SCIENCE

Careers '95: The Future of the Ph.D.

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FERDINAND HAMBURGER, JR., ARCHIVES OF JOHNS HOPKINS UNIV.

Small beginnings. One of the first U.S. graduate school classes gathered in the chemistry lab of Professor Ira Remsen at Johns Hopkins University, circa 1890.

The U.S. science Ph.D. seems to have hit a wall—hard. After decades of expansion, the number of scientists seeking research grants and research jobs appears, in the eyes of many, to have outstripped the money available to supply them. Cell biologist Richard McIntosh, former president of the American Society for Cell Biology, has described the situation as a "Malthusian crisis."

The first group to run into this harsh reality was physical scientists. With the shrinkage of the defense industry after the crumbling of the Iron Curtain beginning in 1989, there were fewer research jobs, says provost Mark Wrighton of Washington University in St. Louis. At the same time, the "biological revolution" of the last few decades had created a renewed surge of interest in the life sciences, says Ed Penhoet, chief executive officer of the biotech firm Chiron Corp. in Emeryville, California. The result: more people competing for fewer jobs. And attempts to reduce the federal deficit have reduced hopes for new growth in science budgets.

The effects of this changing environment are sweeping, and in this special issue of *Science*, we explore some of the most important features. Until now, says Karen Holbrook, vice president for research and dean of the graduate school at the University of Florida, Gainesville, "policies for graduate education, particularly in science and engineering, have not been seriously considered since the end of World War II." But what began as complaints by jobless physicists has grown into a debate that is embroiling the entire community. Many favor curtailing Ph.D. production—and even those who don't are talking about altering the curriculum to make Ph.D.s more marketable in a changing economy. Research universities, too, are changing, in ways that will affect the careers of scientists for years to come. (Early next year, *Science* will examine the changes affecting graduate education in Europe and Asia.)

Birth control. The major sign that things have changed in U.S. science is that some scientists—and some scientific societies, such as the American Chemical Society—are calling for reductions in the number of Ph.D.s being trained. The establishment—that is, scientists representing the National Science Foundation and the National Academy of Sciences—has been resisting calls for restrictions. Instead, the message, as spelled out in a recent report by the Committee on Science, Engineering, and Public Policy (COSEPUP),* is that with a "broadening" of their train-

* "Reshaping the Graduate Education of Scientists and Engineers," COSEPUP; National Academy of Sciences/National Academy of Engineering/Institute of Medicine. National Academy Press, 1995.

Catch "*Science*'s Next Wave"

Along with the Careers issue of *Science*, today marks the beginning of a new medium for providing information, services, and communication among the next generation of scientists. The new medium is an electronic network—"*Science*'s Next Wave"—found on the World Wide Web at **http://sci.aaas.org/nextwave/**. In addition to an electronic version of the Careers section, the network will offer a wide array of specifically electronic features. The first, premiering today, is an interactive forum on "Training Scientists for 21st Century Careers."

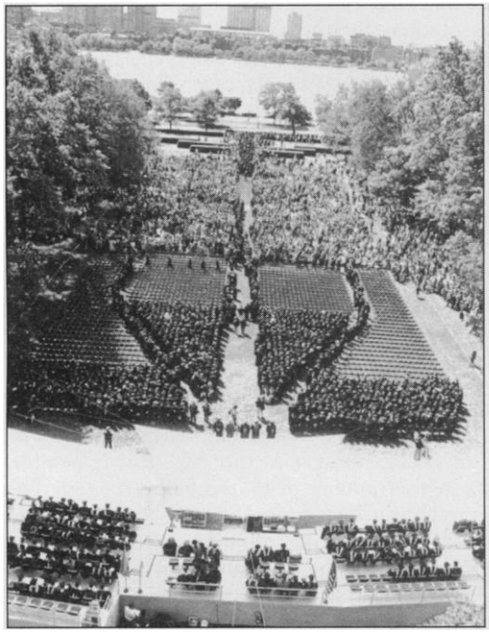
ing Ph.D.s will all be able to find jobs—and jobs that are just as prestigious and intellectually rewarding as research. Reporter Constance Holden documents the debate on page 123.

Changing Ph.D. training. While policy-makers and educators are thinking hard about making a more marketable Ph.D. for the next century, a few universities have actually taken steps to equip their students with a broader doctorate. On page 128, reporter Anne Simon Moffat reports on these efforts as well as attempts to shorten the course of study and to redesign financial aid to students to help accomplish these ends.

There is still much to be sorted out about altering Ph.D. programs to accommodate the changing environment. Some people, including graduate students themselves, oppose any tinkering with the present system. Avik Chatterjee, a Cornell University graduate student in theoretical chemistry, says, "I'm not sure how it's possible to balance" the need for broad education with a "high degree of specialized knowledge" in only 5 years.

Revitalizing master's degree programs may be one solution. But according to the COSEPUP report, any attempt to "hybridize" the Ph.D. itself—as in, for example, "doctor of science" degrees created for people headed for nonresearch careers, is likely to be regarded by academics as a watered-down version of the real thing.

Institutional reformatting. Along with changes in training, universities have to think about how they, as institutions built around the notion of continuous growth, can best survive and flourish in this new "steady state." And these changes will have profound effects on the scientists who work there. As reporter Paul Selvin relates on page 135, schools are seeking to restructure themselves in multiple directions: not only by cutting costs and maximizing efficiency, but by breaking down traditional departmental barriers to make way for a more interdisciplinary focus and forging new revenue-generating ties with industry, government, and the public.



DONNA COVENEY/MIT

Mass production. In 1994, the Ph.D.s sit at front of audience at right in this photo of the Massachusetts Institute of Technology's commencement.

The industry view. Such developments have caught the eyes of corporate research outfits, which have long complained that traditional Ph.D. training ill meets their needs for versatility and the ability to move a research project rapidly to a commercial payoff. On page 133, reporter Jocelyn Kaiser has rounded up industry research directors to get their take on the kind of people they want to hire.

Downsizing expectations. Even those Ph.D.s who do find careers in academia are still not going to find their lives cast in the same mold as those of their advisers. Because of the sluggish employment situation at large research schools, says Richard Brualdi, chair of the mathematics department at the University of Wisconsin, Madison, these doctorate-holders "are not going to be going to research-oriented places but small institutions with greater teaching loads." Reporter Karen Fox looked up young Ph.D.s with new jobs at schools not generally known as research powerhouses, and on page 141 reports on what life is like in the not-so-fast lanes.

Grad students today and tomorrow. In the midst of all this flux, today's graduate students are getting confusing messages. While professors encourage in their students a single-minded dedication to research, those same students are hearing disturbing news from society outside—that they'd better prepare themselves with skills for outside of academia.

Biologist Eliene Augenbraun, a recent Ph.D. from Columbia University, says this puts grad students in something of a "Catch-22," because they don't want to undermine their scientific reputations while trying to prepare themselves for an uncertain future. Augenbraun says that for this reason, in graduate school "I tried to keep my political activities [in the university postdoc association] invisible until that was no longer possible. Professors want total devotion, while everyone else is saying don't put all your eggs in one basket." She now thinks those political activities "did more for my employability than any experiment I ever did." For one thing, they set her up for her next job. After completing a prestigious postdoc at Johns Hopkins University in Baltimore, Augenbraun is now an American Association for the Advancement of Science (publisher of *Science*) diplomacy fellow at the U.S. Agency for International Development.

Yet for every Augenbraun, there are many who take the traditional message—work hard and long, master one area, and your reward will be a university research lab of your own—very much to heart. When *Science* interviewed 26 young people identified as particularly promising by their professors, all but one indicated that they were banking on an academic research career. Some of their comments appear on page 145.

Doctoral evolution. The Ph.D. has, of course, changed before. It was imported from Germany in the middle of the 19th century, and the early format was that of master and apprentice. "If you wanted to do research you went to a particular professor and said, 'will you accept me?' " says historian Sheldon Rothblatt of the University of California, Berkeley. "You really were his disciple and did what he wanted you to do."

Some U.S. schools soon began awarding research Ph.D.s, but it wasn't until 1879 that Johns Hopkins became "the first true graduate university," according to Hopkins archivist James Stimpert. In addition to lab work, Hopkins offered students special seminars and advised them on their research. From those beginnings, the U.S. graduate education system has become the crown jewel of U.S. education and a mecca for the world's scientists, says Rothblatt, because of its "highly structured nature," with systematic coursework and oversight by more than one professor.

Now, as the year 2000 draws nigh, it seems the Ph.D. production machinery must change again. Other institutions have redesigned themselves to face a changing environment. The U.S. auto industry, for instance, has managed to work its way into a viable future with more efficient use of resources, faster retooling capability, and higher quality products. It seems increasingly likely that those who make up the Ph.D. apparatus will be coming out with a new model.

–Constance Holden