More Women in Science

Jo Handelsman,[1,2]* Nancy Cantor,[3] Molly Carnes,[2,4] Denice Denton,[5] Eve Fine,[2] Barbara Grosz,[6] Virginia Hinshaw,[7] Cora Marrett,[8] Sue Rosser,[9] Donna Shalala,[10] Jennifer Sheridan[2]

It has been 25 years since Congress passed the Women in Science and Technology Equal Opportunity Act, which declares it "the policy of the United States that men and women have equal opportunity in education, training, and employment in scientific and technical fields (*1*)." Although there have been major advances, academic institutions are still not fully utilizing the pool of women scientists they have produced. The difference between the proportions of women who earn Ph.D.'s and those who are in faculty positions at top universities is clear in the biological and physical sciences, as well as in engineering (see table at right).

Enhanced online at www.sciencemag.org/cgi/content/full/309/5738/1190

Recently, much has been made of biological differences between men and women that might affect their representation in science. Although there is a substantive body of evidence indicating that overall intelligence does not differ between men and women, controversy persists as to whether specific aspects of cognitive ability differ (*2*, *3*). A recent debate by experts illuminates the issues and provides a summary of the literature in the field (*4*). We chose not to discuss these possible differences here for a number of reasons. First, there is no ideal constellation of cognitive abilities required to be a scientist. To be successful, scientists need deductive reasoning abilities, verbal skills, quantitative reasoning, intuition, and social skills. Men and women may differ, on average, in some of these abilities, but that is not a basis on which we can predict success because different mixtures lead to diverse, yet successful, approaches and styles in science. Second, there is no convincing evidence that women's representation in science is limited by innate ability. Between 1970 and 2003 (a time too brief for observable changes in innate ability), there was a 30-fold increase in the proportion of Ph.D.'s granted to women in engineering. This was a time in which attitudes and laws pertaining to gender changed dramatically, which provides strong evidence of the cultural and structural impediments to women. In this Policy Forum, we focus on the cultural issues that manifest in the behaviors of individuals and the policies of institutions because these factors make a difference and can be changed.

Moral and legal imperatives to ensure equal opportunity provide sufficient reasons to examine the causes of the disparities and to attempt to rectify them. Equally compelling is the impact that equity will have on the quality of our universities and the competitiveness of our nation. Heterogeneity among students, faculty, and staff strengthens universities in fundamental ways (*5*, *6*). Heterogeneous groups design more innovative solutions to problems than do homogeneous ones (*6*, *7*) and bring a higher level of critical analysis to decisions (*6*, *8*). Furthermore, institutions that welcome women foster more favorable working environments for all community members (*9*).

The National Science Foundation (NSF) founded the ADVANCE Institutional Transformation Program (*10*) to analyze the impact of interventions on advancement of women in science. Many universities have launched initiatives to enhance hiring, promotion, and productivity of women scientists, including Harvard University, which recently committed $50 million to this effort (*11*). Initial results from the NSF ADVANCE sites and other universities suggest several strategies that appear to work (*6*). Detailed documentation can be found in the supporting online material.

Barriers and Strategies to Overcome Them

The pipeline. The low number of women trained in certain fields is partially to blame for the paucity of women on the faculty. Nevertheless, many fields continue to suffer a faculty gender imbalance even though women compose from one-quarter to almost half of their graduating doctoral candidates (see table). Superb women scientists may not pursue academic careers simply because they are not encouraged to do so, question whether they have what it takes to be successful, or lack female role models who would help them envision themselves as faculty. Well-meaning advisers may interpret women's hesitation and concerns as disinclination and may fail to press their women students to consider academic careers. Explicit encouragement of outstanding doctoral candidates to enter the professoriate will help close the gap. Programs designed to prepare students to be faculty, such as those offered by many professional societies, universities, and

WOMEN Ph.D.'s AND FACULTY, TOP 50 DEPARTMENTS IN SELECTED DISCIPLINES*

Discipline	Career level (% women)			
	Ph.D.	Asst. Prof.	Assoc. Prof.	Full Prof.
Biology	45.89	30.20	24.87	14.79
Physical Science	24.68	16.13	14.18	6.36
Astronomy	22.88	20.18	15.69	9.75
Chemistry	33.42	21.47	20.50	7.62
Computer Science	15.27	10.82	14.41	8.33
Math & Statistics	26.90	19.60	13.19	4.56
Physics	14.78	11.15	9.41	5.24
Engineering	15.34	16.94	11.17	3.68
Electrical	12.13	10.86	9.84	3.85
Civil	17.90	22.26	11.50	3.52
Mechanical	10.93	15.65	8.89	3.17
Chemical	24.98	21.38	19.19	4.37

*Data on Ph.D.'s and faculty come from the same "Top 50" departments for each discipline; departments are ranked by NSF according to research expenditures in that discipline. Top 50 departments detailed at (*23*). Ph.D. data (*24*) are from 2001 to 2003; faculty data (*23*) are from 2002 except Astronomy (2004) and Chemistry (2003).

[1]Howard Hughes Medical Institute, professor, Department of Plant Pathology, University of Wisconsin–Madison; [2]Women in Science and Engineering Leadership Institute, University of Wisconsin–Madison; [3]Chancellor and president, Syracuse University; [4]Department of Medicine and Center for Women's Health Research, University of Wisconsin–Madison; [5]Chancellor, University of California, Santa Cruz; [6]Higgins Professor of Natural Sciences, Harvard University; [7]Provost and executive vice chancellor, University of California, Davis; [8]Senior vice president and deputy president, University of Wisconsin System; [9]Dean of the Ivan Allen College of Liberal Arts, Georgia Institute of Technology; [10]President, University of Miami. [For complete addresses, see the supporting online material.]

*Author for correspondence. E-mail: joh@plantpath.wisc.edu

Published by AAAS

private organizations (*6*), can provide access to role models and may inspire confidence and commitment (*12*).

To keep women moving through the pipeline to the senior ranks, they need sound advice about how best to invest their time as junior faculty. Women, more often than men, are asked to provide campus service on committees, as speakers, and as advisers to students (*13*). To assist junior faculty in managing pretenure activities, Georgia Tech ADVANCE Professor Jane Ammons developed a "speed mentoring" workshop in which junior faculty members consult for 15 to 20 minutes with each of four experienced tenure case reviewers who identify gaps and offer suggestions for strengthening the tenure case.

Climate. Many women attribute their exit from the academy to hostility from colleagues and a chilly campus climate (*14*). This atmosphere is invisible to many men, who typically describe a better climate for women than women report experiencing, as indicated by faculty surveys at MIT, Princeton, the University of Michigan, and the University of Wisconsin (*6*). Campus-wide programs to educate members of the community can identify and help eliminate discrimination in hiring and promotion, sexual harassment, and other illegal behaviors (*6*, *15*). Faculty members can assist by becoming educated about these behaviors and then taking steps to discourage them, including supporting women who voice concerns about illegal behavior.

Far more pervasive are the subtle effects of exclusion from the department community and its decision-making processes and the slights, ridicule, and attention to women's sexuality in professional settings. Although these behaviors may seem innocuous in isolation, the cumulative effect can be devastating (*6*, *16*). University administrators can set a campus standard in fostering inclusivity. Programs to train department chairs to recognize and combat the isolation experienced by women may transform local environments. The University of Michigan's ADVANCE program developed an interactive theater program that portrays typical academic situations and engages academic audiences in discussion that helps them recognize interpersonal behaviors that affect climate (*6*).

Unconscious bias. People who are committed to egalitarian principles and believe that they are not biased may nevertheless unconsciously or inadvertently behave in discriminatory ways (*6*, *17–19)*. When evaluators rated writing skills, resumes, journal articles, and career paths, they gave lower ratings on average if they were told that the subject of evaluation was a woman (*6*). A study of postdoctoral fellowships awarded by the Medical Research Council of Sweden found that women candidates needed substantially more publications to achieve the same competency rating as men (*18*). On the basis of results in other fields, it might be wise for scientists to consider ways to mask applicant gender. For example, introducing a screen to obscure the gender of musicians auditioning for symphony orchestra positions increased the likelihood that a woman was selected by 30 to 60% (*20*).

A number of interventions undertaken through the ADVANCE programs are predicated on the supposition that unconscious bias can be redressed by awareness. The University of Wisconsin–Madison has designed workshops to train search committees in good search methods and to sensitize them to bias (*6*). In these workshops, faculty members are encouraged to recruit women by deliberate action to overcome unconscious biases and to cultivate professional relationships with promising women scholars at professional meetings. Martell (*21*) showed that sex bias emerged when evaluators were under time pressure and distracted. Consequently, the search committee training includes reminding participants of the time required to conduct a thorough review and encouraging them to devote sufficient time to the evaluation of each individual to prevent assumptions from substituting for data. Georgia Tech has developed a Web-based computer instrument, Awareness of Decisions in Evaluating Promotion and Tenure (ADEPT), to aid promotion and tenure committee members, chairs, and deans to understand biases related to gender, race and/or ethnicity, disability, and interdisciplinarity. It consists of a downloadable application that contains case studies and summaries of scholarly research on bias and other materials to provoke discussion (*6*).

Balancing family and work. The responsibilities for family caretaking (for children and aging parents) continue to fall disproportionately on women (*6*). Young women can be encouraged by meeting or reading about prominent women scientists who have families and by learning about academic programs designed to reduce the conflicts between personal and professional life, including dual-career hiring programs, tenure clock extensions for childbirth and adoption, and on-campus lactation rooms and child care facilities. All members of the university community can advocate for such programs and can provide flexibility for colleagues with family responsibilities.

Conclusion

Institutional transformation necessitates collective examination of attitudes and the behaviors they spawn, which can be disquieting, because it requires engagement with issues of life-style, reproduction, hiring, and academic customs. Most uncomfortable is the discovery that we all harbor unconscious biases that can shape our behavior. Essential to the process is individual ownership of the blueprint for change. Strategies for this blueprint exist and are being tested, but systemic change can only be fostered if propelled by a vigilant and widespread campaign launched by tenacious women and men at all levels (*6*), and advocated by prominent leaders of our universities (*22*). Only such a campaign will fulfill the promise of the Science and Technology Equal Opportunities Act and will create a scientific community reflective of the pluralist society that supports it.

References and Notes

1. Bill S. 568 in the 96th Congress (http://thomas.loc.gov/).
2. American Sociological Association Council, 28 February 2005 (www.asanet.org/public/summers.html).
3. E. S. Spelke, "Sex differences in intrinsic aptitude for mathematics and science: A critical review," draft, 20 April 2005 (www.wjh.harvard.edu/~lds/sexsci/).
4. "The science of gender and science: Pinker vs. Spelke, a debate," 10 May 2005 (www.edge.org/documents/archive/edge160.html#d).
5. J. F. Milem, in *Compelling Interest: Examining the Evidence on Racial Dynamics in Colleges and Universities*, M. Chang, D. Witt, J. Jones, K. Hakuta, Eds. (Stanford Univ. Press, Stanford, CA, 2003), pp. 126–169.
6. Related resources, see http://wiseli.engr.wisc.edu/Products/MoreWomen.htm.
7. P. L. McLeod *et al.*, *Small Group Res.* **27**, 248 (1996).
8. C. J. Nemeth, *Adv. Group Process.* **2**, 57 (1985).
9. K. Miner-Rubino, L. M. Cortina, *J. Occup. Health Psychol.* **9**,107 (2004).
10. For information on ADVANCE, see www.nsf.gov/funding/pgm_summ.jsp?pims_id=5383.
11. L. H. Summers, S. E. Hyman, 16 May 2005 (www.president.harvard.edu/speeches/2005/0516_womensci.html).
12. M. F. Fox, in *Equal Rites, Unequal Outcomes: Women in American Research Universities*, L. S. Hornig, Ed. (Kluwer Academic, New York, 2003), pp. 91–109.
13. S. Park, *J. Higher Educ.* **67**, 46 (1996).
14. E. Seymour, N. Hewitt, *Talking About Leaving: Why Undergraduates Leave the Sciences* (Westview Press, Boulder, CO, 1997).
15. S.V. Rosser, *The Science Glass Ceiling: Academic Women Scientists and the Struggle to Succeed* (Routledge, New York, 2004).
16. V. Valian, *Why So Slow: Advancement of Women* (MIT Press, Boston, MA, 1999).
17. J. F. Dovidio, S. L. Gaertner, *Psychol. Sci.* **11**, 315 (2000).
18. C. Wenneras, A. Wold, *Nature* **387**, 341 (1997).
19. F. Trix, C. Psenka, *Discourse Soc.* **14**. 191 (2003).
20. C. Goldin, C. Rouse, *Am. Econ. Rev.* **90**, 715 (2000).
21. R. F. Martell, *J. Appl. Soc. Psychol.* **21**, 23 (1991).
22. J. Handelsman, J. Sheridan, E. Fine, M. Carnes, 4 April 2005 (http://wiseli.engr.wisc.edu/Products/top_10_tips.pdf).
23. D. J. Nelson, "Nelson diversity surveys" (Diversity in Science, Norman, OK, 2004) (http://cheminfo.chem.ou.edu/~djn/diversity/top50.html).
24. NSF survey of earned doctorates/doctorate records file, WebCASPAR (http://webcaspar.nsf.gov).

Supporting Online Material

www.sciencemag.org/cgi/content/full/309/5738/1190/DC1

10.1126/1113252