Professor emerita of biology at Harvard University. Hubbard did research on the photochemistry of vision early in her career and, more recently, has written extensively about women in science, women's health issues and genetics.

RUTH HUBBARD

Paleoanthropologist who, with her late husband, Louis Leakey, unearthed and analyzed fossil hominids in Africa. Leakey now lives in Nairobi, Kenya.

MARY LEAKEY

Neuroscientist who won the Nobel Prize in Physiology or Medicine in 1986 for her work on nerve growth factor. Levi-Montalcini teaches and continues her research at the Institute of Neurobiology at the National Research Council in Rome.

RITA LEVI-MONTALCINI

Girls are told in myriad ways that they are not as good at mathematics as boys are. This social myth has no foundation in reality. Researchers have found that girls often do as well as boys in math in elementary and junior high school. Yet girls hear "quite early that higher math is for boys," Vetter notes. "Girls are not taught to put themselves forward to get into that group of precocious math kids. You have to push yourself forward, but girls are not encouraged to do that."

Exploiting this perception of feminine math anxiety, the toy manufacturer Mattel last year made a Barbie doll that said, "Math class is tough." The company deleted the statement from the doll's voice track after several women's groups protested. (The NSF's Daniels points out that the pink Lego building blocks designed for girls do not send the right message either.)

A distinct irony surrounds the issue of women and mathematics. Mathematics was at times considered a woman's subject. Schiebinger describes the English *Ladies' Diary*, published between 1704 and 1841, which encouraged women to perfect their "Arithmetick, Geometry, Trigonometry... Algebra... and all other Mathematical Sciences." It goes to show that "when the rules of society change, the girls perform just as well as the boys," remarks Mildred S. Dresselhaus, professor of electrical engineering and physics at the Massachusetts Institute of Technology. "If they act as though they are interested, they get very discouraging signals. I got my share of those, too, I suppose. But I went to an all-girls school, and there I did not know that girls were not supposed to study math."

In addition to discouragement, women cite boredom as the reason that they stopped studying science. Many experts are trying to find new ways of teaching girls and women to maintain interest. Sue V. Rosser, director of women's studies and professor of family and preventive medicine at the University of South Carolina, has found that women tend to be interested in a problem or a question if it has some context or social relevance or the solution produces some benefit. They also respond to a challenge better if the process of meeting it is framed as a collaboration rather than a competition. "Men, in general, find that a technological fix in and of itself is enough," she explains. Rosser and many others have designed successful teaching methods that harness these insights. Re-forming questions and experiments appears to have an unexpected boon: it captures the imagination of male students as well.

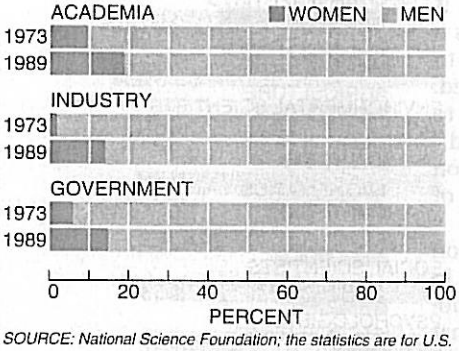
An NSF study of questions for National Assessment of Educational Progress tests reached the same conclusion. When math problems have some social implication, girls do better. On the other hand, boys' scores on tests of verbal ability, which are traditionally lower than those of girls, improve if the excerpts describe sports or science. Ellen Spertus, a graduate student in computer science at M.I.T., observes that computer games in which the objective is, say, to prevent a meteor from hitting the planet are often more likely to interest girls than are games in which the players are supposed to slaughter invading aliens.

Changes in testing and in school curriculums, however, may not be sufficient to hold women in science. Sometimes as many as half of the first-year female college students are interested in science and engineering, yet at some point in their academic careers, their attrition rate exceeds that of the male students. Certain universities and colleges as well as the Association for Women in Science have sought to combat this tendency by establishing mentoring programs.

In 1990, for instance, Dartmouth College set up internships to give as many as 75 female students experience in a laboratory, to demystify science and to introduce them to scientists. "They get to see what is going on in science firsthand, that scientists are not all geeky, that they are very regular people who make mistakes and have to do things over again," according to Mary Pavone, director of the women in science project.

Initially, many of the participants do not think the program is necessary. "They come here freshman year and see that the numbers of men and women in introductory science courses

Science Ph.D.'s, by Employment Sector



SOURCE: National Science Foundation; the statistics are for U.S.

LISE MEITNER

1878–1968
Austrian-Swedish physicist and mathematician who studied the decay of radioactive elements. She was the first person to calculate the energy released during nuclear fission and thereby contributed to the development of the atomic bomb.

MARGARET SANGER

1883–1966
Nurse who became the leader of the campaign for family planning and birth control in the U.S. Her efforts to establish birth-control clinics and to disseminate information were the subject of great controversy.

ETHEL BROWNE HARVEY

1885–1965
American biologist and embryologist whose studies of induction preceded those of Nobel laureate Hans Spemann and Hilde Mangold by more than 10 years. An investigator at Princeton University for 25 years, she was never made a full professor.

Behavioral ecologist with NYZS The Wildlife Conservation Society. Moehlman, who works mostly in the field in Africa, has studied and filmed free-roaming wild animals for over two decades. In recent years, she has turned her attention increasingly to advising about wildlife management.

PATRICIA MOEHLMAN

First director of the Office of Research on Women's Health at the National Institutes of Health. Pinn is a renal pathologist and was professor and chairperson of the department of pathology at Howard University before she joined the NIH.

VIVIAN PINN

Astronomer at the Carnegie Institution of Terrestrial Magnetism. Rubin has worked for more than 25 years with collaborator W. Kent Ford on the existence of dark matter and galactic rotation.

VERA RUBIN

are fairly even—they don't see what happens; they don't see the filter. By junior year, they look around their classes, and all of a sudden a light goes on," Pavone says. The number of women majoring in science at Dartmouth was up in 1993, but it is not clear that the project is responsible.

At the doctoral level the situation becomes more difficult. Women have a higher attrition rate than do men before they enter Ph.D. programs; they are about 15 percent less likely to finish their degrees. "You have to have someone on the faculty who wants you," says C. Megan Urry, chief of the research support branch at the National Aeronautics and Space Administration's Space Telescope Science Institute. Science is ultimately a guild, in which a master passes on skills and professional touch to apprentices. For reasons of ancient tradition and contemporary culture, those apprentices are predominantly male. "No one ever told me what was going on. The men are getting a lot of help, and the male advisers are helping them write. The women don't get it much," Urry says.

A combination of institutional changes, including mentoring programs, educational reforms and affirmative action strategies, has traditionally been perceived as the means for bringing women into science and keeping them there. These approaches address the problem illustrated by the often strange metaphors that have been used to explain why there are so few women in science or in any other field: the pipeline is leaking, the glass ceiling has not cracked, women are stuck on the bottom rung of the ladder.

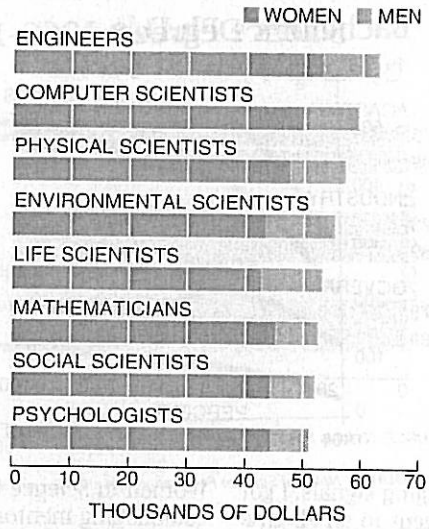
But a growing number of observers are questioning the fundamental and long-term success of these efforts. Feminist thinkers, including Schiebinger and Rosser as well as Brown University biologist Anne Fausto-Sterling and Harvard University professor emerita Ruth Hubbard, take a more radical position. They believe the whole edifice—plumbing, ceiling and ladder—has to be reconstructed. "My view is that getting women into science is not just being nicer to them at younger ages, although that is important. But we really have to rethink our whole notion of what science is and how it functions," says Fausto-Sterling, author of *Myths of Gender: Biological Theories about Women and Men.*

Fausto-Sterling and others are examining how scientific knowledge in the West has been shaped by social mores and by the white male culture that has directed it. The scrutiny is not well received by many in the scientific community. "Scientists think this is not very important," says Harding, who wrote *Whose Science? Whose Knowledge?* "But our conceptions of how we think about the history of science shape how we are doing science now. We want to learn from the past. If we have distorted views, we should understand them."

Perhaps the most prickly issue that some of these thinkers have raised is whether women and men approach science differently and, if they do, whether differences in style account for the low numbers of women attracted to science. Most of the discussion was initiated by Evelyn Fox Keller's 1983 book about Nobel laureate Barbara McClintock. In *A Feeling for the Organism: The Life and Work of Barbara McClintock,* Keller suggests that McClintock's unusual insights into genetics were shaped by intuition, by a more stereotypically "female" approach. The fires have been stoked by other researchers, among them Doreen Kimura, a psychologist at the University of Western Ontario. Her work shows distinctly different patterns of male and female mentation with respect to solving problems and framing intellectual challenges [see "Sex Differences in the Brain," by Doreen Kimura; SCIENTIFIC AMERICAN, September 1992].

Many scientists think this idea of difference has some validity in the biological sciences in particular. "There is a strong argument that when you bring women in, they look at what the female [subjects] are doing," Schiebinger notes. "So far we have found these examples only for sciences

Median Annual Salaries at the Doctoral Level, 1989



SOURCE: National Science Foundation; the statistics are for U.S.

GERTY RADNITZ CORI

1896–1957
Biochemist who won the Nobel Prize in Physiology or Medicine in 1947 with her husband, Carl Cori, for their work on how cells use and convert food into energy—a process now called the Cori cycle.

IRÈNE JOLIOT-CURIE

1897–1956
Won the 1935 Nobel Prize in Chemistry with her husband, Frédéric Joliot-Curie, for their synthesis of new radioactive elements.

BARBARA McCLINTOCK

1902–1992
Geneticist who revolutionized the field through her observations of jumping genes. McClintock's novel ideas were not accepted for many years. In 1983, however, she won the Nobel Prize in Physiology or Medicine.

Mathematician at Rutgers University and the University of Minnesota's Geometry Center. Taylor studies soap bubbles and crystals and simulates them on computers in order to understand their underlying mathematical properties.

JEAN E. TAYLOR

Secretary of the Air Force. Widnall is on leave from M.I.T., where she is associate provost and professor of aeronautics and astronautics. She has served as president of the American Association for the Advancement of Science.

SHEILA WIDNALL

Mathematician at Wesleyan University in Connecticut, who recently served as the president of the Association for Women in Mathematics. She does work on logic, specifically model algebraic theory.

CAROL WOOD

where there is sex involved." Perhaps the best example of this view is the work of Jane Goodall, Dian Fossey and Birute Galdikas, anthropologists who revolutionized understanding of the primates by changing the way animals were observed, by following individuals. "They looked at female-female interactions and saw new behaviors," Rosser explains.

Rosser has her own example. She recalls that when she first taught animal behavior she asked the class to examine Siamese fighting fish: What were the reactions of males to males, to self and to females? The exercise never included female reactions to females or to males. Sandra Steingraber, a Bunting Fellow at Radcliffe and Harvard, studied dioramas of white-tailed deer in natural history museums and found that the males were always depicted in a warriorlike stance, about to defend a doe and fawn. In reality, Steingraber says, does and bucks unite only to mate. Does and fawns stay together only until they begin to compete for food. The dioramas, an educational tool, were shaped by the anthrocentric and anthropomorphic social vision of the men who designed them.

If it is true that women can bring a different perspective, feminist scholars argue, that is all the more reason to encourage women, minorities and people from diverse cultures to practice science. "I think there is a lot of validity to the idea that women do things differently, not from a biological basis but from a sociological perspective. There is a clash between women's and men's cultures," Schiebinger says. "Women and men are not interchangeable parts. They act in very different ways, and it seems to me that that carries over into the professional world. It brings an enriching perspective."

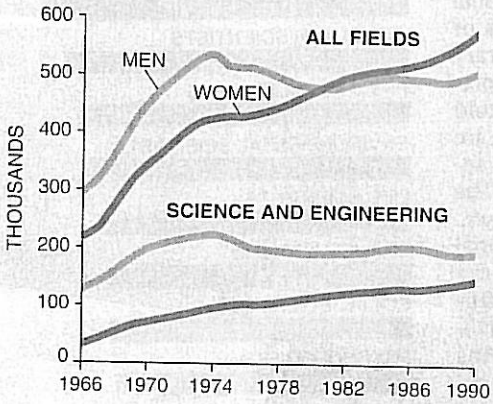
Anecdotal reports suggest that many women organize their laboratories differently, in a less hierarchical fashion, than do their male colleagues. "I don't think I think differently in terms of questions, because I have been trained," says Kathie L. Olsen, a program director at the NSF. "The difference is in the daily operation in the laboratory and in terms of how I interact with people." Ruth Ginzberg, a philosopher at Wesleyan University in Connecticut, has observed the same phenomenon in other fields, such as business. "For a long time, women were not thought of as good managers. Then somebody decided that perhaps women might have a different management style. Women were not rising in the ranks, because they were doing things differently—not because they were doing it less well."

Other differences have also been found. Studies of men and women interacting in groups suggest that women are interrupted more frequently, that their contributions are more often attributed to men in the group and that they are less comfortable with antagonistic discussions. "The problem is that women are being judged by men in a system set up by men that basically reflects their standards and criteria," Urry maintains. "Some of that has not to do with excellence in science but with style."

Whereas many female scientists agree that women and men may act differently, the idea that this variation translates into a different way of doing science remains sticky. "I find this topic a bit difficult," Dresselhaus admits. "Spending a lot of time on this doesn't do credit to women in fields with few women. In medicine, say, gynecology, women may have a different approach. But if you are solving a flow equation, there is not a woman's way or a man's way: there is the way the air flows around an airplane wing—it just flows around the wing."

There is a lack of very solid evidence for the proposition, Zuckerman concurs. In an unpublished study the sociologist and her colleagues found that sex differences were minor with respect to how scientists think about and describe their work. The criteria were how they chose their research topics and the significance of the research they were doing. "Gender is not a good predictor of difference," Zuckerman says. "Science is supposed to be attentive to evidence, and there is a lack of it here. These are matters about which people feel very strongly."

Bachelor's Degrees: 1966–1990



SOURCE: National Science Foundation, the statistics are for U.S.

MARIA GOEPPERT MAYER

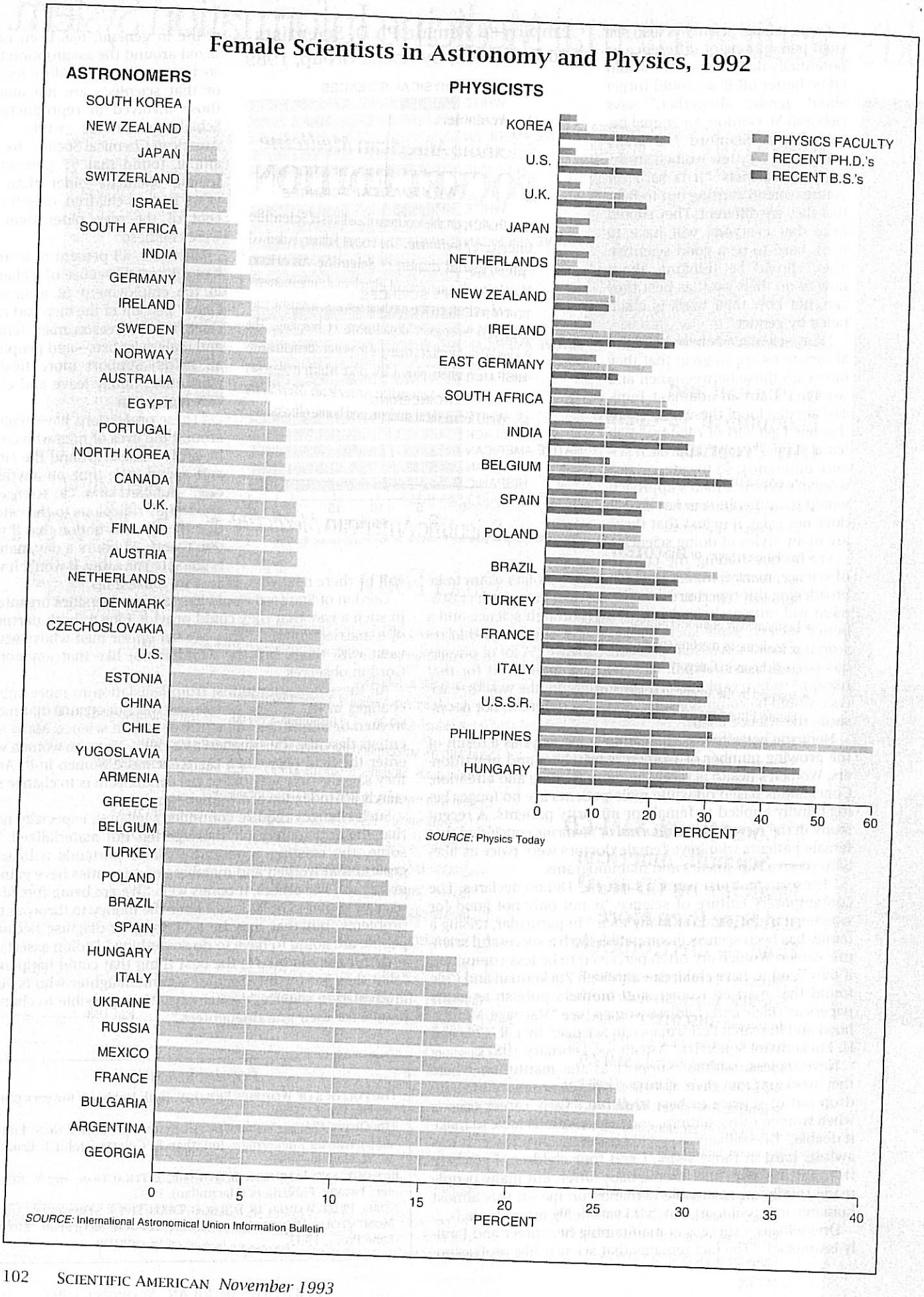
1906–1972
Mathematical physicist from Germany who won the 1963 Nobel Prize in Physics for her discovery of nuclear shells—the discrete energy levels that neutrons occupy— which Mayer described as similar to layers of onion skin.

RACHEL LOUISE CARSON

1907–1964
Marine biologist and author of several books, including *Silent Spring*. Carson's work alerted the scientific community and the public to the dangers of pesticides and to potentially destructive interactions between people and the environment.

ROSALIND ELSIE FRANKLIN

1920–1958
X-ray crystallographer. Franklin studied the structure of DNA and provided information needed by James Watson and Francis Crick, who later won a Nobel Prize, to describe the molecule as a double helix.


Female Scientists in Astronomy and Physics, 1992
ASTRONOMERS
SOUTH KOREA
NEW ZEALAND
JAPAN
SWITZERLAND
ISRAEL
SOUTH AFRICA
INDIA
GERMANY
IRELAND
SWEDEN
NORWAY
AUSTRALIA
EGYPT
PORTUGAL
NORTH KOREA
CANADA
U.K.
FINLAND
AUSTRIA
NETHERLANDS
DENMARK
CZECHOSLOVAKIA
U.S.
ESTONIA
CHINA
CHILE
YUGOSLAVIA
ARMENIA
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MEXICO
FRANCE
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PERCENT
SOURCE: International Astronomical Union Information Bulletin
PHYSICISTS
KOREA
U.S.
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JAPAN
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NEW ZEALAND
IRELAND
EAST GERMANY
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PHYSICS FACULTY
RECENT PH.D.'s
RECENT B.S.'s
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PERCENT
SOURCE: Physics Today

Some female scientists also see such perceptions of difference as potentially dangerous. "We would all be better off if we could forget about gender altogether," says Deborah M. Gordon, an animal behaviorist at Stanford University and one of very few women studying social insects. "It is hard for young women starting out to hear that they are different. They should hear that everyone will have to work hard to be a good scientist. They should be thinking about how to do their work as best they can, not how their work is channeled by gender."

Many scientists believe individual variations are so great that they outweigh those between men and women. "I am an adamant feminist about a lot of these issues, but this one I get sort of riled by," Williams states. "People approach science differently, so to categorize a woman's versus a man's approach would be difficult. It is not that it does not exist, it is just that there are many styles of doing science."

Yet by questioning the culture of science, many feminist scientists and scholars claim to be broadening this repertoire of styles. In their view, such enrichment will ultimately lead to a more thorough science and a better society. Some such thinkers have suggested that research priorities may shift as a consequence. "A lot of physics has been defense related, and many women left it for that reason," Didion explains. "At the minimum, the way that science would be communicated would be different, not necessarily the science itself."

Medicine has already changed in some ways as a result of the growing number of women researchers and practitioners. Women's health is receiving more funding and attention. Conclusions based on white male patients are no longer being blindly applied to female or minority patients. A recent study in the *New England Journal of Medicine* concluded that female patients who have female doctors were twice as likely to receive Pap smears and mammograms.

"These are not just women's issues," Didion declares. The contemporary culture of science "is not only not good for women, it is not good for many men." In particular, raising a family has been seen as incompatible with a successful scientific career. Women are often perceived to be less committed if they want to have children—although Zuckerman and Cole found that married women and mothers publish as many papers as single and childless women [see "Marriage, Motherhood and Research Performance in Science," by J. R. Cole and H. Zuckerman; SCIENTIFIC AMERICAN, February 1987].

Nevertheless, without support at the institution where they work or from their spouses, women are more likely to drop out of science to have children. "Early career time is when women raise children, and organizations have to make it doable," Dresselhaus says. "I know in my own career it was awfully hard in those years. I had four children. I got help from my husband and hired a baby-sitter. But many people made totally unreasonable demands on me—it was almost humanly impossible to do what I was being asked to do."

Dresselhaus's success at maintaining her career and family is unusual. "The fact remains that science, like professional life in general, has been organized around the assumption that society need not reproduce itself—or that scientists are not among those involved in reproduction," Schiebinger notes wryly. The American Chemical Society, for example, found that 37 percent of female chemists older than 50 years had no children; only 9 percent of the men older than 50 were childless.

Moreover, 43 percent of women had relocated because of a change in the employment of a spouse. Only 7 percent of the men had relocated. For that reason, many female and male scientists—and people in all fields—support more flexible work time, family leave and child care legislation.

"These professions have evolved around the lives of men who could be professionals around the clock and spend little time on anything else," Hubbard says. "In science, it is certainly ridiculous to the extent that there is this notion that if you don't work 24 hours a day, nature is going to run away. It won't. It will still be there next year, unless we louse it up."

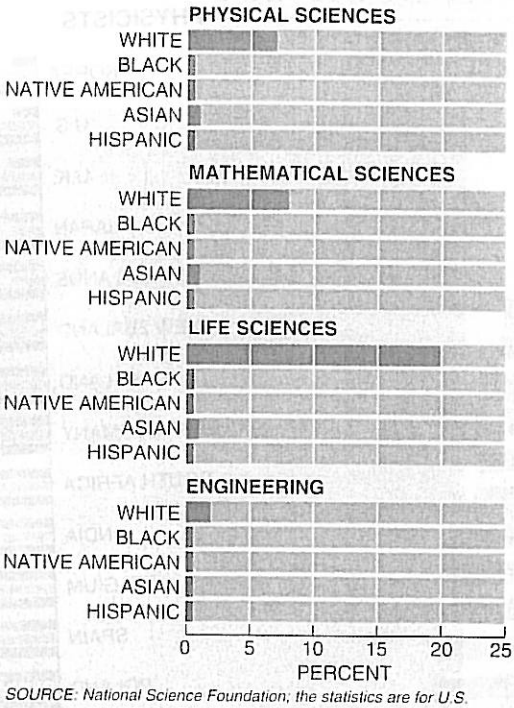
Gordon of Stanford would like to see universities organized in such a way that they could provide jobs to both partners of a married couple. "They are set up for men whose wives went with them, but the world is not like that anymore," Gordon observes.

All these considerations, from legislation to more subtle changes in the culture of science, will not ensure that more women or minorities will study or stay in science. Many scientists describe the situation as a catch-22: more women will enter the field only when there are more women in it. And, they say, the only way out of the conundrum is to change society's attitudes toward women—and men.

Such changes require continued vigilance, especially now that the anticipated job shortage has not materialized. To some, the existing economic malaise portends a loss of ground that women and members of minorities have gained in science. For others, it bodes well. "We are being forced to recognize that people do not have the money to throw at the problems, but that may be a blessing in disguise because people are going to have to do something," Didion asserts.

As for the old guard, the best thing that could happen is "that they get terribly fond of a granddaughter who is very interested in science," Vetter says. "It is possible to change people for their granddaughters."

Employed Female Ph.D. Scientists and Engineers, by Racial Group, 1989



SOURCE: National Science Foundation; the statistics are for U.S.

FURTHER READING

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THE OUTER CIRCLE: WOMEN IN THE SCIENTIFIC COMMUNITY. Edited by Harriet Zuckerman, Jonathan R. Cole and John T. Bruer. W. W. Norton, 1991.

BIOLOGY AND FEMINISM: A DYNAMIC INTERACTION. Sue V. Rosser. Twayne Publishers (Macmillan), 1992.

NOBEL PRIZE WOMEN IN SCIENCE: THEIR LIVES, STRUGGLES, AND MOMENTOUS DISCOVERIES. Sharon Bertsch McGrayne. Birch Lane Press, 1993.

Leaks in the pipeline

Why do women remain curiously absent from the ranks of academia?

Mary Anne Holmes

Suzanne O'Connell

Family issues can cause women to abandon academia at every rung of the career ladder. Policy-makers have addressed some ways to get more women on to the lower rungs of the ladder. But solutions at the higher steps — tenure and beyond — are proving a little more difficult.

In the United States, the past 30 years have seen a dramatic rise in the number of women gaining PhDs in the fields of science, technology, engineering and mathematics, according to the National Science Foundation (NSF). In the geosciences, the proportion of PhD degrees awarded to women has increased from none in 1966 to 46% in 2003. But, according to a database held by the American Geological Institute, there are 'leaks' in the geosciences pipeline for academics — particularly in the hiring for assistant professor positions. In the field, 42% of BS/BA degree recipients, 45% of MS recipients and 39% of PhD recipients are women. But only 26% of assistant professors, 14% of tenured associate professors and 8% of full professors are women.

The biggest barrier lies in the structure of academia. Women may hesitate to apply for tenure-track jobs because they lack role models among the upper echelons. We conducted focus groups of active, employed geoscientists, including students, and found that nearly half of the women participants seriously considered leaving the geosciences at some point in their career, as opposed to only one-third of the men. The reasons for considering leaving are strikingly different between the two genders: the top two reasons for women were family issues (caring for children or elderly relatives) and problems with advisers (mostly a failure to communicate). By far and away, the main reason males considered leaving was an uncertain job market — a distant second was a tie between difficult classes and choosing the wrong sub-discipline. We think that 'problems with advisers' is a barrier that can be minimized by training junior (and willing senior) faculty members in mentorship.

Clearly women's biological clocks play a role. Apart from medicine, in what other profession is it common for careers to begin in the early to mid-thirties? A new assistant professor, with an average age of 33, is facing the most intense work period of his or her life. For women at this age, fertility declines every year while the chances of a miscarriage or conceiving a child with Down's syndrome increase. Few graduate schools have provisions for family leave. Most graduate students answer directly to a single PhD adviser, who might not allow time off for childbearing.

More universities should provide paid family leave for graduate students and faculty members. Only one-third of PhD-granting institutions provide any sort of daycare for graduate students and most have no childbirth policy. Stanford University recently took the lead and introduced an automatic institution-wide childbirth policy for graduate students that includes six weeks' paid leave. Offering high-quality, affordable campus childcare will mitigate worries that could seriously lessen students' academic productivity.

> "Although overt discrimination against hiring women has mostly disappeared, unconscious biases persist."

Departments could actively recruit women and educate hiring committees. As departments often know about openings a couple of years in advance, potential candidates in broad subject areas can be identified and courted.

There should be an automatic extension to tenure so that junior female faculty members do not have to choose between children and their job. Tenured women continue to leave because of family responsibilities. In a 40-year academic career, why not allow a temporary (one to three years) part-time option? Better assistance in spousal employment would help as well. Pennsylvania State University, for example, has temporary two- to three-year spousal appointments.

Although overt discrimination against hiring women has mostly disappeared, unconscious biases persist. As noted previously in this column (L. Bornmann *Nature* **445**, 566; 2007), gender bias can influence the awarding of grants and academic prizes. Unconscious bias in hiring and promotion has also been documented (B. J. Tesch *et al. J. Am. Med. Assoc.* **273**, 1022–1025; 1995). There needs to be a concerted effort to bring this to an end.

To help explore some of these professional and structural impediments, we are convening a consortium of geoscientist academics in New England. This NSF-funded endeavour has three components: a week-long retreat to focus on writing in the absence of departmental and domestic distractions; skills workshops on topics such as strategic persuasion and negotiation; and workshops for departmental chairs to learn about unconscious bias and ways it can be overcome. With attention to these details, we hope that the science faculty will look more like the student body in 2027. ■

Mary Anne Holmes is at the University of Nebraska in Lincoln. Suzanne O'Connell is at Wesleyan University in Middletown, Connecticut.

PLUGGING THE LEAKY PIPELINE

MORE WOMEN ARE EARNING DOCTORATES IN SCIENCE AND ENGINEERING, BUT INDUSTRY IS DRAINING THEM AWAY FROM ACADEME. MIT HAS DEVELOPED PROGRAMS AND POLICIES IT HOPES WILL PLUG THE HOLE.

BY ELIZABETH DURANT ILLUSTRATIONS BY HADLEY HOOPER

ON A LATE AFTERNOON last April, as sunlight streamed into the atrium of the Wiesner Building, some 250 women gathered at the fifth annual Celebrating Graduate Women reception, mingling at the risotto bar and munching on red grapes stuffed with chèvre and roasted pistachios. Provost Robert Brown wished them well and described his own hopes for the event: that one day it would exceed the capacity of the atrium and require a larger space. He concluded with a note of urgency: "We need you in the academic profession."

That need is particularly acute in science and engineering. Although MIT has made strides in gender diversity, expanding the ranks of female faculty in recent years, the numbers are still low. Between 1995 and 2004, the percentage of women on the faculty increased from 7 to 13 percent in engineering and from 8 to 13 percent in science. Meanwhile, by 2004, the percentages of women in the undergraduate and graduate programs reached 34 and 24 percent, respectively, in engineering and 53 and 34 percent in science.

Some call this disproportion evidence of a "leaky pipeline." Although the number of women students in science and engineering at U.S. universities has grown steadily, in some disciplines reaching parity with men, the proportion of female faculty hasn't kept pace. A recent study of the top 50 U.S. research universities found that in most science and engineering fields, the percentage of women earning doctorates is significantly higher than the percentage of female faculty. It's not just a numbers game, according to Catherine Didion, executive director of the International Network of Women Engineers and Scientists. "The assumption we've had in the past is that if we can get the numbers and degrees up, it would translate into a movement in terms of [women faculty]," she says. "Clearly there's some hiccup."

A complex set of issues inhibits women from pursuing academic careers: the difficulty of balancing work and family, the demands of spouses' or partners' careers, an unfavorable academic climate, poor self-esteem. And the syndrome feeds on itself: the paucity of women professors means few role models for ambitious grad students to emulate. MIT has developed programs and policies to encourage graduate women to stay in academia and to attract and retain female faculty. In the past few years, for example, graduate student women have witnessed the growth of support groups and programs, the establishment of a maternity leave policy, and the allocation of some scholarship funds for day care. At the faculty level, the Institute has changed search committee practices to facilitate broader searches, added a childbearing-leave policy, built a new child-care center, and made efforts to change the cultural climate, so that women don't feel as marginalized.

"We can't afford to lose talent," says Alice Hogan, director of the National Science Foundation's Advance program. "You hear a lot about the Chinese brain drain. Well, we've got a national brain drain here. It's the women and [minorities] that aren't active in science." Because the stakes are so high, MIT agreed last spring to team up with eight other universities to study the leaky-pipeline issue. Preliminary plans call for the universities to collect and compare baseline data and exchange ideas about improving the situation at each university.

were costly. By starting a club, Moore and Marvin were able to secure a room on campus to house the layout and pool resources with other club members to defray costs. (Later, a Coke machine owned and operated by the club would bring in thousands of dollars.)

But more than space and money, creating and maintaining their model empire required a level of dedication that bordered on obsession. From the club's start, students spent endless hours solving problems of topography, scheduling, switching theory, and logical design, not to mention crafting the meticulously detailed scenery. With every passing year, the layout became more elaborate. After the first 15 years, the track and scenery filled an entire room in the club's home base in Building 20; the Tech Nickel Plate railroad wove through cities named for faculty advisors, around a lone scenic mountain, and through kilometers of open countryside. The trains were controlled by an ever evolving network of telephone relays, put together from surplus equipment procured by one of the club's faculty advisors, who had friends in the telephone industry.

Students spent endless hours solving problems of topography, scheduling, switching theory, and logical design, not to mention crafting detailed scenery.

The room in Building 20 became a second home to club members. "It was a 24-hour-a-day operation," says Andrew Miller '67, who remains active in the club. Inevitably, the club members developed a strange and unique culture. A quirky newsletter and extensive invented vocabulary (one member even wrote an official dictionary of their jargon) made them less of a club and more of "a fraternity—with a theme," says Miller.

Though united in their dedication, club members fell into two distinct categories: those with an intrinsic love of railroads and modeling, affectionately called the knife and paintbrush contingent, and those fascinated by the control system, the signals and power, or S&P, people. The S&P people were obsessed with the way the system worked and its increasing complexities. When the first computers arrived on campus in the late 1950s, the S&P people were immediately drawn to the adventure of programming, and not only for its uses in controlling model trains. They began using a primitive computer language to program calculators, electronic music, and the first known video game. Steven Levy, in his book *Hackers: Heroes of the Computer Revolution,* credits several club members with originating the culture of computer hacking.

Although computers added new dimensions to railroad control, they were a divisive force within the club. Malcolm Laughlin '59, SM '61, says computers actually diverted the interests of many model railroaders. Miller recalls that "by the late 1960s and '70s, we started acquiring members who would spend their whole life working on computers under the bench, and then sometime before they graduated they'd stand up, look around, and say, 'What are all these trains doing here?'"

Club membership dwindled in the 1980s and '90s as computers, video games, and an increasingly coed campus vied for the interest of new students. And then in 1997, the imminent demise of Building 20 forced the club to dismantle its 50-year-old layout and start from scratch in Building N52. Though heartbreaking, the move provided an opportunity to build, de novo, an updated control system. Members built new cities in the spirit of the old, keeping city names, several important buildings, and plenty of inside jokes intact.

The Tech Model Railroad Club is no longer a 24-hour-a-day operation, nor is it the bastion of computer-programming genius it once was; but it still holds the interest and devotion of about a dozen students and returning alumni. Laughlin, looking with satisfaction at a particularly complicated segment of the track, says, "Designing this layout, building this switch from hand and sight—that's what it's all about." At an institution where students spend so much time sitting in front of computer screens, model railroading remains for some the ultimate hands-on hobby.

The railroad passes through kilometers of countryside and industrial zones and a city reminiscent of Boston.

ROADBLOCKS ALONG THE WAY

Balancing work and family is one of the biggest challenges women mention when discussing their academic careers. Laura Anne Lowery was sure she wanted to be an academic when she started her PhD at the Whitehead Institute four years ago. After she got married last year, she started to have doubts. "My family is the most important thing for me. That really is what drives me, and research, although I love it, is second to that," she says. She worries about waiting too long to start a family. "I hear that a lot. Older women faculty say they waited, and then it was too late."

Today's academics often secure tenure only in their late 30s, which for women makes having children even more difficult. Didion cites the need for postdoctoral training due to the increasingly interdisciplinary nature of science and engineering and the limited number of faculty positions as reasons for the delay. "Women are realizing if they put off having children, they may have difficulty doing it later," says biology professor Hazel Sive.

For some, the price of waiting is too high. Anna Thornton was on the tenure track in mechanical engineering but decided to leave MIT in 2000, so she would have more time for her family and because work in industry appealed to her. "I was very concerned about the whole tenure thing and having a child," she says. "I didn't want to risk my ability to have my kids at a decent age."

Another problem is that of competing careers. Studies indicate that women engineers are likely to marry other engineers or scientists. Women are also more apt to make career sacrifices to keep their relationships intact. When Penny Beuning started her postdoc in biology in 2001, about half of the 15 people in her lab were in long-distance relationships. Her husband was in Minnesota finishing a postdoc, and she found the six-month separation stressful. "I was considering giving up my postdoc if he didn't get a job here," she says. Now she's looking for an academic position, knowing that if her husband doesn't get tenure at Northeastern University, she may have to give up her job.

The cultural marginalization of women is another common theme. Jessica Tsay '04, who next fall will start her doctorate in environmental fluids at the University of California, San Diego, says she is concerned about gender bias. Professors evaluate the performance of women differently and give them lower grades, she maintains. Beuning says that at times women are not taken seriously. For example, she says, when a woman has an idea, it's ignored, but when a man later makes the same suggestion, "it's a great idea."

According to Nancy Hopkins, professor of biology, the cultural climate can vary depending on the field. "Math, physics, and computer science are traditionally fields where there are very few women," she says. Anette Hosoi, assistant professor of mechanical engineering, believes changing the academic environment takes time. "[In] traditionally male-dominated fields, there's a lot of culture to get by in order to bring women into them."

Self-esteem is another "hiccup" in the pipeline. A 2002 survey of MIT freshmen showed that 48 percent of men rated themselves in the top 10 percent of all college freshmen in terms of intellectual self-confidence. Only 18 percent of women rated themselves similarly. Among graduate students, a 2003 survey found a less pronounced but still significant disparity: 29 percent of women rated themselves in the top 10 percent, versus 39 percent of men. That comes as no surprise to Hosoi. "Undergrad and grad women come up to me and say, 'I'm not going to make it through here because everybody's smarter than I am.' And then you look at their tests, and they're at the top of the pile."

And academia is no place for those lacking self-confidence. "If you think about it, there are not many careers in which you are constantly under scrutiny as much as an academic career," says Simona Socrate, SM '90, PhD '95, assistant professor of mechanical engineering. Biology professor Sive believes that the competitive, aggressive nature of science may send some women packing. "It can become very stressful to be self-promoting enough, be competitive enough to really feel that [they] are competing equivalently with men."

The absence of female role models is also part of the problem for some young women. "When women graduate students look around, they see very few women [faculty], and they wonder why," says Beuning. Tsay made the same observation as an undergraduate. "There were women in mechanical engineering," she says, "but not nearly enough."

Women faculty can find it difficult to act as role models, especially when they are few and far between. Krystyn Van Vliet, PhD '02, an assistant professor of materials science,

believes that a woman faculty member could grow weary of being the "representative woman of academia." And faculty who have children, such as Socrate, feel a tension between encouraging women and being candid about the challenges of having a family and an academic career. "There is a price to pay, and you wonder, should you be quiet, or should you let them know? I am trying to keep quiet, because I think that the rewards are better than the price."

The overall quality of life associated with a faculty position is yet another stumbling block for women. Thornton's experience of the academic life was that "you either worked 80-hour weeks or you didn't succeed." Socrate compares working in the academy to founding a startup business. Even after you get tenure—a grueling process that she believes is a major deterrent to women—the pace never slows down.

STOPGAP MEASURES

Despite these deterrents, there is some cause for hope. Blanche Staton, associate dean for graduate students, says the last two years have seen a twofold increase in the number of department women's groups, which provide support systems, networking opportunities, and workshops. Staton's office offers counseling, access to programs such as MentorNet (an electronic mentor-

ing service), and discussions on topics such as harassment and balancing work and family.

Such programs create a climate of openness about women's issues that students find helpful. Lowery has attended several workshops on women in science and is reassured to hear the perspectives of women faculty, especially on the topic of juggling a family and an academic career. "I think the more we hear stories like that, the easier it will be for women to not be so afraid."

MIT has addressed the issue of childbearing by adding a maternity leave policy for graduate students and designating some scholarship funding for day care. Postdocs funded by MIT also get maternity leave, but the 36 percent of fellows funded by outside agencies do not; nor do they receive many other MIT benefits. The MIT postdoctoral-scholars association, which provides resources and advocacy for postdocs, is working to solve this problem.

Perhaps most significant, however, have been the Institute's efforts to recruit and retain women faculty. Following widely publicized reports on the status of women faculty at MIT, released in 2002, the Institute looked critically at its policies and practices. It created an Institute-wide Council on Faculty Diversity and a gender equity committee in each school. It also encouraged departments to conduct broader hiring searches. Professor of materials science Lorna J. Gibson developed a search handbook that describes best practices, and copies were sent to the faculty. Broadening hiring searches is beneficial to everyone, Gibson says. "It's not always good for the Institute to keep hiring people who look like people who just retired. You want to have something new and different," she says. Success in recruiting women faculty has been mixed, Brown says, but he believes that with heightened awareness and a continuing emphasis on expanding search committees' scope, "the Institute will eventually reach uniformity" in the percentage of women faculty across disciplines.

SIMONA SOCRATE, SM '90, PHD '95, COMPARES WORKING IN THE ACADEMY TO FOUNDING A STARTUP BUSINESS, WHERE THE PACE NEVER SLOWS DOWN.

The School of Engineering—particularly the mechanical-engineering department—has made what Brown terms "spectacular progress." Overall, the school has hired 22 women faculty since 2002—six in mechanical engineering alone. "It really is a quantum change in the way they search and in the results," says Brown. Dean Thomas Magnanti says part of that success comes from hiring across traditional disciplinary boundaries. "We've looked in places we hadn't looked before, and we hired faculty with backgrounds that might not be the natural ones you think of."

Hosoi, a physicist by training who teaches in the mechanical-engineering department, is a case in point. Quite by accident, she discovered another secret to the school's success at a luncheon for junior women faculty. "I was surprised to learn that every single one of them had been asked to apply to MIT"—and that none of them would have applied otherwise, she says. Socrate believes this proactive recruiting is critical, because unlike men, who are more apt to take risks, most women won't apply for a job unless they feel confident they fit its requirements exactly.

Although recruitment is a significant challenge, retention is equally important. To help keep women on the faculty, MIT has changed policies and taken steps to improve their quality of life. A childbearing leave implemented in 2002 recognizes the physical components of bearing a child—as distinct from gender-blind child-rearing leave. The policy allows a woman who bears one or more children to extend her tenure deadline for up to a year. But Brown acknowledges that it's hard for women to take time off. Faculty research funding averages around $600,000 per person per year, he says, and "if someone pulls out for a year or two years, their funding goes to zero. Then they have to start up again, and if the startup period is three to four years, they have a huge sacrifice they've made in the middle of their careers."

Creating additional child care on campus in a new facility at the Stata Center is another amenity Brown hopes will make a real difference. He notes that this past year, MIT hired several women faculty members where the most important negotiating point was the availability of day-care slots for their children.

Efforts to change the overall academic climate seem to be paying off, too. "I'm sure I've benefited from the Institute-level interest in making junior faculty who are women comfortable," says Van Vliet. She cites lunches for junior faculty women and opportunities to interact with senior faculty women. MIT has also placed women in leadership roles—directing programs, centers, and recently, for the first time, a department within the School of Science—which inspires other women faculty. "It's nice to see them as role models," Van Vliet says. "There is status attached to leading these big organizations."

FINDING ANSWERS

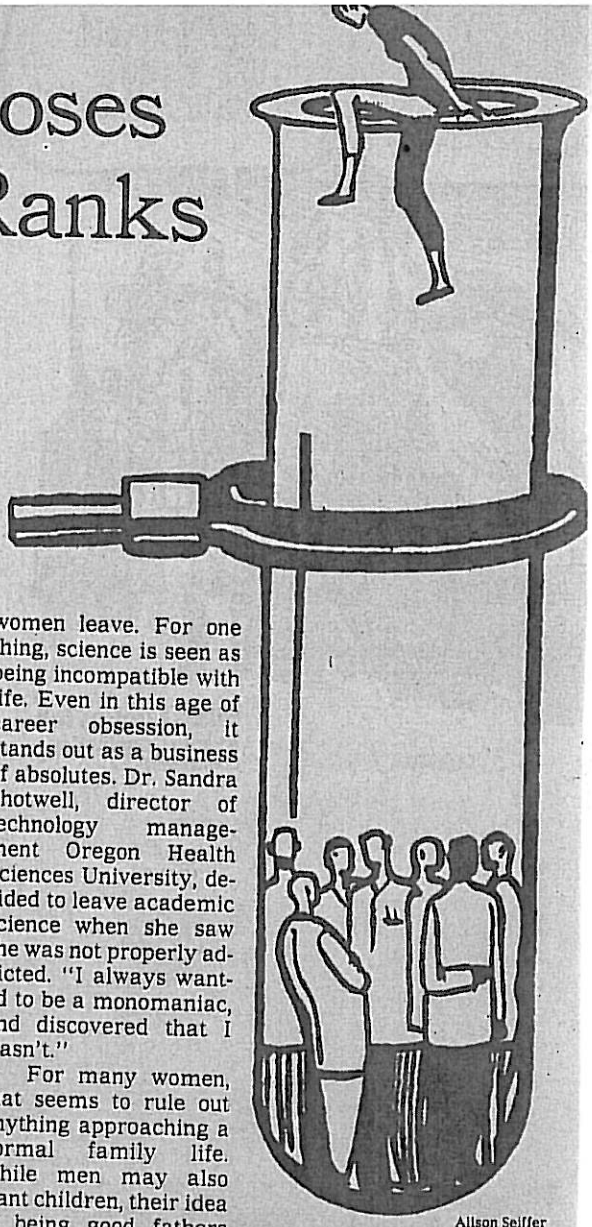
Biology professor Hopkins, who was one of the forces behind the groundbreaking 2002 report on the status of women faculty in the School of Science, has closely followed the aftermath of the report's publication. She believes MIT has done a "fantastic job" addressing the issues it brought forth but adds that there's more work to be done. "The question is, how do you get the applicant pools up? We've got to find out why the women don't apply."

That's just what MIT and eight peer institutions—Princeton, Yale, Harvard, the University of Pennsylvania, the University of Michigan, Stanford, UC Berkeley, and Caltech—intend to do. Last April, at their second Presidents Conference on Gender Equity in Academic Science and Engineering, the universities resolved to ascertain whether they have statistically common experiences and then identify solutions and best practices.

MIT's legacy of institutional courage in acknowledging and responding to systemic problems will serve it well as it faces this challenge. And after all, says Hosoi, it's part of MIT's nature to tackle tough issues. "This is the thing I like about MIT. We're all engineers, and we solve problems." Although the Institute has made some inroads already, there's plenty of work ahead as it struggles to plug the leaky pipeline.

Why Science Loses Women in the Ranks

By NATALIE ANGIER



Allson Seiffer

THE best metaphor to describe the plight of women in science, and their continued scarcity at the upper reaches of their profession, is not the glass ceiling or the broken ladder or even the old boy and their clubs, but rather a bit of plumbing: the leaky pipe. It is a pipe with leaks at every joint along its span, a pipe that begins with a high-pressure surge of young women at the source — a roiling Amazon of smart graduate students — and ends at the spigot with a trickle of women prominent enough to be deans or department heads at major universities or to win such honors as membership in the National Academy of Sciences or even, heaven forfend, the Nobel Prize.

The difficulties that women have in pushing forward to scientific stardom in anything beyond what look like statistical errors was underscored recently when the academy announced its new members for the year. Female scientists had been hoping for an improvement on the encouraging results of last year, when 9 of the 60 of the new members were women, a significant jump from the annual standard of roughly 10 percent. But the number dropped back to 6 out of 60. And forget the Nobel Prize: of the 131 scientists who have won it in the last 20 years, only 4 have been women, all in physiology or medicine. If there is a trend afoot, it has a distinct limp.

Last week, Mills College in Oakland, Calif., released a report showing the ways that women lag behind men in the most visible arenas of science. Even in the female-friendly field of medicine, where 40 percent of the students and 20 percent of the physicians are women, only 3 percent of medical school deans and 5 percent of department heads are. At Harvard Medical School, the 1994 class was 52 percent female; yet only 7 percent of the tenured professors are women.

"Originally we thought if we got enough women in, the problem would take care of itself," said Dr. Eleanor G. Shore, dean for faculty affairs at Harvard Medical School. "Now we know we must take steps to keep women on track." Dr. Carla Shatz, a neurobiologist at the University of California in Berkeley and a new member of the academy, said that when she began graduate school 15 years ago, there were enough women in her class to change the profession's face. "But when I look around now at the number of women in my cohort, in senior positions, it's very small," she said.

The difficulty does not seem to be overt discrimination, or an unwillingness to celebrate women's accomplishments, although subtle forms of neglect, belittlement and cliqueism continue. Male and female scientists alike said the stubborn problem is that women abandon science at every stage of their career in greater numbers than men. "There's talk of real attrition," said Dr. Shatz.

Dr. Bruce Alberts, the president of the academy and a molecular biologist at the University of California in San Francisco, said that half the graduate students in biology at his university are women. "But by the time you get to the post-doctoral level, it's no longer half," he said. And after that, the number drops further still.

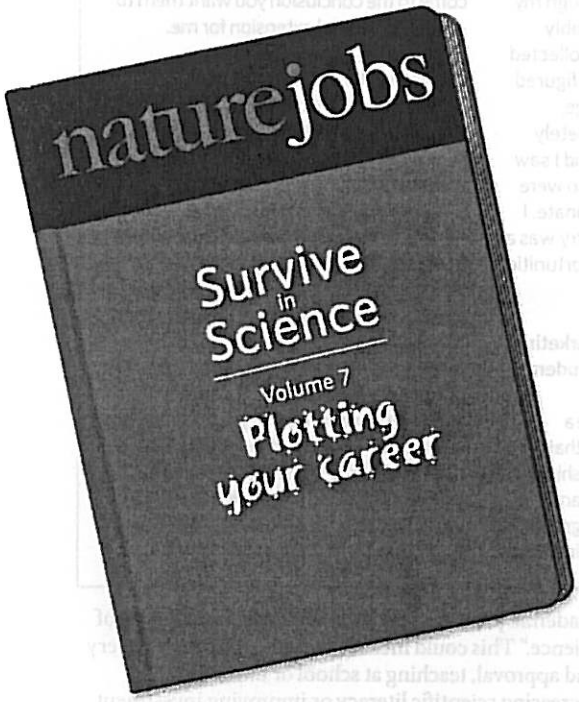
Exact figures on the female attrition rate do not exist, but scientists offer guesses about the reasons why women leave. For one thing, science is seen as being incompatible with life. Even in this age of career obsession, it stands out as a business of absolutes. Dr. Sandra Shotwell, director of technology management Oregon Health Sciences University, decided to leave academic science when she saw she was not properly addicted. "I always wanted to be a monomaniac, and discovered that I wasn't."

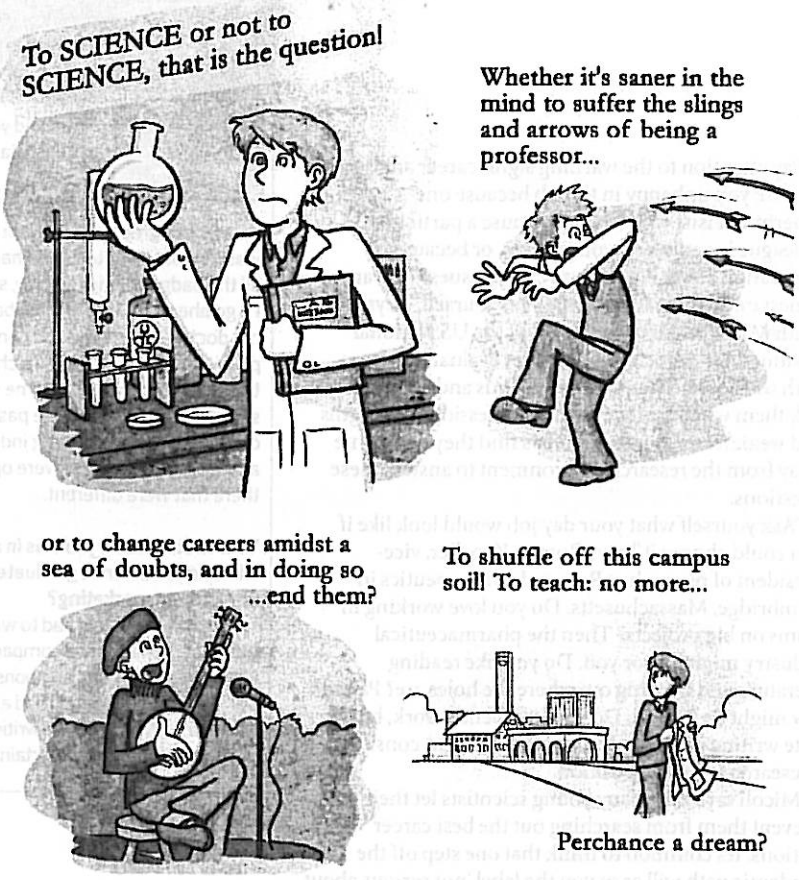
For many women, that seems to rule out anything approaching a normal family life. While men may also want children, their idea of being good fathers seems not to demand as many hours. Dr. Alberts said, "If you're going to be successful in science, it helps a lot to have a wife."

He also suggested that while men feel they have no choice but to push forward in science, women always have the alternative of leaving to raise a family. "Science is really hard work," he said, "and if you don't feel this is the only option, you'll do something else."

Many women reject this as posturing. "Personally, I don't think it's necessary to sacrifice everything for your career, and this macho climate makes it much worse than it needs to be," said Dr. Sandra C. Greer, a chemistry professor at the University of Maryland in College Park. "There's a contest for who gets into the lab first and who's there on the weekends. But you should never confuse activity for accomplishment."

In fact, science does have demands beyond displays of one-upmanship. Experiments do not respect timetables; you have to be around the lab at 2 A.M. when that enzymatic reaction is through. A number of women said the best model for a successful life in science might be one of serial obsession: devoting time to the kids when they are young, and coming back to the lab full-force when infant needs abate. Many prominent women scientists have followed just such a path, and they are working mightily now to persuade their female students that they need not sacrifice their lives — or their children — for science. The trick lies not in being a superwoman, but rather in taking life one fix at a time.





SHOULD I STAY OR SHOULD I GO?

Do you have a nagging feeling that academic research might not be the place for you? Listening to your intuition and trying your hand at new things could place you in your dream career. **Kendall Powell** tests the water.

Four years into her doctoral work in organic chemistry, Sarah Webb began surfing the Internet for potential postdoc positions. Since her first year as an undergraduate, she had always thought she would become a professor at a liberal arts university. That was about to change.

"As I read research descriptions, I had this visceral, gut reaction that said, 'Wow, this is really interesting science, but I don't want to do it'," Webb recalls. She then had what she describes as her mid-graduate-school crisis and a psychological meltdown. "If you think like an academic, you have your whole life mapped out and then all of a sudden it was 'Oh no!'."

Webb, now a freelance science writer based in Brooklyn, New York, approached her dilemma with a methodical plan of action to find what other careers might suit her. To avoid making a wrong move, career advisers encourage young scientists to make a careful analysis of what they like about science, what their strengths are, and how they could transfer those strengths to another career track.

Start thinking about your 'plan B' as early as halfway through your doctorate. Even if you think you want to stay in academia, investigate other options. And if you do plan to leave academia, the bench, or even science altogether, you should network and gain experience in the new area before making a switch, career advisers say.

Go with your gut

The academic track is a well-beaten path with a clear set of steps towards a particular destination. It can become comfortable staying on a familiar path, even if your talents and interests no longer match the end goal. "It is easy to get stuck in a rut and end up in the world of someone else's expectations — advisers, colleagues, family," says Webb. "Ultimately, you are the one who has to live with the career expectations you have."

Pay attention to the warning signs, career advisers say. Are you unhappy in the lab because one experiment isn't working, or because a particular colleague is getting on your nerves, or because of trepidation about big-picture career issues? "Do an honest evaluation and be tough on yourself," says Keith Micoli, chair of the board of the US National Postdoctoral Association. And get evaluations from both science and non-science friends and colleagues. Ask them what they see as your professional strengths and weaknesses. Some scientists find they need time away from the research environment to answer these questions.

"Ask yourself what your day job would look like if you could choose it," says Rosana Kapeller, vice-president of research at Renegade Therapeutics in Cambridge, Massachusetts. Do you love working in teams on big projects? Then the pharmaceutical industry might be for you. Do you like reading literature and figuring out where the holes are? Patent law might be for you. Do you love bench work, but hate writing grant applications? You might consider a research associate position.

Micoli says that many young scientists let their fears prevent them from searching out the best career options. It's common to think that one step off the academic path will earn you the label 'not serious about research', says Micoli, now a research instructor at the University of Alabama, Birmingham. But the sooner you bring up other career interests with your adviser the better, he says.

Taking the blinkers off

How do you go about making a big career transition when you have only been exposed to academia? Michael Alvarez, director of the Stanford School of Medicine's career centre, says that every graduate student should commit to going to at least one seminar or activity per week to explore other career opportunities and make more informed career decisions.

"I'm doing everything I can to eradicate the word 'alternative'," he says. "There may be 15 alternatives and one of them is academic research. To say another career is lesser is a fallacy. The scientist who does not stay in academia provides service to the overall well-being of science." This could include expediting drug discovery and approval, teaching at school or university, increasing scientific literacy or improving investment decisions, says Alvarez.

Alvarez also suggests working with a professional career counsellor, consulting books, and doing some rough mental exercises to identify career priorities. In one test, he has the scientist draw a bar graph with three bars, one for geography, one for professional opportunity and one for personal life. The person has 100 units of value to ascribe to the different categories across three different points in time, say at ages 25, 35 and 45.

When trying to decide between two options, make the usual list of pros and cons, but set up a list of categories and weight each category by importance before making your list. Each pro or con item falls into a category and gets assigned a predetermined weight, giving you a more realistic view of which choice aligns with your goals.

Don't make choices based on negatives, says Kapeller.

LEE FRASER

Philadelphia, Pennsylvania
Lead clinical-development scientist

How did you know academia wasn't for you?
Midway through my master's degree I realized it probably wasn't what I wanted. But I had collected all the badges along the way, so I figured I'd go ahead and get the last badge, my doctorate. But I wasn't completely passionate about the research and I saw that all the people around me who were successful scientists were passionate. I didn't know what the drug industry was all about but I knew there were opportunities there that were different.

Your first industry job was in marketing; what does a science graduate student know about marketing?
I was cycling a lot and had to write a business proposal for a company that we were approaching for sponsorship of our racing team. I found I had a knack for marketing. When you are writing grants or a paper, you always put a certain spin on it, to make a connection between a disease and the state of your protein. Marketing is just about delivering a set of facts so that people come to the conclusion you want them to — it was a natural extension for me.

Did you make the right choice?
The moment I got my first job and had my own office and sat down at my desk, I knew I had been like a plant in a pot that was too small.

How is working for a large drug company different from academia?
At 2 p.m. on a Friday, I can't shut down and go for a beer because an experiment failed. That freedom is gone. But if you take that 18-hour-day work ethic from graduate school and apply it here, even with weekends off, you'll be really successful. I now work on projects that have budgets greater than the research budget for my old university. But if my kids get sick, my colleagues say: "Go home, we'll take care of it."

SUNITA JONES

Manchester, UK
Hospital research facilitator

How did you end up as a research administrator at a hospital?
During the second year of my postdoc, my career plans began to take shape and I realized that bench work was not for me. Interacting with people and helping to get things done was more fulfilling. I had started on the administrative path at Stanford after my postdoc when someone recommended me to my current boss. I am involved in grant submissions, student and postdoc project reviews, and manuscript preparations.

How was the transition?
Shifting gears and moving away from the bench was definitely the right decision, although I miss my friends and the support network I had established in the United States. I am going through a long period of adjustment and working hard to establish myself as I am a newcomer to the group. I am enjoying learning the new system.

Is there anything you would have done differently?
I would perhaps start sooner. I think the key was that I did get support when venturing outside my field. My postdoc principal investigator let me explore what I wanted to do beyond my postdoc training and I discussed options with him.

MHAIRI DUPRÉ

Oxford, UK
Doctoral candidate in plant science

You left a doctoral programme in Canada and eventually started again in a programme in Britain. What made you decide to come back to academic science?
When I left Canada, I came back to my village of Ballachulish, Scotland, and began working as a waitress. It was a good break, to be around people just doing the job for the money, to try to figure out what I really want to do. I realized that I do like science and that I have not really wanted to get up and work in a bank or be a lawyer every day. Also, I went to different lectures on history and philosophy to see if I'd be good at those, but when I was reading newspapers, I would see the science stories and think, "Oh, that's really interesting." To be able to change people's lives through science, to discover something new — no other job can do that.

Would you recommend a break from science for others who are undecided?
For sure. Otherwise, I just would have rushed into another decision. It gave me time to have no pressure and find out what really excites me.

Would you do anything differently?
If I was beginning a PhD again, I would try to work in the lab a bit before starting. Ask yourself, can I do my PhD in this lab, can I get along with this supervisor, can I do the project I want to do? Also, don't be scared to say "This isn't working" and cut your losses.

For example, don't choose to move into industry solely because of the downsides to academia, such as writing grants or working long hours. "It's not that the grass is greener on the other side of the fence, but just a different shade of green," she warns. Instead make choices based on what you like about science. But don't be fooled into thinking the next academic stage will be easier, says Micoli. If you are stressed and overwhelmed now, moving up is unlikely to solve your problems.

Find something you're passionate about before fleeing the lab, suggests scientist-turned-artist Tia Vellani. She finished a postdoc in biochemistry at the University of Miami in Florida before deciding to follow her passion for jewellery designing. "It was finally obvious to me that I could never be a good scientist, because I just really didn't want to be," she says.

And finally, if you do decide to leave academia, don't drop a bomb on your adviser by waiting until the last minute to make your plans known. "Leave as many doors open as you can," advises Micoli. "You never know when you might need a recommendation. Be professional."

Landing on your feet

Open and early communication with an adviser may help you find ways to gain experience in a new area. When Webb was searching for a new path, she volunteered to do a few hours a week at a local science museum and enrolled in a science-writing course on her campus. Others have gained insights from volunteering to sit on committees for professional organizations such as the local biotechnology board or even non-science committees, just to build business skills and savvy. Kapeller suggests seeking out a 6–8-week summer internship with a local biotech or drug company (positions that are common, but often unadvertised).

Although some advisers may be dead-set against anything that detracts from time at the bench, most will be reasonable about a request to explore other interests, says Micoli. Explain that you would like to take on more teaching duties, offer to help the technology-transfer office with a patent application, or suggest an industry internship that will lead to a collaboration. Webb negotiated with her adviser to have two months away from the lab to work half-time on writing her thesis and half-time building her science journalism portfolio.

Most importantly, find people who are already doing the job you want to do and talk to them about their own transition. See if you can visit them at their workplace or shadow them for a day. If possible, find someone who has made exactly the same transition that you are contemplating.

For those pondering a switch to industry, Kapeller strongly advises doing an academic postdoc before making the jump. Not only will it let you step on to the corporate ladder on a higher rung, she says, but it will confirm your ability to work and publish independently more effectively than the doctorate alone or an industry postdoc would. If you know you will be moving to industry, she suggests choosing a postdoc with a focus on animal models,

KATY HINMAN

Atlanta, Georgia
Executive director, Georgia Interfaith Power and Light

What is Interfaith Power and Light?
It is a non-profit organization that works with congregations and faith communities on environmental issues, with a particular focus on energy. We do a lot of practical education about energy efficiency. Right now, we are making our compact fluorescent light-bulb kits to distribute during the Chanukah and Christmas holidays.

How did you end up working at the interface of science and religion?
After I finished my doctorate, I became really interested in why people weren't more interested in conservation — particularly in faith communities. They should be thinking about environmental stewardship just like the other ways they think about stewardship. I had been active in my church throughout graduate school and it really seemed to me that, in general, the relationship between science and religion was one people don't talk about.

Why did you decide to go to seminary on top of your PhD in ecology?
My thought was, "Well, of course churches should be involved in conservation", but that argument doesn't fly with most people. It got me thinking about making a theological case for them to get involved. My scientific and seminary training helps me cross that gap. I have credibility on both sides.

Would you recommend working for a non-profit organization to others?
Yes, these organizations need people who are good at science — people who know how to interpret it and translate it.

Do you miss research?
I really miss doing fieldwork and talking with other scientists. So I go to the North American Symposium on Bat Research just for my own intellectual stimulation.

PETE BERQUIST

Williamsburg, Virginia
Research assistant, National Park Service employee, adjunct professor

You were encouraged by your master's supervisor to stay on and get a PhD in geology. What made you decide against it?
Overall, graduate school was a great experience. I loved doing research and teaching, but both of these took so much time. One conversation I had with a friend stuck with me. He asked: "Are you working too hard?" And I said: "I don't know, how do you tell?" His response was telling, he said: "Well, are you having fun?" I felt as though there were other parts of life that I was missing.

So what have you found?
I went to Maine and worked for a non-profit advocacy group in Acadia National Park. I was outside hiking all day, so it was hard to call it a job. I then interned with the National Park Service, teaching at a residential science camp for middle-school students and teachers. I came back to work with my undergraduate adviser as a research assistant doing geologic mapping. He jokes that I'm doing a "post-master's" instead of a postdoc. And I've been a visiting professor, teaching geology at the College of the Atlantic, a very small liberal arts college in Bar Harbor, Maine.

What have you learned from these experiences?
I discovered that I want to pass on and share what I've learned with people who may not have had a lot of geology or Earth science. Interacting with a more diverse group of people than in academia, it is satisfying to introduce a geological perspective that they might not get anywhere else.

What advice do you have for others searching out their own career paths?
Be open. There's a lot of room in there to open your eyes to new things. Every time I've done that, I've made new contacts.

pharmacology or imaging that would be applicable in a corporate setting.

Those who have left science suggest making sure that you can live with the prospect of never being a scientist again. Being away from the swift changes in the literature and technologies of specialized fields for even a few years can make returning an uphill battle.

And finally, maybe you could learn from Katy Hinman, the executive director of Georgia Interfaith Power and Light, a non-profit organization in Atlanta that counsels religious communities about environmental stewardship. Her job certainly never appeared in any 'alternative careers' books or panels. But she identified two things that were important to her — conservation and her faith — and followed where they led after her PhD in ecology and evolution from the State University of New York in Stony Brook, even though it meant going to seminary.

"People get into a kind of trap, thinking that if a job doesn't require a PhD in its description, then they are underemployed," says Hinman. "If you are doing something you love and are good at it, then you are not underemployed." ■

Kendall Powell is a freelance writer based in Broomfield, Colorado.

Web links and further reading

Stanford SOM Career Center profiles
http://med.stanford.edu/careercenter/spotlight
US National Postdoctoral Association's career development resources
www.nationalpostdoc.org/site/c.eoJMIWOBIrH/b.1389993/k.B38F/Career.htm
Tia Vellani's site
www.artistbynight.com
Sarah Webb's site
www.sarahannewebb.com

Bolles, R. N. *What Color is Your Parachute?* (Ten Speed Press, 2006).

Covey, S. *The 7 Habits of Highly Effective People* (Free Press, 2004).

Kreeger, K. Y. *Guide to Nontraditional Careers in Science* (Taylor & Francis, 1998).

Lloyd, C. *Creating a Life Worth Living* (Harper, 1997).

Robbins-Roth, C. *Alternative Careers in Science: Leaving the Ivory Tower* (Academic Press, 2005).

STACEY IVANCHUK

Toronto, Ontario, Canada
Training to be a patent agent

Why did you leave academic science for patent work?
Seven years after starting my doctorate, I was struggling to finish it. I had two potential manuscripts, but nothing that was going to point me in the direction of being a professor. I have a lot of friends who are lawyers, familiar with intellectual-property law, and they suggested that maybe I was burnt out on the lab and needed a new perspective. They said, "It's still science, but coming at it from a different angle."

What advice do you have for others?
You need to get out of the lab and see what else there is. It was only after I left that I started to learn about networking — that getting a job is sometimes about timing and sometimes about who you know. Be more proactive and think, "This is what I want to do: who do I need to know to make this happen?"

What are the pros and cons of working for a law firm?
Suddenly, it's no longer the flexibility of the lab. You have a deadline, sometimes before the day is over — you must get back to a litigator by 5 p.m. That part takes some getting used to. As for the pro side, I get exposure to so many different inventions in the world of molecular biology.