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Redesigning Science: Recent Scholarship on Cultural Change, Gender, and Diversity

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The current debate over girls and women in science and engineering abounds in contradictions. On the one hand, the debate includes ideas like those proposed last year by Lawrence Summers, former president of Harvard University, that women may be innately less capable than men of excelling at science and engineering. Such arguments are often used to explain why women have rarely broken through to the top echelons of these fields. At the same time, articles in the popular press claim that girls and young women are outperforming boys and young men by attending college at higher rates and putting more effort into their studies. "Women are leaving men in the dust" (Lewin 2006), according to these articles, and boys are being failed by schools that do not engage them or allow them to learn as they do best—hands on, in a less structured environment, and preferably in the great outdoors like the hunters of the past. Both of these arguments ignore basic facts, including recent biological and sociological data. An interesting point about them, however, is that when girls and women lag behind men in their performance (especially in the more quantitative disciplines, such as physics, engineering, and computer science), the argument is that there's something wrong with the women, whereas when boys or men lag behind, it is because the educational system is failing to engage them. For girls, the usual proposal is "fix the girls," with the implication that such a fix is probably unattainable; for boys, it is "fix the system," or at least provide them with the opportunity to play football (see Pennington 2006).

New, sophisticated brain imaging tools and techniques have allowed researchers to view the differences in male and female thought patterns. These differences have captured the public imagination and gained considerable attention in the popular media. Men, for example, exhibit more schadenfreude and women more empathy. Women tend to use both sides of the brain when solving problems, while men generally use the left side. But brain imaging cannot determine whether this gives one sex or the other advantages or disadvantages in the pursuit of scientific or engineering excellence. In fact, most evidence shows that men and women are equally capable of solving math problems or navigating through problem-solving exercises, although they may take different brain paths to the same destination. In other words, although there may be some biological differences between the sexes in terms of how they think—that is, whether they use more gray or white matter in a specific task—this does not add up to significant differences in the ability to do science and engineering. Furthermore, any true innate differences may be subject to change through targeted education and training. Males' advantage in spatial reasoning, for example, can be virtually erased when girls and women are trained in spatial learning (The Economist 2006).

If the differences between the sexes in terms of brain processes or innate ability cannot account for the differential gendered career choices of women and men, what does? Social scientists have found, through data analysis and extensive interviewing, that women who choose science and engineering fields do so because they love the subject and because they find they can excel at it. They are more likely than their male counterparts, however, to drop out of science and engineering, both in academia and in industry; those who remain earn significantly less, get fewer honors and awards, and struggle more than their male colleagues. Social scientists have largely concluded that the underlying reasons for such outcomes are more likely attributable to gender discrimination and systemic bias than to innate differences. The evidence for this conclusion is growing as data analysis and gathering continues and as more attention is paid to women in science and engineering fields.

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Dropping out and documenting barriers

Within the last several years, a number of volumes have emerged that present data to support both the substantial attrition of women from scientific fields and the systemic biases that women face. Scientists often use the "pipeline" metaphor to describe the way in which individuals enter into science education and progress to a scientific career. For women, the "leaky pipeline" has been the dominant problem, with women exiting the pipeline at predictable points. Girls and boys, for example, show equal interest in science and math in middle school, but by high school many of the girls no longer express interest in a scientific career. This puts many of them at a disadvantage in college, where many science and engineering majors assume a background in high school calculus and physics (courses often bypassed by high school girls in the past, although this is changing). Introductory science and engineering courses in college often emphasize "weeding out" weaker students to ensure that only the best students continue. By this point, women are often reduced to minuscule numbers in certain fields, and those who remain are not necessarily motivated to continue after receiving their baccalaureates. Women in science, technology, engineering, and mathematics (STEM) fields, therefore, are often survivors who have already endured significant hurdles. It is surprising, then, to find that after earning their degrees, many of these women still drop out of the pipeline by exiting scientific and engineering careers.

In comparison with other STEM fields, the life sciences are often held up as successes in attracting women into the pipeline. In the October 2005 edition of *BioScience,* Eleanor Babco and I outlined some current data regarding women in the life sciences. Baccalaureate production in the life sciences increased steadily in the 1990s, mostly as a result of the addition of women choosing majors in biological fields. By 2002, 59 percent of bachelor's degrees in the life sciences were earned by women. Similar trends are documented at the doctoral level, with women earning approximately 45 percent of the doctorates awarded in the life sciences in 2003. Employment opportunities in the life sciences also increased steadily throughout the 1990s, as more funding poured into biological research, especially in medical research and human genomics. This spawned a growing biotech industry that employed a number of postdoctoral researchers across several different disciplines. But 2004 survey data from the American Association for the Advancement of Science still revealed a bleaker picture for women than for men in the life sciences. Women consistently reported lower salaries and lower levels of satisfaction than their male colleagues, and women in academia were less likely to be tenured or on the tenure track. Although respondents from both sexes responded positively to their work, indicating that it was intellectually challenging and provided a desirable level of autonomy in decisionmaking, women reported fewer opportunities for promotion and indicated more often than men that they would not recommend their career path to younger students (Babco and Jesse 2005).

Results such as these are not anomalous. In *Leaving Science: Occupational Exit from Scientific Careers* (2004), Anne Preston uses US Census and National Science Foundation (NSF) survey data, and data from surveys and interviews with graduates from a large public university, to track the career outcomes of a broad spectrum of scientists and engineers. The data from the US Census and NSF were gathered in the 1980s through surveys with scientists and engineers in 1982 and resurveys of the same population in 1984, 1986, and 1989 (Surveys of Natural and Social Scientists and Engineers), providing a unique longitudinal survey data set. The public university data were compiled from alumni who received degrees in STEM fields from the mid-1960s until 1991. Preston then conducted extensive interviews with respondents to the university survey in matched pairs of those who left science and those who remained in science, ultimately interviewing matched pairs of 52 women (26 pairs) and 52 men.

Data from all sources show that of the respondents who indicated that they were working in a scientific or engineering job, women were anywhere from one and a half times to twice as likely as men to leave scientific or engineering jobs over the survey periods. The national data reveal that between 1982 and 1989, 8.6 percent of men and 17.4 percent of women left a scientific or engineering career. The university data show an even more drastic exodus for science graduates with at least 12 years of work experience: 31.5 percent of women and 15.5 percent of men had left science. Most of those who leave enter nonscientific employment or pursue further graduate study, usually in the professional fields (MBA, MD, JD) or in education, where women far outnumber men.

Preston's main research goal is to uncover the reasons why individuals who have worked hard to earn a degree or degrees in STEM fields (some with PhDs) decide to leave after they enter the workforce. She finds that the reasons are fairly simple for men—most leave for more pay or better opportunities relative to what they think they can earn by staying in their chosen field. But for women, the reasons are much more complicated. While increased pay and opportunities definitely play a factor, women's reasons for leaving include more nuanced responses: a preference for other jobs, the difficulty of combining a family and a scientific career, the long work hours, and the perception that science and engineering are simply unfriendly domains for women. Moreover, Preston finds that for women, leaving a science and engineering career rarely leads to a higher income, and for men such an increase only comes with an investment in further education.

Using interviews to flesh out the survey responses, Preston observes that among her matched pairs of women, three important reasons for exit are evident. The first is unhappiness in scientific careers because of a mismatch of interests (and often a corresponding pull from other fields). A related finding is that women who stayed in STEM jobs often indicated that they had a strong mentor who was guiding them, while those who left often had no one playing that role during the time they were pursuing a STEM career. Finally, women were significantly more likely than men to report that family responsibilities were a major factor in their decision to leave science. Although Preston did not find evidence that gender discrimination or double standards play direct or key roles in women's decisions to leave a scientific or engineering career, she asserts a secondary role for these factors in that "they contributed to low levels of mentoring, a mismatch of interests, and difficulties in shouldering the double burdens of family and career" (p. 35).

While Preston looks broadly at a large subsection of the scientific and engineering workforce, other recent works have focused on the academic workforce, and on university faculty in particular. The most cited of these is probably Sue Rosser's *The Science Glass Ceiling: Academic Women Scientists and the Struggle to Succeed* (2004). Rosser outlines the results of survey and interview data collected from female scientists and engineers awarded NSF Professional Opportunities for Women in Research and Education (POWRE) grants in the late 1990s and 2000. While few of these women are contemplating leaving their science and engineering careers, most provide interesting insight into the opportunities and challenges they have faced and continue to face in their efforts to persist. Interestingly, many of Rosser's observations on the POWRE recipients mirror Preston's findings among women and men from multiple scientific career trajectories.

Are women simply asking for too much? Are interest in a healthy family life and the pursuit of science mutually exclusive? Is the isolation that seems to dampen women's enthusiasm for STEM research a necessary by-product of the scientific process?

Rosser sent out e-mail surveys to women who received POWRE awards in 1997, 1998, 1999, and 2000, the years in which the POWRE competition existed at NSF. POWRE provided research support for women faculty members across a broad spectrum of disciplines supported by NSF. Rosser posed a series of open-ended survey questions that asked respondents for spontaneous answers rather than giving them categories or choices among preset answers. Among the academic women who answered Rosser's first question, which asked them to identify "the most significant issues/challenges/opportunities facing women scientists today," a set of five issues emerged as most salient. The most frequent challenge these women identified was the balance between work and family, followed by time management, isolation and lack of mentoring, gaining credibility and respectability among peers, and the problem of two-career placements for academic couples. Affirmative action backlash and discrimination were also often mentioned by the 1998, 1999, and 2000 cohorts, although far fewer women among the 1997 POWRE awardees indicated this as a problem.

Rosser also asked respondents about the climate in the laboratory and how that affects the careers of women scientists. Here the results are less than clear, with many respondents simply unable to answer the question for various reasons. Rosser's interpretation of the data hinges on categorizing women as participating in "ideal types" or "phases" of labs, based on their responses. These phases correspond to five different levels of acceptance of women in the lab: (1) absence of women (complete gender bias), (2) women as an add-on ("tokens"), (3) women as a problem, (4) focus on women, and (5) a redefined laboratory climate where diversity is encouraged. These are seen as a linear progression of change as women become more present in laboratories within a field of study. Besides the obvious problems with categorizing labs into any one of the ideal-type phases identified (especially phase 5, which seems to be completely idealized), Rosser takes a logical leap here in identifying women as participating in a particular "phased" lab on the basis of their responses. Is a woman who answers that she perceives no problems in lab climate living in denial or ignoring negative gender bias? Or is she in the idealized fifth lab phase, in which diversity is valued and women are included without bias? What about someone who fails to answer the question? Should she also be categorized as being in a phase 1 lab? Rosser suggests that non-answerers and those who indicated no problems belong in phase 1 labs, and this interpretation places a decidedly negative spin on her analysis. She finds that most women described labs that seem to fall somewhere in phase 3 (women as problem), on the basis of answers indicating problems that stem from trying to balance family and work life, from a "boys' club atmosphere," from a "lack of camaraderie," and from a "hostile environment."

Regardless of the validity of Rosser's typology of laboratory environments, a picture is emerging of the problems facing some women in science and engineering—a lack of mentoring and isolation, the apparent conflict between the culture prevalent in many science and engineering labs and family life (or other outside interests), and, simultaneous with these, a dwindling of interest in science and engineering fields. Although there are some differences across disciplines in terms of the magnitude and frequency of the various problems and the corresponding loss of women, in general, across a number of different fields, women all seem to express some or all of these same problems. Are women simply asking for too much? Are interest in a healthy family life and the pursuit of science mutually exclusive? Is the isolation that seems to dampen women's enthusiasm for STEM research a necessary by-product of the scientific process? Are science and engineering fields simply carrying on with traditions that ensure that excellent science and engineering are performed? After all, hasn't it been through competition, long hours in the lab, and complete devotion to a field that science has excelled in the last century?

While science has made amazing strides in the last century, it is unclear whether this has been facilitated or hindered by prevailing institutional norms. What seems clear, however, is that institutionalized cultures that consciously or unconsciously lead to gender bias, in which men persist and women drop out, do not utilize the talent pool efficiently, and may eventually lead to scientific inertia rather than a robust scientific enterprise. In fact, it is becoming more and more evident that men as well as women are rejecting the scientific norms of long lab hours, complete devotion to work, and cutthroat competition. The question then becomes: What is the alternative, and how do we get there?

What's in an organizational structure?

It has long been assumed that women should fare better in hierarchical organizations where there are clear rules and avenues to address grievances, and where conscious policies such as affirmative action may be used to rectify past discrimination. Therefore, women in industry should suffer more consequences of gender discrimination and have far fewer opportunities for advancement than their counterparts in academia, who stick it out through the predictable, if strenuous, tenure slog. This was what Laurel Smith-Doerr expected to find as she began her research for *Women's Work: Gender Equality vs. Hierarchy in the Life Sciences* (2004). Smith-Doerr started from the premise that organizational context should have a marked impact on women's careers in the life sciences. Her "laboratory" was the relatively new biotechnology industry that sprang up in the 1980s and flourished throughout the 1990s. Although biotech companies do not employ nearly the same number of PhD scientists as academia or the large pharmaceutical companies (the other alternative employer), during the 1980s and 1990s they provided a viable career option for many new PhDs. Biotech companies became the venue for new medical discoveries, the mapping of the human genome, and other scientific advances. At the same time, according to Smith-Doerr, they also became innovators in human resource management.

Using both qualitative (interview) and quantitative (survey) data, Smith-Doerr traces the career experiences of a number of PhD scientists who entered either academia or the biotech industry from 1992 to 1996. What she finds is that whereas academia and the large pharmaceutical industries are hierarchical organizations, the biotech firms are largely networked organizations, both within each biotech company and between biotech firms. This networked organizational structure relies more on trust and collaboration, has permeable boundaries, and reshapes roles and opportunities for individual employees in ways not dreamed of in hierarchical organizations. Indeed, Smith-Doerr's most astonishing finding is that women scientists in biotech companies are *eight times* more likely to direct a major project than women in universities and big pharmaceutical companies, where women are 60 percent less likely to run a lab than men.

How do networks differ from hierarchies? First of all, they're flatter. Leadership roles shift among labs and lab workers as products are proposed, developed, and delivered. The output is the product of the network, not of a single research lab. This kind of cooperation among organizations and individuals requires transparency and trust, because it's the relationship among entities that is the priority, not the reputation of a single principal investigator. While hierarchies have struggled with interdisciplinary research, networks embrace the required teamwork and flexibility such research requires as a matter of good business strategy. Moreover, although traditional hierarchies display a facade of neutrality, fairness, and deference to formalized rules, in reality they often lead to "old boy networks" and less-than-formal norms that only those in the know are privy to. Networks require open communication and cooperation. Unknown rules and clandestine cliques are simply not sustainable where cooperation is key to successful projects.

In the process of adopting networks, according to Smith-Doerr, biotech firms have also embraced diversity as a good business strategy, and have consciously hired diverse workers. In fact, Smith-Doerr finds a distinct lack of gender segregation in the biotech firms she examines: Both men and women PhDs were equally likely to enter careers in biotechnology, and had done so from the beginning of the biotech movement. Once hired, both men and women took leadership roles on projects, established relationships across organizations, and found considerable flexibility in directing their careers. Interviews also revealed that some biotech firms seemed more accommodating than more hierarchical organizations on issues such as on-site child care and family leave, and that because biotech firms are often located in more urban areas, dual-career couples have a somewhat easier time finding two positions.

Smith-Doerr does take some pains to say that biotech firms are not utopias. Not all researchers excel in networked organizations, as not everyone is cut out for the shorter project cycles and the demands of the private market, which often require much quicker turnarounds. Moreover, there is still a gender gap in the upper leadership of biotech companies. Most biotech firms were founded by academic stars—almost exclusively men—who used their reputation to generate needed entrepreneurial capital to start the business. This leadership still seems to be a male domain.

In addition, Smith-Doerr is quick to point out that there were definite contextual conditions that led to more gender equity in biotech industries. First, the industry grew up around highly specialized and skilled workers, and relied on the reputation of both leaders and researchers in developing new enterprises and hiring new workers. This ensured that the women who entered these organizations were highly credentialed (and usually highly recommended by well-placed advisors). A second contextual condition was the critical mass of women hired from the very beginning by these companies, so that there wasn't a history of gender segregation to overcome. These two conditions, coupled with a network of laterally organized employers and a resource base that required considerable transparency, produced organizations in which gendered hierarchies were simply not sustainable.

All of this begs the question of whether the biotech example is transferable or even sustainable. Smith-Doerr herself expresses some reservations about the sustainability of the biotech network model over time. It was unclear during her research whether the institutional change represented by networked organizations was really complete, or still in flux. In other words, would biotech firms continue to work as small entities tied together for short project cycles, free to move on to other partnerships and collaborations at the end of each cycle? Or would they eventually get bought out by, or grow into, much larger and more hierarchical organizations? The downside of the interdependence of networked organizations is that they are often very vulnerable to downturns in the market, and indeed, some biotech firms in the last several years have experienced layoffs. Who is laid off first and how these organizations will deal with scarcer resources may determine whether they continue to embrace diversity in hiring and adopt innovative human resource management strategies.

Perhaps our focus should instead be targeted toward providing educators and employers with more information about how to manage education and work environments so that individuals' interest in science and engineering is maintained.

How to change?

It is unlikely that hierarchical organizations will change to networked ones overnight (if ever). And it is unclear whether all networked organizations will necessarily foster gender equity. So how do we reach a point where women and men are equally likely to pursue STEM careers, excel in them, and feel rewarded by the experience? Not surprisingly, Preston and Rosser offer similar policy prescriptions from their analyses. First and foremost is the adoption of policies that allow for a balance between career and family. These include allowing family leave, establishing on-site day care, lengthening the tenure clock, and facilitating two-career hires. These policies can benefit both men and women, and those organizations that do not offer them may find it more and more difficult to attract the most talented candidates to their ranks. Rosser advocates "a cafeteria of benefits" that would allow employees to choose options if and when circumstances change. Such flexibility could include adaptable work hours, telecommuting, and professional development accounts in addition to child care options.

Preston and Rosser also address the mentoring issue in their policy prescriptions by advocating more formal mentoring programs for women. Preston supports policies that focus on the apparent mismatch of interests reported by women pursuing STEM careers by providing students with more information when they make decisions about majors. She believes that more data should be gathered about the situation of scientists in the workforce, and that there should be more career counseling at colleges and universities that includes accurate information about what students might expect from a career and salaries in a given field. Presumably, with more information about what a career would be like, students will make more informed choices, and not choose fields in which they would lose interest or be unable to find a job that is stimulating over the long haul. However, this begs the question of whether the mismatch or loss of interest in science is due to a genuine mismatch or to a gradual loss of interest due to inadequate mentoring and an unfriendly environment. People are much more likely to lose interest in an activity when negative experiences add up over time, a workplace feels hostile, or there is no support. Perhaps our focus should instead be targeted toward providing educators and employers with more information about how to manage education and work environments so that individuals' interest in science and engineering is maintained. Gathering data about the situation of scientists and engineers would then give educators and employers more information about what the needs of their students or employees are and how to help them remain in the field.

In 2001, NSF moved away from targeted research grants for women, such as POWRE, and toward funding institutional transformation at colleges and universities. The ADVANCE program is designed to give institutions resources to help them adopt policies that will transform then into more gender-equitable places. Rosser emphasizes repeatedly that it is institutions that must embrace change if they want to hire a diverse workforce. Smith-Doerr contends, "In biotech firms, diversity is pursued up front; in universities, it is seen as good, if it happens" (p. 102). Pursuing diversity up front requires new and innovative strategies, and it is finding the strategies that work that is the current challenge. In the end, both Preston and Rosser advocate interventions that are already fairly well known in the gender equity literature. Change and innovation, however, may require rethinking how science and engineering are best accomplished, as well as experimenting with different human resource strategies and changing institutional structures. This may require colleges and universities, especially, to think very differently about their enterprises.

In their engaging edited volume *Removing Barriers: Women in Academic Science, Technology, Engineering, and Mathematics* (2006), Jill Bystydzienski and Sharon Bird have compiled an impressive set of essays that not only chronicle the history of women's experiences and the barriers they have encountered in science and engineering but also push the boundaries of the discussion of how to change. Some of the usual suspects are included in the volume, including Sue Rosser discussing POWRE and ADVANCE. Other essays focus on the experiences of subgroups of women, both by discipline and by race or ethnicity.

The advantage of this volume is its compilation of seemingly disparate subjects under one cover. There is a multitude of ways in which change could affect STEM fields in a positive way to allow for more participation by women and by others from underrepresented groups. These have been discussed in different places at different times, but having the information and results from various gender researchers in one volume allows the reader to make connections among them. A major theme that threads all the essays together is that in order to effect change, we need to challenge the myths surrounding the organization and practice of science and engineering and move beyond them. These myths are challenged in a no-holds-barred way in this volume.

By challenging how science is done and how it is taught, women have often opened up new areas for examination and found new ways to make sense of the world. These new pathways to scientific discovery may move science and engineering forward in unanticipated ways, as well as open fields to new participants.

Some of those myths—as described by Preston, Rosser, and Smith-Doerr, and reiterated in Bystydzienski and Bird's volume—are the need for hierarchy, competition, independent research, and a monofocus on work in order for the best science to be produced. Another myth is that science, as practiced, is "value free." In other words, the way science is taught, discussed, investigated, and presented is free from the values of individual researchers, and therefore free of bias. However, several essays in this volume contest this myth of value-free science, pointing out instances where language and perspectives used in classrooms and research, as well as methods for pursuing scientific results, have included implicit (and explicit) gender biases, especially in the biological sciences. These biases exclude women's participation by limiting what can and cannot be studied in certain fields, and by discouraging alternative methods that may reach different conclusions. By challenging how science is done and how it is taught, women have often opened up new areas for examination and found new ways to make sense of the world. These new pathways to scientific discovery may move science and engineering forward in unanticipated ways, as well as open fields to new participants.

Another major contribution of the Bystydzienski and Bird volume is the inclusion of several essays that address the situation of women of color in science, a topic woefully under-researched. Sandra Hanson's essay challenges the notion that women of color and white women face the same obstacles and draw on the same supports in pursuit of STEM education and careers. She finds that African American women are actually more interested in science and engineering careers than their white counterparts, and that they are more likely, in the long run, to choose a science or engineering career. Hanson discovers through interviews that gender is constructed very differently in African American and white communities. African American families often give more resources to girls to pursue careers, as marriage may be seen as a less than viable option, and female-headed households predominate. As a result, African American families are more likely to send their girls to college, rather than their boys, and to imbue girls with a sense of self-esteem, assertiveness, and high occupational expectations as avenues to escape poverty. These traits potentially afford African American women more chances at success in STEM education and careers.

Analyzing data from the National Educational Longitudinal Survey, or NELS, Hanson shows that white women often do better on standardized tests and get better grades than African American women, but that eight years after high school graduation, African American women are more likely to be working in science and engineering careers. African American women still face the obstacles of racism, invisibility, and a lack of role models and mentors; and the numbers of African American women in STEM careers are still quite low. But the fact that African American women are more likely to choose and stay in STEM careers is quite a striking finding. One way that these women seem to overcome some obstacles, such as isolation and lack of adequate mentoring, is by attending Historically Black Colleges and Universities—institutions that overwhelmingly produce more African American women scientists than majority institutions by offering a more diverse faculty and a more nurturing environment.

Josephine Beoku-Betts provides an inside look at an extremely marginalized group in the sciences: African women graduate students in Western universities. These women face not only the race and gender bias that African American and other women of color endure but also the marginality experienced by people from the developing world. They struggle with overcoming other people's perceptions that they can't speak English, that their education to this point has been substandard, that they lack real ability, and that their societies are backward. In addition, the isolation and lack of support is not only on the part of faculty; other graduate students may also question African women's ability, thus providing more of a burden to prove the legitimacy of their being there. Compared with their Western colleagues, African women are more likely to be married with children, and they often have little or no help in the household from husbands or domestic workers. Little wonder that so few African women attend graduate school in Western countries. Those who have succeeded appear to have survived out of a combination of pure self-motivation, spiritual beliefs, and support from other international students or faculty. Beoku-Betts's major prescription to help overcome the biases these women face is to increase mentoring opportunities.

Anne MacLachlan offers further prescriptions for helping women of color succeed in STEM graduate education. She explores the graduate school experiences of an ethnically diverse group of women who earned PhDs in science and engineering from schools in the University of California system between 1980 and 1990. Her narrative provides rich details of these women's experiences that point to specific recommendations for transforming graduate education and training.

MacLachlan advocates numerous orientation sessions throughout the entire graduate school experience, not just in the first week. These should increase the flow and frequency of information to graduate students, and should include skills training in teaching methods, laboratory management, grant writing, publishing, job hunting, and networking. More intensive one-on-one advising and the establishment of formal mentoring programs, especially between female faculty and students, are also included in MacLachlan's policy prescriptions. To be effective, according to MacLachlan, these changes must come from the departments and the faculty, rather than be imposed top-down from administrators. Administrators and government funders should serve supporting roles by encouraging changes and providing needed resources.

Finally, Abbe Herzig's essay explores what is needed to provide diverse students a "sense of belonging" in a field—in this case mathematics. She finds that this sense of belonging is essential for the successful retention of diverse graduate students. A sense of belonging is accomplished through participation in the activities of the field and through inculcation of inclusiveness in the curriculum and instruction. However, most graduate education, according to Herzig, is structured to present more obstacles to belonging than support for inclusiveness. By perpetuating certain myths about a field, and following long-held norms of graduate education, faculty undermine this sense of belonging. The first of these myths in mathematics is the myth of difficulty. Faculty present math problems as being virtually impossible to solve, thus fostering a sense of doubt among students that they can succeed in the field. Related to this is the myth of abstraction, which portrays mathematics as being disconnected from real-world applications, rather than showing the social connectedness of the field. Both of these tendencies isolate students and facilitate the "weeding out" of presumably weaker students.

Many mathematicians, according to Herzig, are unwilling or unable to share the enthusiasm they feel for their subject matter with their students (although in interviews they often describe the field as exciting and math as beautiful). This aloofness exacerbates their inability to develop mentoring relationships with students. The paucity of women in the field, especially at the university level, also means there are fewer role models for female students, and even fewer mentors that can relate to their situation. Herzig points out, like Beoku-Betts, that students of color face even more extreme isolation, as their relations with other students are often strained.

Herzig rejects efforts to address the problem of belonging simply by informing students about how to navigate the system. In a proposal reminiscent of Rosser and Smith-Doerr, Herzig calls for a restructuring of educational context that would increase students' opportunities to participate in a field, provide flexible support mechanisms (especially for students with families), and facilitate learning rather than weeding out students. The reform she calls for would also present the field of mathematics to students as connected to society, would offer opportunities to students to share the enthusiasm for the field that many mathematics faculty members express privately, and would promote positive relations among students and between faculty and students—a very tall order indeed.

What becomes clear from all these essays is that real change requires rethinking—rethinking teaching, research, institutional structures, and interpersonal relationships. One thing that none of these volumes discusses in depth, but that calls for a more substantive debate, is the differential gender impact of the seemingly immutable norm of tenure in academia. Tenure is usually considered untouchable, and for good reason: There are real benefits to faculty who gain needed job security when they've achieved tenure, and the system can preserve academic freedom. However, there is a growing trend on many campuses of hiring non-tenure-track personnel, the majority of whom tend to be women. Moreover, tenure is an inherently hierarchical institution, and one fraught with the kind of "old boy networks" and unwritten rules that are potentially hostile toward diverse tenure seekers (although, once earned, tenure may protect them).

Preston does discuss the need for "more imaginative compensation schemes and career trajectories" in science and engineering, although these are not discussed in terms of challenging academic tenure. The idea that more "pay-for-performance schemes" might be helpful in scientific and engineering employment is intriguing, and could lead to some interesting discussions, although this is only briefly mentioned in Preston's book. Smith-Doerr also mentions alternatives to tenure in a few sentences at the end of her volume. She proposes, "As a creative thought experiment, consider the issue of tenure in a different light. Imagine if team tenure were an option, in which three or four academics would be evaluated on their collective productivity" (p. 151). The thought ends there, unfortunately, leaving open the conversation for others to have.

Tenure needs to be discussed, alternative forms debated, a meaningful dialogue opened, and substantial social science research conducted on the impacts of the tenure system on organizational diversity. The value of volumes like Smith-Doerr's is that comparative organizational research can effectively point out how context may shape different experiences among individuals from diverse groups. We need much more research on the scientific workforce as a whole, and on STEM organizations both within and outside academia, in order to uncover innovative solutions to the pressing problems of underrepresentation in STEM fields.

In the meantime...

If comprehensive organizational change is unlikely in the near term, what should women and members of other underrepresented groups do in the meantime? What strategies can they adopt that might alleviate some of the more negative impacts of gender bias in science and engineering fields? When I was finishing my PhD and about to test the waters of the academic job market, one of the female professors in my department handed me a book for women on how to search for a job in academic engineering. Having just completed a degree in political science, I was a bit skeptical of the relevance of this volume to my situation, but decided to read it with an open mind. What I found was exactly the kind of advice I should have gotten throughout my graduate training. Ultimately I opted out of academia, but the advice I found in that volume continued to guide me in my pursuit of a rewarding career.

Two volumes have appeared in the last year that provide women in STEM fields inspiration to continue on their chosen path, and a number of strategies that have worked for a diverse population of women in STEM. The Association for Women in Science's volume *A Hand Up: Women Mentoring Women in Science* (AWIS 2005) provides personal stories both from women in academic science and industry and from female students still grappling with their own pathways to a STEM career. In addition, this substantial volume provides advice on specific topics that women may encounter in their STEM journey, including challenging the philosophy of science (e.g., "Ways of Being Rational"), surviving STEM education, dealing with covert and overt sex discrimination, fostering self-confidence, and mentoring other women, among others. All of this is augmented by a comprehensive list of resources available to women on the World Wide Web and elsewhere. There are also reprints of articles that give specific advice and strategies for tackling the academic job market.

Personal narratives are also interwoven with practical strategies throughout Peggy Pritchard's *Success Strategies for Women in Science: A Portable Mentor* (2006). Some of the strategies presented seem like common sense, and some are now almost clichés—find a mentor, develop a network. Some are less often discussed: for example, how to train or work abroad, or how to develop "mental toughness." For each topic, seasoned women scientists offer very explicit strategies for success, while sidebars offer personal anecdotes from scientists describing barriers they encountered and how they got around them. Reading the entire volume undoubtedly mirrors sitting through the graduate-level course that Pritchard offered and that inspired this book. Although the book primarily addresses graduate students and those who have recently graduated with a PhD in a science discipline, the final chapter, "Transitions," offers advice for those who are at practically every stage in a scientific career, from girls in high school through women at retirement age.

The challenge, as presented in all of these volumes, is ultimately to increase the diversity of the scientific and engineering enterprise. The desirability of this goal stems in large part from the hope that more diversity will ultimately lead to greater scientific progress. To achieve not only diversity but the promise of diversity, however, we need to continue to research the question of when diversity works and when it doesn't, both in terms of what methods successfully maintain diverse peoples in the workforce and in terms of how, when, and why diverse workforces produce more and better science.

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