibaldi. "So that's an example of vertical integration."

VIGRE has fueled a big jump in the overall number of postdoctoral positions in mathematics. Those positions provide a welcome safety valve for new Ph.D.s seeking jobs in a recession-weakened job market. The VIGRE grants have also created grassroots opportunities. Last month, Brown University hosted a first-ever math symposium organized by and for undergraduates. The event, called Brown SUMS (Symposium for Undergraduates in the Mathematical Sciences), drew 75 students from across New England—a number that organizer Miguel Daal says was depressed by unseasonably warm weather. Even so, the conference gave the students an opportunity to network and to learn about the growing variety of mathematical research that goes on outside of math departments.

As NSF's Lewis intended, VIGRE has spurred many departments to reorganize their programs. The applied mathematics department at the University of Colorado, Boulder, whose grant was renewed this year, has created "tetrahedral research groups" that include faculty, postdocs, graduate students, and undergrads. "I think the idea was one reason we got the award in the first cycle," confesses James Meiss, the director of the program. Gareth Roberts, a VIGRE postdoc at Colorado for 2 years before getting a tenure-track job at the College of the Holy Cross in Worcester, Massachusetts, says that "the tetrahedra gave me a nice research feeling. In graduate school, I felt it was just me and my adviser, and mostly me. The VIGRE program put oomph into my research."

If anyone seems disgruntled with VIGRE, it is faculty members at top-tier schools. The Massachusetts Institute of Technology, for example, has failed in repeated attempts to get a grant. Lewis's own school, the University of Michigan, Ann Arbor, failed the first time around, perhaps because it had already implemented some of the changes envisioned. "No good deed goes unpunished," wryly notes Al Taylor, a principal investigator on the (successful) second application. Some Ivy League universities chafed at having to recruit more U.S.-born graduate students, with inferior mathematical background, because foreign students were ineligible for traineeships. "At some schools, it was a rarity to have an American student," Lewis says.

But no department had quite as traumatic an experience as the three (out of 12) that lost their grants this spring after a scheduled third-year review: Carnegie Mellon University, Rutgers University, and the University of California, Berkeley. The rebuff to Berkeley, America's largest producer of mathematics Ph.D.s, came as a shock to many mathematicians.

At a VIGRE workshop earlier this month in Reston, Virginia, Berkeley's chair, Calvin Moore, struck a defiant note, saying that mentoring isn't everything. "One of our goals is to cultivate self-reliance," he said. "Berkeley is a tough place. Berkeley is not a warm and fuzzy place. Students react to this atmosphere: Some thrive, and others don't." At the same time, he acknowledged, VIGRE has made a difference: The number of undergraduate math majors soared from 170 to 475 in 3 years.

Henry Warchall, a VIGRE management officer at NSF, says there's no mystery about why some schools lost their grants. The criteria are spelled out in the eight questions the grantees have to answer during the site review, he says, and those who don't have good answers get the hook. "There's no hidden agenda," Warchall said.

That level of micromanagement may be exactly the problem for some departments. "I've talked with people in other departments who resent the social engineering aspect of VIGRE," says David Targan, the principal investigator on the Brown University VIGRE grant. "But I think it's perfectly reasonable. If we want to advance as a field and get support from the NSF, we need to do it in certain ways." –DANA MACKENZIE

With additional reporting by Robert Coontz.

SOURCE: NSF

VIGRE WINNERS

Brown University, 2000
Carnegie Mellon University, 1999*
Columbia University, 1999
Cornell University, 2000
Duke University, 2000
Harvard University, 1999
Indiana University, 2001
Iowa State University, 2001
New York University, 2000
Pennsylvania State University, 1999
Princeton University, 1999
Purdue University, 2000
Rensselaer Polytechnic Institute, 2000
Rutgers University, 1999*
SUNY Stony Brook, 2000
Texas A&M University, 2000
University of Arizona, 1999
UC Berkeley, 1999*
UCLA, 2000
University of Chicago, 2000
University of Colorado, Boulder, 1999
University of Georgia, 2001
University of Illinois, Chicago, 2000
University of Illinois, Urbana-Champaign, 2000
University of Michigan, Ann Arbor, 1999
University of North Carolina, 1999
University of Texas, Austin, 2001
University of Utah, 2001
University of Washington, 1999
University of Wisconsin, Madison, 1999
Yale University, 2000

* Terminated after 3 years.