SOLUTIONS FOR TODAY'S HIGHER EDUCATION

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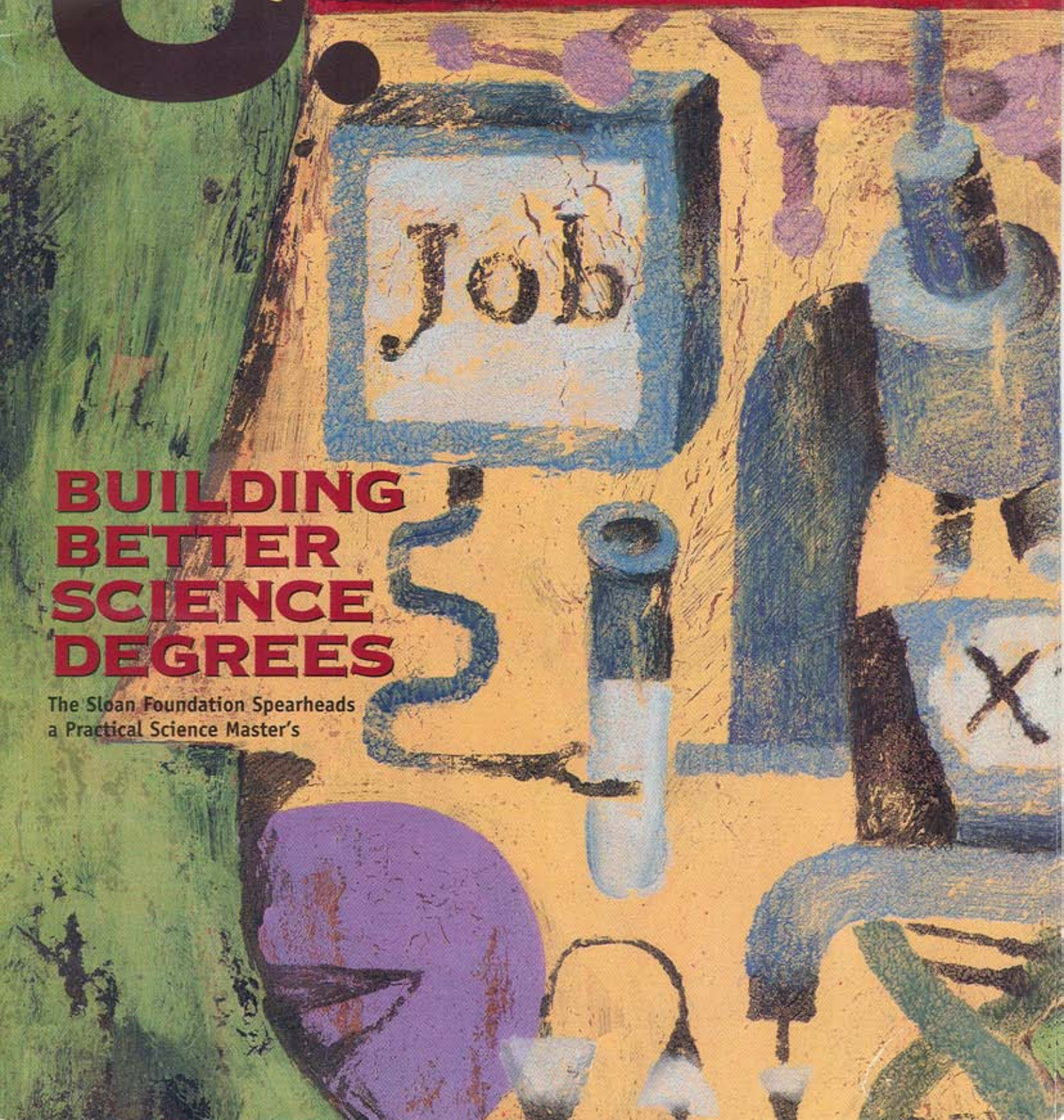

BUILDING BETTER SCIENCE DEGREES

The Sloan Foundation Spearheads a Practical Science Master's


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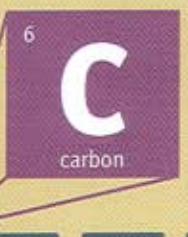

THE SCIENCE OF NEW DEGREES

BY MARGARET LITTMAN

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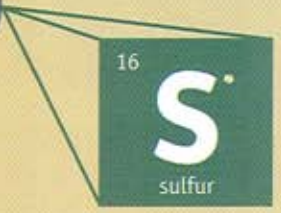

How to meet a demand for scientists in our high-tech economy? The Sloan Foundation's plan: Create a scientific equal to the M.B.A.

ARE WE TRAINING TOO MANY SCIENTISTS? GIVEN THE GLUT OF PH.D.'S VYING FOR elusive research positions, it would seem so. Yet executives at high-tech companies complain of a shortage of employees trained in the sciences. How can this be? This paradox is at the heart of the issue of how to teach science students in today's changing, increasingly high-tech economy. Until now, students wanting to pursue a career in science or math typically embraced the Ph.D. track, which led them exclusively to work in research or education. But as the number of research positions at both universities and governmental and nonprofit

institutions declines, those opportunities are becoming scarce.

As a result, the number of bachelor's degrees in science is dropping. Take physics: "We are at pre-sputnik levels," says Philip W. "Bo" Hammer, director of the Society of Physics Students and assistant manager of education for the American Institute of Physics in College Park, Maryland. "We are finding simply not enough jobs in academia to absorb all the people who want those jobs." The market creates a self-perpetuating cycle: If there are fewer research jobs for science doctorates, fewer students enroll in those programs—and so the demand for science faculty continues to diminish.

In the private sector, however, demand for the scientifically skilled has never been higher. Human-resources professionals at biotech firms, dot-coms, and other high-tech companies say that those who understand the fine points of biotechnology, chemistry, and mathematics are in hot demand—and that demand will continue to grow. But students are unaware of this fact, and the schools—with curricula based on theoretical research rather than on practical applications—have not trained them for such careers. That's the problem.

In recent years this issue has concerned a group of research universities, academics, and industry leaders—including the Alfred P. Sloan Foundation, the National Academy of Sciences, the American Institute of Physics, and the W.M. Keck Foundation. Sheila Tobias, a Tucson, Arizona–based science-education consultant, was one of the first crusaders for the cause. In 1995 she co-authored a book with Kevin Aylesworth and Daryl E. Chubin titled *Rethinking Science As a Career: Perceptions and Realities in the Physical Sciences,* outlining the need for new scientific training. When those at Sloan read it, they hired Tobias part-time to develop a grant program. The resulting program, called the Science Master's Outreach Initiative, began dispensing money in 1997 to help interested research universities create a new kind of degree—a terminal, practical two-year degree—and promote it to prospective students, faculty members, and industry leaders. Considered scientific equivalents of the M.B.A., these new degree programs have sprung up at a handful of leading institutions—including the first recipients of the Sloan grant: the University of Southern California, the University of Arizona, Georgia Institute of Technology, Michigan State University, and the University of Wisconsin at Madison. The degrees are starting to attract the attention of students, faculty, and industry experts alike.

TRAINING THE TRAINERS

"Everyone cannot be trained to be a trainer" is a mantra often uttered at Sloan. And indeed, these days not everyone *wants* to be a trainer. The long time commitment for a Ph.D., the tough competition for a dearth of university and research jobs, and the relatively low pay are primary reasons science students are backing away.

"There are a reasonable number of young people with physics, math, and other scientific orientation who may not be able to wait until they are 35 years old for their first real job and income," says Jesse Ausubel, program director at the Sloan Foundation.

Ph.D. programs have been slow to address the decline in their fields, in part because

OTHER PROGRAMS

THE LEADER IN NEW SCIENCE MASTER'S degree programs may be the Sloan Foundation, but in addition to those it has funded, several other schools have science master's degrees. Here are a few, taken from the Sloan Foundation's Web site: (www.sciencemasters.com).

• **Instrumentation.** SUNY Stony Brook. A two-year program launched 15 years ago, it draws on students with bachelor's degrees in physics and engineering.

• **Chemical and material physics.** University of California–Irvine. Enrolled its first class in 1998.

• **Technology, education, and commercialization.** North Carolina State University's College of Management. Students receive practical instruction in technology transfer, commercialization strategies, venture capital, project and team management, and technology-based business plans.

• **Applied Physics (with internships in the semiconductor industry).** Texas Tech University.

• **Microelectronics-photonics.** University of Arkansas. Interdisciplinary program in physics, chemistry, and engineering, began in fall 1999. In addition, has an applied physics degree, also implemented in 1999.

• **Biotechnology.** Kean University in Union, New Jersey. New degree offering students option of biotechnology/genetic engineering, biotechnology/structure-based interactions, and environmental biotechnology. Designed to prepare researchers and not managers.

• **Biotechnology.** Northwestern University. More than seven years old, with more than 200 students enrolled, it is a professional, 13-month program in the science and business of biotechnology.

• **Waste management and environmental science.** Idaho State University.

• **Biotechnology.** University of Pennsylvania, jointly sponsored by Penn's engineering and arts and sciences schools. Three tracks offered: basic biotechnology, engineering biotechnology, and computational biology/bioinformations (preparing students to handle genomic databases).

• **Science B.S./M.B.A.** Pennsylvania State University. Began in 1995.

many science faculty were unaware of possibilities outside research—often lucrative, intellectually challenging possibilities—and so did not steer their students toward them.

In addition, old habits die hard—and perhaps nowhere is this more true than in academia. Faculty were loath to suggest creating degrees without a research component. Some were hesitant to consider science in a commercial, for-profit world as pure a use of the discipline as research. Others worried that without outside research grants, their already dwindling departments would disappear.

"What we have to do is work with departments and change the culture there," says Hammer. "What faculty know as career advisors is what they do, and that is academic research, not corporate work."

And there are challenges regarding student perception too. While researching her book, Tobias found that fewer than 3 percent of the master's degrees awarded in the United States were in the sciences. Part of the problem was that the master's degree in science was thought of merely as a failed Ph.D. And in some sense this was true, for the programs were designed to feed students into the Ph.D. track, not to offer a viable master's degree.

Students who did want to put their undergraduate science degrees to use in industry have had few options. Many turned to an M.B.A., seeking management training while hoping their science background would serve them in good stead. Yet recruiters lament that few programs teach management skills without skimping on the technology needed to understand the operations side of business.

"M.B.A.'s are woefully unprepared in technical areas, unless they come out of engineering, and even then they've had to give up the engineering for business," says Tobias. "The time has come for a professional degree grounded in science and mathematics, but not limited to science."

So the Sloan Foundation, a 20-employee nonprofit organization based in New York City, set out to do just that. Founded in 1934 by Alfred Pritchard Sloan Jr., then president and CEO of General Motors Corp., the foundation seeks to fund both scientific and technological research and education in those fields. The science master's initiative is just one of the many grants it gives to schools to foster new ways of teaching math and science. In 1999, Sloan awarded more than $50 million in general education and research grants.

Sloan and others conceived of programs that were structured enough to have clear objectives and expectations, but fluid enough to adapt to different institutions' strengths and to the specific needs of the individual disciplines. The new degrees, they decided, should:

- Be intensive two-year, postgraduate, professional degrees that qualify graduates to work, for instance, as full professionals in groups engaged in high-quality research and development activities.
- Be analogous to professional degrees that have long been highly prized in professions such as engineering, business, and law.
- Enable degree recipients to be hired in middle management and higher positions at such companies as DuPont, Bayer, and Motorola as well as smaller, new high-tech companies.
- Cover emerging new fields, interdisciplinary study, or science and math combined with business, law, and communications. Possible new fields include quantitative finance, human-computer interaction, or biomedical informatics.
- Allow graduates to compete for jobs with other professional students in a way that a certificate program would not.

Pedagogies for such degrees will undoubtedly vary, and Sloan's program was conceived to allow each institution to design its curriculum, as long as it adhered to Sloan's unifying principles. But in general, the programs provide a professional platform for work in: new and emerging fields (human-computer interaction); consulting (technology transfer at such firms as Andersen Consulting); commerce in banks, insurance firms, and brokerage houses; patent and regulatory affairs for both private industry and government; research management in nonprofits and for-profits; and production and marketing of new science-based products.

Sloan highlights one long-term advantage: If science professionals are placed in positions of power, then they can plant the seeds for a positive attitude toward science. "Science-trained professionals will contribute to positive attention toward research in whatever company they work for, whether in the position of financial vice president or in marketing," says Tobias.

But will these degrees have long-term viability if—or when—the economy slows and biotech companies have less money for hiring? Yes, says R. Timothy Mulcahy, associate dean for biological sciences in the graduate school at the University of Wisconsin, one of the first developers of a science master's degree. The degrees are sustainable because graduates

Abstract

HIGH-TECH COMPANIES complain of a shortage of workers skilled in science because most schools train their students only for research. Yet academic and research positions for scientists are declining. The answer? A new professional master's degree.

★ The Sloan Foundation and others have set out to create a viable science master's degree. It is a two-year, practical, professional program similar to those in business and law.

★ With Sloan grants up to $400,000, 15 schools have created new programs in such fields as applied bioscience, computational biology, physics for business applications, and industrial physics.

★ A long-term goal: Filling corporations with managers who will understand and support scientific research.

understand both scientific and economic principles, he says. "The prospects are growing, not withering."

THEORY INTO PRACTICE

The Sloan grants provide $400,000 for multiple programs over a three-year start-up phase (or $150,000 for schools starting a single track program). Fifteen percent of the grant is for overhead expenses—but none of it will go to student stipends. Additional funds, in small increments such as $25,000, are sometimes awarded to schools to allow them to research the viability of a new degree more fully.

Sloan funds cannot be used to pay tuition because the aim is to create professional degrees that generate revenue through tuition—the way business, law, and journalism programs work. This requires a significant shift in the way graduate students in the sciences think, since Ph.D. programs are almost always subsidized by research grants and teaching fellowships. Because the new master's degrees are expected to have a real-world value that will translate into high salaries in the high-tech business world, those at Sloan argue, eventually the concept of self-financed science education will be easy for students to grasp. For now, however, it is one of the most difficult parts of the sales pitch to make.

Proposals for Sloan grants must include: demand-side analysis for graduating students, including substantial evidence of efforts by faculty members to understand industrial and commercial employment opportunities; evidence of interest in the programs by at least three science and math departments; and a local group of business executives willing to help develop curriculum and interview the students after graduation. Most programs include internships with the partnering companies.

Ausubel says the Sloan Foundation expects to give $3 million in the next year, though there is no real limit to the number of grants it gives. Since 1997, when the first five programs received funding, the foundation has awarded grants to: Boston University, the University of California at Los Angeles, the University of California at Santa Cruz, Keck Graduate Institute, New Jersey Institute of Technology, Northeastern University, Rensselaer Polytechnic Institute, the University of South Carolina, the University of Texas at El Paso, and the Worcester Polytechnic Institute.

Half of the programs have been launched, though most have only 10 to 15 students enrolled. But Sloan has a target of 1,000 students enrolled nationally by 2002. About half of the schools are developing three or more degrees, and each illustrates different manifestations and challenges.

Here's a closer look at a few programs:

UNIVERSITY OF ARIZONA
PROGRAM START DATE: *Fall 2000*
NUMBER OF STUDENTS: *Nine enrolled*
DEGREE FIELD: *Applied biosciences, applied and industrial physics, and mathematical sciences*

IN 1995 LESS THAN 3 PERCENT OF THE MASTER'S DEGREES AWARDED WERE IN THE SCIENCES, IN PART BECAUSE THE DEGREE WAS THOUGHT OF AS A FAILED PH.D.

ADMISSIONS REQUIREMENTS: *Undergraduate degrees in mathematics or science*

At Arizona's Tucson campus, students "hadn't been taught to ask" what they thought of job prospects and master's degrees that were considered "incidental" to the Ph.D., says Eugene H. Levy, former dean of the College of Science (and now provost at Rice University). But after developing three coordinated degrees in applied mathematics, applied and industrial physics, and applied biosciences, he was "gratified by the interest" from students. The school approved the programs last winter, and Levy says the departments could not start actively recruiting until they had that approval. Therefore, he did not see the current low enrollment figures as indicative of a lack of interest. With the program up and running, the school will increase advertising over the next two years, a move Levy thinks will boost applications and enrollment.

Levy sees these degrees as part of a larger shift in professional education.

"I think the developments that will emerge are degrees like the technological master's degree. The bachelor's degree has assumed a role in society that is now comparable to the high school diploma in the 1950s," he says. "The bachelor's degree is not carrying education far enough to meet the needs of today's employers. In a sense, the master's will be the differentiating degree."

KECK GRADUATE INSTITUTE
PROGRAM START DATE: *August 2000*
NUMBER OF STUDENTS: *Enrolled 28 students in the first year; 55–60 projected to enter by the third; school plans a total enrollment of no more than 125*
DEGREE FIELD: *Master of Bioscience (M.B.S.), a name coined by the school, says John Friesman, director of admissions and student services*
ADMISSION REQUIREMENTS: *Strong science undergraduate course work or degree, with preference given to candidates experienced in bioengineering, biotechnology, and other life sciences. KGI hopes that 30 percent of its students will be returning to school from industry*
ADDITIONAL FUNDING: *KGI was created in 1997 by the Claremont Colleges consortium with a $50 million grant from the Los Angeles–based W.M. Keck Foundation. The school is hoping to raise an additional $60 million from other sources*

Sloan most commonly funds programs at existing departments in big research universities. "It is easier by far to create programs within existing degree structures than to create new degrees," Tobias says. "We have done it in the past with biochemistry, materials science, and computer science, which was once a track within mathematics."

But the Keck Graduate Institute (KGI) is an exception. The only new institution to be awarded Sloan funding, KGI bills itself as "located in the biotech, life-sciences hub" of Southern California, and in many ways it personifies the aims of the science master's movement. It is part of the Claremont Colleges, a consortium of seven colleges. It was

the first U.S. school dedicated solely to the emerging field of applied sciences.

"The Claremont Colleges have a history of starting new schools but had not done so since 1963," says Friesman. So when Henry Riggs—former president of Harvey Mudd College, Claremont's esteemed science school, and now president of KGI—saw the need to develop new degrees, the consortium created KGI. Riggs and other interested faculty members thought that starting a new school, rather than running new programs through Harvey Mudd, was both true to the mission of the Claremont schools and would better fill the need for a new kind of science training.

Unlike other schools, Friesman says KGI may add noncompeting Ph.D. programs—"very small and applications-driven"—down the road. And KGI offers full tuition to its first 28 students and stipends for others. The program did this to attract "high-caliber students," Friesman says, and though it will continue to provide "generous grants," it will not provide full tuition for everyone in the future.

KGI has also faced the unique challenge of recruiting new faculty members, which is tough because "the pedagogical approach is so unusual," says Friesman, whose job it is to sell the program to prospective students, faculty, and employers, and who has hired a high-profile media-relations firm to help with the effort nationally. At the beginning of the semester, KGI had nine faculty members.

"We are going head-to-head with Ph.D. programs. This is a new option," Friesman explains. "We really do think that we will be competitive with M.B.A.'s in terms of earnings potential, but we'll have to see."

UNIVERSITY OF SOUTHERN CALIFORNIA

PROGRAM START DATE: *Fall 1999 and fall 2000, depending on the degree*

NUMBER OF STUDENTS: *23 for this fall*

DEGREE FIELD: *Master's degrees in four fields: physics for business applications; computational biology; environmental risk assessment; and computational linguistics*

ADMISSIONS REQUIREMENTS: *Computational biology requires course work in biology, physical science, computer science, or mathematics; computational linguistics requires degrees in computer science, linguistics, or mathematics.*

One of the only private universities in the original Sloan-funded group, USC has started four programs. Its physics for business applications offers a three-part curriculum that includes: physics courses to enhance basic skills; business training, including information systems, operations management, and corporate finance; and a review of emerging technologies with an internship at a local business.

According to a survey of its alumni, the USC Department of Physics and Astronomy

found that only 8 percent of its graduates felt they had been well informed about the diversity of careers in science. Moreover, USC found that the programs don't necessarily train students appropriately—alumni had turned to graduate business programs to get the training they needed, says Hans Bozler, professor of physics and project director for the grant from Sloan. "The clearest direction we could take was from our own alumni." So they started there and spent two years surveying graduates, faculty, and employers before the current programs were approved by the administration—a long process that is by no means over.

"Selling to the students is taking longer than I originally thought," Bozler concedes. "They are limited by the financial aspect of it more than we anticipated."

The program materials boast: "Graduates... should expect enhanced career opportunities within the business and finance communities and in firms engaged in the development of new technology." As a result, Bozler insists the program will not be "apologetic" in asking students to foot the bill (though USC plans to ask for corporate support in providing fellowships). "We think we are worth it," he says.

UNIVERSITY OF WISCONSIN
PROGRAM START DATE: *Fall 1999 and fall 2000*
NUMBER OF STUDENTS: *17*
DEGREE FIELD: *Environmental monitoring, computational sciences (which includes computer graphics for multiple applications including meteorological science), and bioinformatics (new discipline that merges computational science with medical/biological research)*
ADMISSIONS REQUIREMENTS: *Undergraduate degrees in related fields; unlike other science master's that specifically require science or math degrees, the Wisconsin Environmental Monitoring program also considers students with training in architecture and urban planning*
ADDITIONAL FUNDING: *$200,000 from UW*

Billing them as nonthesis M.S. degrees, Wisconsin markets its new programs as being heavy on "real-world experience enhanced by collaboration with commercial and government partners." While recruiting students with such prose, Mulcahy, associate dean for biological sciences, says the faculty and administration have been a harder sell.

The program's biggest challenge, he says, has been to assure the faculty that the degrees will be quality products. "For Research I institutions like us, the prime focus has always been research. So this is a new type of program for us, and there is always a little bit of an attitude when you try to do a new thing."

The departments have been cautious, wanting to avoid the perception of "stealing students or funds from other disciplines and departments, without attacking the purpose or integrity of the other departments," he adds.

WE ARE GOING HEAD-TO-HEAD WITH PH.D. PROGRAMS. WE THINK WE WILL BE COMPETITIVE WITH THE M.B.A. IN TERMS OF EARNING POTENTIAL.

"The value of these programs—because they're based on a link between research and business-commercial research—demands that you get faculty from outside academia involved in curriculum development," Mulcahy says. "At the same time, you want a stable program, which means having a stable, regular faculty."

To convince the administration of the viability and integrity of the proposed degrees, each individual program had to provide evidence of contact with employers as part of the developmental process. "The process has been one of deliberate solicitation," Mulcahy says.

SEED BED

Opposition to the new degrees has been surprisingly limited, although some faculty members fear that the programs will siphon funding, students, and credibility from established Ph.D. programs. But even those whom Tobias expected to be critical—scientists she thought would instead favor lobbying the government to support more research Ph.D.'s—turned out to have been working on similar education programs of their own. Leon M. Lederman—director emeritus of the Fermi National Accelerator Laboratory in Batavia, Illinois, resident scholar at the Illinois Mathematics and Science Academy in Aurora, and Pritzker Professor of Science at Illinois Institute of Technology—is one scientist who supports the idea. In fact, he sees it as part of a necessary reorientation for higher education in general and has suggested that everyone would be well served by being science-literate, since exploding technology affects all professions.

"Science is overtaking problems in law and culture in general. There are new crises all the time, and people at the professional level are not prepared," says Lederman, internationally known specialist in high-energy physics and winner of the 1988 Nobel Prize in Physics. "In a more sane universe, this would be folded into college curriculum. But in truth, most students go through college without science. In the long run we need to get people in Congress with these degrees."

Are the new programs destined to succeed? Tobias and others know they face quite a challenge. "In 1908, the M.B.A. invented management science, a new pedagogy," Tobias says. "I think there are parallels." She explains that it took 40 years before the M.B.A. was uniformly accepted in academia, and so she expects to have to sell the science master's for several years—at least until the pioneering students graduate and can prove the fair market value of the degree. Still, she says it's conceivable that the new science master's degree will become the consummate degree for the 21st century.

"The final issue for me is quality control," says Tobias. "If you look at law, medicine, business, they have tested and tried systems for controlling graduates, such as accrediting programs and board exams.

"We are giving a party," she concludes. "It will be interesting to see who comes." ◻

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