GRADUATE EDUCATION

Professional Science Master's Programs Merit Wider Support

A recent study shows the potential of an alternative career path in building a scientific work force.

Rita R. Colwell

The United States faces growing global competition in the development of innovative products and services, a challenge much like a "silent Sputnik" to which the nation must pay more attention (*1*). One component of the U.S. educational system that can help us meet that challenge is master's level education in the natural sciences.

In most fields in the natural sciences, master's degrees have long been viewed mainly as milestones en route to a doctorate, rather than destinations in their own right. But about a decade ago, foundations and universities began experimenting with new master's programs that develop advanced scientific knowledge and professional skills such as communication, project management, and commercialization. Most of these innovative Professional Science Master's (PSM) degree programs are interdisciplinary and provide hands-on learning through internships and team projects. They are not intended to displace traditional programs. Instead, they aim to engage students with professional goals and help them become scientists uniquely suited to the 21st-century workplace, equipped with a deeper and broader scientific knowledge than that acquired with a Bachelor of Science degree and the skills to apply it.

The experiment has yielded promising results. Beginning with seed money from the Alfred P. Sloan Foundation to establish individual PSM programs at existing institutions and an endowment from the W. M. Keck Foundation to establish the Keck Graduate Institute of Applied Life Sciences, the experiment has resulted in 128 PSM programs now under way at 64 universities in 23 states, producing about 600 graduates per year. (Examples of these PSM programs are listed in the table on the right.) The America COMPETES Act (Public Law 110-69) provides an opportunity for further growth by authorizing the National Science Foundation (NSF) to provide grants for the creation or expansion of up to 200 programs. With broader support from the community, these programs could engage and benefit far more students and employers, providing a powerful contribution to our nation's competitiveness. That was the conclusion of a recent study from the National Research Council, for which I served as chair (*2*).

The report committee found that many stu-

Professional Science Master's Programs*

Institution and Field	Description and Features
California State University, Chico	Targeted to scientists who want to improve their business skills, the program includes business training complemented by science training in fields such as agriculture, biology, chemistry, and engineering.
Environmental Sciences	www.csuchico.edu/psm
Middle Tennessee State University	Designed to prepare students for careers in the management of bioscience firms and organizations—specifically, research positions in laboratories applying biotechnology to problems in medicine, industry, and agriculture; and management positions in the biotechnology and pharmaceutical industries. Most students are full time.
Biotechnology	http://frank.mtsu.edu/~msps
University of Connecticut	Designed to train scientists with interdisciplinary competency in genetics, molecular biology, and computational analysis. The program is intended to meet the needs of biotechnology and pharmaceutical companies and to prepare for genomics-related work in the law enforcement, legal, and political communities.
Applied Genomics	www.smasters.uconn.edu/applied_genomics
Georgia Institute of Technology	Designed to give students the knowledge and skills necessary to start a career in industry as a bioinformatics or biocomputing specialist.
Bioinformatics	www.biology.gatech.edu/graduate-programs/bioinformatics/new/program_overview.php
Michigan State University	The Online Master of Science in Food Safety Program was created in response to recognizing an undeniable need on the part of the food industry, government, and public health for their employees to be specifically educated in the many aspects of safeguarding our food supply.
Food Safety and Toxicology	http://online.foodsafety.msu.edu
State University of New York at Buffalo	Focuses on how to apply existing chemical software to problems in quantum chemistry, molecular biology, environmental chemistry, and industrial chemistry, for example. Training in business and ethics is also included, and training in software development is available. The program is geared primarily to full-time students.
Computational Chemistry	http://professionalmasters.cas.buffalo.edu
Arizona State University	The program consists of interdisciplinary courses that provide a knowledge base required for full appreciation of research and innovation in nanoscience and nanotechnology. Students choose courses in physics, chemistry and biochemistry, materials science, biotechnology, and intellectual property and innovation.
Nanoscience	http://physics.asu.edu/graduate/psm/overview
Worcester Polytechnic Institute	Designed to prepare students for quantitative careers in the financial industry, including banks, insurance companies, and investment and securities firms. The curriculum includes mathematics and statistics courses along with studies in financial management, information technology, and/or computer science.
Quantitative Finance	www.wpi.edu/Academics/Depts/Math/Grad/financial.html

* From program Web sites and the Council of Graduate Schools.

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dents who could have useful and interesting careers in the sciences shy away from graduate school, uncertain about both the length of study for the doctorate and the career outcomes. PSM degree programs, typically 2 years in length, offer a different path for these students, whose interests and talents might otherwise be lost to the scientific work force.

Indeed, the creation of PSM programs could provide the United States with a competitive advantage by both providing opportunities for more domestic students in graduate science and attracting international talent as well. PSM program data have already shown that these programs have attracted greater numbers of women than other graduate programs in similar fields; it is hoped that this can be extended to underrepresented minorities as well. Meanwhile, programs in areas such as bioinformatics have begun to attract large numbers of international students.

Those who follow the PSM path will likely find employers—whose work-force needs are evolving—eagerly awaiting them, our study found. Biotech companies, information technology firms, banks and financial companies, and government agencies have testified to their need for employees with the knowledge and skills these programs cultivate. And the salaries of those who hold master's degrees in science and engineering have grown faster over the last 10 years than salaries of those with bachelor's degrees or Ph.D.'s.

Members of this new cadre of science-trained professionals become investment analysts, science and technology acquisition managers, and forensic scientists. They work in emerging fields such as business intelligence, which uses data mining and mathematical modeling to solve business problems, and service science, which seeks ways to increase industry productivity and efficiency in the rapidly growing service economy. Some PSM graduates can be predicted to emerge as leaders in industry, government, and nonprofits.

In these jobs for which they are so well qualified, PSM graduates will benefit both individual employers and our nation's ability to compete in the global marketplace. The capacity to innovate depends not only on scientific discovery but also on the ability to translate new knowledge into products and services. This is where PSM graduates can have a major impact. To accomplish this on a broad scale—especially for expanding industries such as biotechnology, which increasingly are focused on production—current PSM programs need to be scaled up and new programs created, a challenge for the concerted action of government, universities, foundations, and employers.

The report recommends Congress take the lead by fully funding and expanding the PSM initiative it authorized at the NSF in the 2007 America COMPETES Act. Congress has now provided an initial $15 million at the NSF for the PSM through the American Recovery and Reinvestment Act, which became law in February. These funds are available through 30 September 2010. Congress has an opportunity to provide additional funding under the COMPETES Act authorization in the Fiscal Year 2010 Budget; after that, Congress will need to provide both new authorization and appropriation. This initiative should be expanded to include other federal science agencies.

Congress should also add scholarships for U.S. citizens who enroll in PSM programs. The typical cost of a program varies greatly, depending on the type of institution, and so far PSM students have had to fund their master's education. This is unlike many Ph.D. students who receive support through fellowships and research and teaching assistantships. However, it is not unlike students in professional programs in law, business, public policy, or medicine, who see the cost of such education as an investment in themselves that will pay off in the long run. Scholarships will allow many more students, particularly those from less advantaged backgrounds, to participate in PSM programs and will expand the number of domestic students who continue in science at the graduate level. In the meantime, many PSM programs are preparing to meet the educational needs of veterans who will benefit from the Post-9/11 Veterans Education Assistance Act, which became law in July 2008.

States, which have had a historic role in both higher education and economic development, must also play a role. They should regard PSM programs as critical to producing a cadre of science professionals who can manage and grow science- and technology-based industries in their states and regions and make wise investments to support them. In several states—North Carolina, New York, and California, for example—state universities have established systemwide plans for PSM programs across their campuses to meet key economic needs.

Universities, in turn, should continue to support existing programs, to create new ones, and to ensure that curricula evolve to reflect scientific developments and work-force needs. PSM programs have a responsibility within this context to engage in ongoing evaluation that will provide feedback on both processes and outcomes. This information will allow for midcourse corrections to increase program effectiveness.

Employers must be key partners in these efforts. PSM programs need to establish employer advisory boards and work with them to develop and evolve curricula and to develop linkages to the workplace. Employers can additionally sponsor student team projects, provide mentoring and internship opportunities for students, and hire graduates who meet their personnel needs.

To be sure, there are challenges in the development of PSM programs. A case must be made that funds for PSM development are a wise investment, justifying the opportunity costs. Individual faculty members also need to support these programs. While some do, others view master's level education only as an incidental step for doctoral students. Worse, they claim to be too busy to give it attention. With appropriate incentives—program resources, credit for program development in tenure review—surely, more faculty would participate in starting and sustaining these programs.

Professional organizations in the sciences have a role as well. These societies historically have focused on encouraging and supporting the work of a doctorate-educated work force, but many are now considering a broader role in advancing education. The professional societies should take master's education under their wings—creating committees to foster master's education, recognizing faculty who have led successful PSM programs, and serving as field-specific clearinghouses of information about the programs.

PSM programs can make a vital contribution to this century's work force, which needs employees who can work well in teams and across disciplines (*3*). It is time for leaders in government, education, and industry to show similar teamwork in supporting these programs—an investment to yield a talented group of scientists with the skills our nation requires most to meet the global challenges of the 21st century.

References and Notes

1. R. R. Colwell, *Bioscience* **58**, 3 (2008).
2. National Research Council, *Science Professionals: Master's Education for a Competitive World* (National Academies Press, Washington, DC, 2008); www.nap.edu/catalog.php?record_id=12064.
3. The PSM has also been endorsed in reports by the National Science Board, the President's Council of Advisors on Science and Technology, the Council on Competitiveness, the U.S. Chamber of Commerce, the Association of American Universities, the Council of Graduate Schools, and the National Governors Association [see Appendix I of the study report (*2*) for details].

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