

BEYOND BIAS AND BARRIERS

FULFILLING THE POTENTIAL OF WOMEN IN ACADEMIC SCIENCE AND ENGINEERING



EXECUTIVE SUMMARY

NATIONAL ACADEMY OF SCIENCES,
NATIONAL ACADEMY OF ENGINEERING, AND
INSTITUTE OF MEDICINE
OF THE NATIONAL ACADEMIES

COMMITTEE BIOGRAPHIC INFORMATION

DONNA E. SHALALA [IOM] (*Chair*) is President of the University of Miami and the former Secretary of the US Department of Health and Human Services.

ALICE M. AGOGINO [NAE] is the Roscoe and Elizabeth Hughes Professor of Mechanical Engineering at the University of California, Berkeley.

LOTTE BAILYN is a professor in the Sloan School of Management at the Massachusetts Institute of Technology.

ROBERT J. BIRGENEAU [NAS] is Chancellor of the University of California, Berkeley.

ANA MARI CAUCE is the executive vice provost and Earl R. Carlson Professor of Psychology at the University of Washington

CATHERINE D. DEANGELIS [IOM] is the Editor-in-Chief of the Journal of the American Medical Association, Chicago, Illinois.

DENICE D. DENTON* was the chancellor of the University of California, Santa Cruz.

BARBARA J. GROSZ is Higgins Professor of Natural Sciences in the Division of Engineering and Applied Sciences, and dean of science at the Radcliffe Institute for Advanced Study at Harvard University.

JO HANDELSMAN is Howard Hughes Medical Institute Professor in the department of plant pathology at the University of Wisconsin, Madison.

NANNERL KEOHANE is president emerita of Duke University and Laurance S. Rockefeller Distinguished Visiting Professor of Public Affairs at Princeton University.

SHIRLEY MALCOM [NAS] is head of the directorate for Education and Human Resources Programs at the American Association for the Advancement of Science.

GERALDINE RICHMOND is the Richard M. and Patricia H. Noyes Professor of Chemistry and Materials Science at the University of Oregon.

ALICE M. RIVLIN is a senior fellow at the Brookings Institution and is the former director of the White House Office of Management and Budget.

RUTH SIMMONS is president of Brown University.

ELIZABETH SPELKE [NAS] is Berkman Professor of Psychology at Harvard University.

JOAN STEITZ [NAS, IOM] is Sterling Professor of Molecular Biophysics and Biochemistry at Yale University School of Medicine and an investigator at the Howard Hughes Medical Institute. She is a recipient of the National Medal of Science.

ELAINE WEYUKER [NAE] is a Fellow at AT&T Laboratories

MARIA T. ZUBER [NAS] is E. A. Griswold Professor of Geophysics at the Massachusetts Institute of Technology

* Served from September 2005 to June 2006. This report is dedicated in her honor.

PRINCIPAL PROJECT STAFF

LAUREL L. HAAK, Study Director

JOHN SISLIN, Program Officer

JUDY GOSS, Senior Program Assistant

IAN CHRISTENSEN, ERIN FRY, JENNIFER HOBIN, MARGARET HORTON, RACHEL SCHOLZ,
Christine Mirzayan Science and Technology Policy Graduate Fellows



EXECUTIVE SUMMARY

The United States economy relies on the productivity, entrepreneurship, and creativity of its people. To maintain its scientific and engineering leadership amid increasing economic and educational globalization, the United States must aggressively pursue the innovative capacity of *all* of its people—women and men. Women make up an increasing proportion of science and engineering majors at all institutions, including top programs such as those at the Massachusetts Institute of Technology where women make up 51% of its science undergraduates and 35% of its engineering undergraduates. For women to participate to their full potential across all science and engineering fields, they must see a career path that allows them to reach their full intellectual potential. Much remains to be done to achieve that goal.

Women are a small portion of the science and engineering faculty members at research universities, and they typically receive fewer resources and less support than their male colleagues. The representation of women in leadership positions in our academic institutions, scientific and professional societies, and honorary organizations is low relative to the numbers of women qualified to hold these positions. It is not lack of talent, but unintentional biases and outmoded institutional structures that are hindering the access and advancement of women. Neither our academic institutions nor our nation can afford such underuse of precious human capital in science and engineering. The time to take action is now.

CHARGE TO THE COMMITTEE

The National Academies, under the oversight of the Committee on Science, Engineering, and Public Policy, created the Committee on Maximizing the Potential of Women in Academic Science and Engineering to develop specific recommendations on how to make the fullest possible use of a large source of our nation's talent: women in academic science and engineering.

Specifically, the committee was charged

- To review and assess the research on gender issues in science and engineering, including innate differences in cognition, implicit bias, and faculty diversity.
- To examine institutional culture and the practices in academic institutions that contribute to and discourage talented individuals from realizing their full potential as scientists and engineers.
- To determine effective practices to ensure that women who receive their doctorates in science and engineering have access to a wide array of career opportunities in the academy and in other research settings.
- To determine effective practices for recruiting women scientists and engineers to faculty positions and retaining them in these positions.

- To develop findings and provide recommendations based on these data and other information to guide faculty, deans, department chairs and other university leaders; scientific and professional societies; funding organizations; and government agencies in maximizing the potential of women in science and engineering careers.

The report presents the consensus views and judgment of the committee members, who include five university presidents and chancellors, provosts and department chairs, named professors, former top government officials, leading policy analysts, and outstanding scientists and engineers—nine of whom are members of the National Academy of Sciences, National Academy of Engineering, or the Institute of Medicine, and many of whom have dedicated great thought and action to the advancement of women in science and engineering. The committee's recommendations—if implemented and coordinated across educational, professional, and government sectors—will transform our institutions, improve the working environment for women and men, and profoundly enhance our nation's talent pool.

FINDINGS

1. Women have the ability and drive to succeed in science and engineering. Studies of brain structure and function, of hormonal modulation of performance, of human cognitive development, and of human evolution have not found any significant biological differences between men and women in performing science and mathematics that can account for the lower representation of women in academic faculty and scientific leadership positions in these fields. The drive and motivation of women scientists and engineers is demonstrated by those women who persist in academic careers despite barriers that disproportionately disadvantage them.

2. Women who are interested in science and engineering careers are lost at every educational transition. With each step up the academic ladder, from high school on through full professorships, the representation of women in science and engineering drops substantially. As they move from high school to college, more women than men who have expressed an interest in science or engineering decide to major in something else; in the transition to graduate school, more women than men with science and engineering degrees opt into other fields of study; from doctorate to first position, there are proportionately fewer women than men in the applicant pool for tenure-track positions; active recruiting can overcome this deficit.

3. The problem is not simply the pipeline. In several fields, the pipeline has reached gender parity. For over 30 years, women have made up over 30% of the doctorates in social sciences and behavioral sciences and over 20% in the life sciences. Yet, at the top research institutions, only 15.4% of the full professors in the social and behavioral sciences and 14.8% in the life sciences are women—and these are the only fields in science and engineering where the proportion of women reaches into the double digits.

Women from minority racial and ethnic backgrounds are virtually absent from the nation's leading science and engineering departments.

4. Women are very likely to face discrimination in every field of science and engineering. Considerable research has shown the barriers limiting the appointment, retention, and advancement of women faculty. Overall, scientists and engineers who are women or members of racial or ethnic minority groups have had to function in environments that favor—sometimes deliberately but often inadvertently—the men who have traditionally dominated science and engineering. Well-qualified and highly productive women scientists have also had to contend with continuing questioning of their own abilities in science and mathematics and their commitment to an academic career. Minority-group women are subject to dual discrimination and face even more barriers to success. As a result, throughout their careers, women have not received the opportunities and encouragement provided to men to develop their interests and abilities to the fullest; this accumulation of disadvantage becomes acute in more senior positions.

These barriers have differential impact by field and by career stage. Some fields, such as physics and engineering, have a low proportion of women bachelor's and doctorates, but hiring into faculty positions appears to match the available pool. In other fields, including chemistry and biological sciences, the proportion of women remains high through bachelor's and doctorate degrees, but hiring into faculty positions is well below the available pool.

5. A substantial body of evidence establishes that most people — men and women — hold implicit biases. Decades of cognitive psychology research reveals that most of us carry prejudices of which



we are unaware but that nonetheless play a large role in our evaluations of people and their work. An impressive body of controlled experimental studies and examination of decision-making processes in real life show that, on the average, people are less likely to hire a woman than a man with identical qualifications, are less likely to ascribe credit to a woman than to a man for identical accomplishments, and, when information is scarce, will far more often give the benefit of the doubt to a man than to a woman. Although most scientists and engineers believe that they are objective and intend to be fair, research shows that they are not exempt from those tendencies.

6. Evaluation criteria contain arbitrary and subjective components that disadvantage women.

Women faculty are paid less, are promoted more slowly, receive fewer honors, and hold fewer leadership positions than men. These discrepancies do not appear to be based on productivity, the significance of their work, or any other measure of performance. Progress in academic careers depends on evaluation of accomplishments by more senior scientists, a process widely believed to be objective. Yet measures of success underlying the current “meritocratic” system are often arbitrary and applied in a biased manner (usually unintentionally). Characteristics that are often selected for and are believed, on the basis of little evidence, to relate to scientific creativity—namely assertiveness and single-mindedness—are given greater weight than other characteristics such as flexibility, diplomacy, curiosity, motivation, and dedication, which may be more vital to success in science and engineering. At the same time assertiveness and

single-mindedness are stereotyped as socially unacceptable traits for women.

7. Academic organizational structures and rules contribute significantly to the underuse of women in academic science and engineering.

Rules that appear quite neutral may function in a way that leads to differential treatment or produces differential outcomes for men and women. Structural constraints and expectations built into academic institutions assume that faculty members have substantial spousal support. The evidence demonstrates that anyone lacking the work and family support traditionally provided by a “wife” is at a serious disadvantage in academe. However, the majority of faculty no longer have such support. About 90% of the spouses of women science and engineering faculty are employed full-time; close to half the spouses of male faculty also work full-time.

8. The consequences of *not* acting will be detrimental to the nation’s competitiveness.

Women and minority group members make up an increasing proportion of the labor force. They also are an increasing proportion of postsecondary students. To capture and capitalize on this talent will require revising policies adopted when the workplace was more homogeneous and creating new organizational structures that manage a diverse workforce effectively. Effective programs have three key components: commitments to take corrective action and to analyze and use data for organizational change, and a campus framework for monitoring progress.

To facilitate clear, evidence-based discussion of the issues, the committee compiled a list of commonly-held beliefs concerning women in science and engineering (see Table 1). Each is discussed and analyzed in detail in the text of the report.

Table 1: Evidence refuting commonly-held beliefs about women in science and engineering.

BELIEF	EVIDENCE	WHERE DISCUSSED
(1) Women are not as good in mathematics as men.	Female performance in high school mathematics now matches that of males.	Chapter 2
(2) The matter of “under-representation” on faculties is only a matter of time; it is a function of how many women are qualified to enter these positions.	Women’s representation decreases with each step up the tenure-track and academic leadership hierarchy, even in fields that have had a large proportion of women doctorates for 30 years.	Chapter 3
(3) Women are not as competitive as men. Women don’t want jobs in academe.	Similar proportions of men and women science and engineering doctorates plan to enter postdoctoral study or academic employment.	Chapter 3
(4) Behavioral research is qualitative; why pay attention to the data in this report?	The data are from multiple sources, were obtained using well-recognized techniques, and have been replicated in several settings.	Chapters 2-5
(5) Women and minorities are recipients of favoritism through affirmative-action programs.	Affirmative action is meant to broaden searches to include more women and minority-group members, but not to select candidates on the basis of race or sex, which is illegal.	Chapter 4
(6) Academe is a meritocracy.	Although scientists like to believe that they “choose the best” based on objective criteria, decisions are influenced by factors—including biases about race, sex, geographic location of a university, and age—that have nothing to do with the quality of the person or work being evaluated.	Chapter 4
(7) Changing the rules means that standards of excellence will be deleteriously affected.	Throughout a scientific career, advancement depends upon judgments of one’s performance by more senior scientists and engineers. This process does not optimally select and advance the best scientists and engineers, because of implicit bias and disproportionate weighting of qualities that are stereotypically male. Reducing these sources of bias will foster excellence in science and engineering fields.	Chapter 4
(8) Women faculty are less productive than men.	The publication productivity of women science and engineering faculty has increased over the last 30 years and is now comparable to men’s. The critical factor affecting publication productivity is access to institutional resources; marriage, children, and eldercare responsibilities have minimal effects.	Chapter 4
(9) Women are more interested in family than in careers.	Many women scientists and engineers persist in their pursuit of academic careers despite severe conflicts between their roles as parents and as scientists and engineers. These efforts, however, are often not recognized as representing the high level of dedication to their careers they represent.	Chapter 5
(10) Women take more time off due to childbearing, so they are a bad investment.	On the average, women take more time off during their early careers to meet their caregiving responsibilities, which fall disproportionately to women. But, over a lifelong career, a man is likely to take significantly more sick leave than a woman.	Chapter 5
(11) The system as currently configured has worked well in producing great science; why change it?	The global competitive balance has changed in ways that undermine America’s traditional S&E advantages. Career impediments based on gender or racial or ethnic bias deprive the nation of talented and accomplished researchers	Chapter 6



CONCLUSIONS

The United States can no longer afford the underperformance of our academic institutions in attracting the best and brightest minds to the science and engineering enterprise. Nor can it afford to devalue the contributions of some members of that workforce through gender inequities and discrimination. It is essential that our academic institutions promote the educational and professional success of all people without regard for sex, race, or ethnicity. So that our scientists and engineers can realize their greatest potential, our academic institutions must be held accountable and provide evidence that women and men receive equitable opportunities, resources, and support. Institutional policies and practices must move from the traditional model to an inclusive model with provisions for equitable and unbiased evaluation of accomplishment, equitable allocations of support and resources, pay equity, and gender-equal family leave policies. Otherwise, a large number of the people trained in and capable of doing the very best science and engineering will not participate as they should in scientific and engineering professions.


RECOMMENDATIONS

Career impediments for women deprive the nation of an important source of talented and accomplished scientists and engineers who could contribute to our nation's competitiveness. Transforming institutional structures and procedures to eliminate gender bias is a major national task that will require strong leadership and continuous attention, evaluation, and accountability. Because those obstacles are both substantial and systemic, there are no easy fixes; however, many practices developed in the last decade by universities and funding agencies have proven effective in increasing both the participation of women on faculties and their appointment to leadership positions. In part, the challenge is to use such strategies more widely and evaluate them more broadly to ensure we are accessing the entire talent pool to find truly the best people for our faculties. We need to think creatively about opportunities for substantial and overarching reform of the academic enterprise—its structure, incentives, and accountability—to change outcomes and achieve equity.

The committee's recommendations are large-scale and interdependent, requiring the interaction of university leaders and faculties, scientific and professional societies, funding agencies, federal agencies, and Congress.

Trustees, university presidents, and provosts should provide clear leadership in changing the culture and structure of their institutions to recruit, retain, and promote women—including minority women—into faculty and leadership positions.

- University leaders should *incorporate into campus strategic plans goals of counteracting bias against women in hiring, promotion, and treatment*. This includes working with an inter-institution monitoring organization (see below) to perform annual reviews of the composition of their student body and faculty ranks, publicizing progress toward the goals annually, and providing a detailed annual briefing to the board of trustees.
- University leaders should *take action immediately to remedy inequities in hiring, promotion, and treatment*.
- University leaders should as part of their *mandatory overall management efforts hold leadership workshops for deans, department heads, search committee chairs, and other faculty with personnel management responsibilities that include an*



integrated component on diversity and strategies to overcome bias and gender schemas and strategies for encouraging fair treatment of all people. It is crucial that these workshops are integrated into the fabric of the management of universities and departments.

- University leaders should *require evidence of a fair, broad, and aggressive search before approving appointments and hold departments accountable for the equity of their search process and outcomes* even if it means canceling a search or withholding a faculty position.
- University leaders should *develop and implement hiring, tenure, and promotion policies that*

take into account the flexibility that faculty need across the life course, allowing integration of family, work, and community responsibilities. They should provide uniform policies and central funding for faculty and staff on leave and should visibly and vigorously support campus programs that help faculty with children or other caregiving responsibilities to maintain productive careers. These programs should, at a minimum, include provisions for paid parental leave for faculty, staff, postdoctoral scholars, and graduate students; facilities and subsidies for on-site and community-based child care; dissertation defense and tenure clock extensions; and family-friendly scheduling of critical meetings.

Deans and department chairs and their tenured faculty should take responsibility for creating a productive environment and immediately implement programs and strategies shown to be successful in minimizing the effect of biases in recruiting, hiring, promotion, and tenure.

- Faculties and their senates should initiate a *full faculty discussion of climate issues.*
- Deans, department chairs, and their tenured faculty should *develop and implement programs that educate all faculty members and students in their departments on unexamined bias and effective evaluation; these programs should be integrated into departmental meetings and retreats, and professional development and teacher-training courses. For example, such programs can be incorporated into research ethics and laboratory management courses for graduate students, postdoctoral scholars, and research staff; and*
- Deans and department chairs and their tenured faculty should *expand their faculty recruitment efforts* to ensure that they reach adequately and proactively into the existing and ever-increasing pool of women candidates.
- Faculties and their senates should immediately *review their tenure processes and timelines* to ensure that hiring, tenure, and promotion policies take into account the flexibility that faculty need across the life course and do not sacrifice quality in the process of meeting rigid timelines.

University leaders should work with their faculties and department chairs to examine evaluation practices to focus on the quality of contributions and their impact.

Professional societies and higher education organizations have a responsibility to play a leading role in promoting equal treatment of women and men and to demonstrate a commitment to it in their practices.

Together, **higher education organizations** should consider forming an inter-institution monitoring organization. This body could act as an intermediary between academic institutions and federal agencies in recommending norms and measures, in collecting data, and in cross-institution tracking of compliance and accountability. Just as the opening of athletics programs to girls and women required strong and consistent inter-institutional cooperation, eliminating gender bias in faculty recruitment, retention, and promotion processes requires continuous inter-institutional cooperation, including data-gathering and analysis, and oversight and evaluation of progress.

As an initial step, the committee recommends that the American Council on Education, an umbrella organization encompassing all of higher education, convene national higher education organizations, including the Association of American Universities (AAU), the National Association of State Universities and Land Grant Colleges (NASULGC), and others to consider the creation of a cross-university monitoring body.

A primary focus of the discussion should be on defining the scope and structure of data collection. The committee recommends that data be collected at the department level by sex and race or ethnicity and include the numbers of students majoring in science and engineering disciplines; the numbers of students graduating with bachelors or master's degrees in science and engineering fields; post-graduation plans; first salary; graduate school enrollment, attrition, and completion; postdoctoral plans; numbers of postdoctoral scholars; and data on faculty recruitment, hiring, tenure, promotion, attrition, salary, and allocation of

institutional resources. The committee has developed a scorecard that can be used for this purpose.

Scientific and professional societies should

- Serve in helping to set professional and equity standards, collect and disseminate field-wide education and workforce data, and provide professional development training for members that includes a component on bias in evaluation.
- Develop and enforce guidelines to ensure that keynote and other invited speakers at society-sponsored events reflect the diverse membership of the society.
- Ensure reasonable representation of women on editorial boards and in other significant leadership positions.
- Work to ensure that women are recognized for their contributions to the nation's scientific and engineering enterprise through nominations for awards and leadership positions.
- Provide child-care and elder-care grants or subsidies so that their members can attend work-related conferences and meetings.

Honorary societies should review their nomination and election processes to address the underrepresentation of women in their memberships.

Journals should examine their entire review process, including the mechanisms by which decisions are made to send a submission to review, and take steps to minimize gender bias, such as blinded reviews.

Federal funding agencies and foundations should ensure that their practices—including rules and regulations—support the full participation of women and do not reinforce a culture that fundamentally discriminates against women. All research funding agencies should:

- Provide workshops to minimize gender bias. Federal funding agencies and foundations should work with scientific and professional societies to

host mandatory national meetings that educate members of review panels, university department chairs, and agency program officers about meth-

ods that minimize the effects of gender bias in evaluation. The meetings should be held every 2 years for each major discipline and should include data and research presentations on subtle biases and discrimination, department climate surveys, and interactive discussions or role-modeling. Program effectiveness should be evaluated on an ongoing basis.

- *Collect, store, and publish composite information* on demographics, field, award type and budget request, review score, and funding outcome for all funding applications.
- *Make it possible to use grant monies for dependent care expenses* necessary to engage in off-site

or after-hours research-related activities or to attend work-related conferences and meetings.

- *Create additional funding mechanisms* to provide for interim technical or administrative support during a leave of absence related to caregiving.
- *Establish policies for extending grant support* for researchers who take a leave of absence due to caregiving responsibilities.
- *Expand support for research* on the efficacy of organizational programs designed to reduce gender bias, and for research on bias, prejudice, and stereotype threat, and the role of leadership in achieving gender equity.

Federal agencies should lay out clear guidelines, leverage their resources, and rigorously enforce existing laws to increase the science and engineering talent developed in this country.

Even without additional resources, federal agencies should *move immediately to enforce the federal anti-discrimination laws* at universities and other higher education institutions through regular compliance reviews and prompt and thorough investigation of discrimination complaints.¹ Federal enforcement agencies should ensure that the range of their enforcement efforts covers the full scope of activities involving science and engineering that are governed by the anti-discrimination laws. If violations are found, the full range of remedies for violation of the anti-discrimination laws should be sought.

Federal enforcement efforts should *evaluate whether universities have engaged in any of the types of discrimination* banned under the anti-discrimination laws, including: intentional discrimination, sexual harassment, retaliation, disparate impact discrimination, and failure to maintain required policies and procedures.

Federal compliance review efforts should *encompass a sufficiently broad number and range of institutions* of higher education to secure a substantial change in policies and practices nationwide. Types of institutions that should be included in compliance reviews include 2-year and 4-year institutions; institutions of undergraduate education; institutions that grant graduate degrees; state universities; private colleges; and educational enterprises, including national laboratories and independent research institutes, which may not be affiliated with universities.

Federal enforcement agencies, including the Equal Employment Opportunity Commission, the Department of Justice, the Department of Labor, the Department of Education, and individual federal granting agencies' Offices of Civil Rights should *encourage and provide technical assistance* on how to achieve diversity in university programs and employment. Possible activities include providing technical assistance to educational institutions to help them to comply with the anti-discrimination laws, creating a clearinghouse for dissemination of strategies that have been proven effective, and providing awards and recognition for model university programs.

¹Applicable laws include Title VI, Title VII, and Title IX of the Civil Rights Act; Executive Order 11246; the Equal Protection clause of the Constitution; the Equal Pay Act; the Pregnancy Discrimination Act; and the Family Medical Leave Act. Each of these statutes is discussed in detail in Chapter 5.



Congress should take steps necessary to encourage adequate enforcement of antidiscrimination laws, including *regular oversight hearings* to investigate the enforcement activities of the Department of Education, the Equal Employment Opportunity Commission, the Department of Labor, and the science granting agencies—including the National Institutes of Health, the National Science Foundation, the Department of Defense, the Department of Agriculture, the Department of Energy, the National Institute of Standards and Technology, and the National Aeronautics and Space Administration.

CALL TO ACTION

The fact that women are capable of contributing to the nation’s scientific and engineering enterprise but are impeded in doing so because of gender and racial/ethnic bias and outmoded “rules” governing academic success is deeply troubling and embarrassing. It is also a *call to action*. Faculty, university leaders, professional and scientific societies, federal agencies and the federal government must unite to ensure that all our nation’s people are welcomed and encouraged to excel in science and engineering in our research universities. Our nation’s future depends on it.

FOR MORE INFORMATION

This report was developed under the aegis of the National Academies Committee on Science, Engineering, and Public Policy (COSEPUP), a joint committee of the three honorific academies—the National Academy of Science (NAS), the National Academy of Engineering (NAE), and the Institute of Medicine (IOM). Its overall charge is to address cross-cutting issues in science and technology policy that affect the health of the national research enterprise. More information on the study, including the full body of the report, is available at <http://www7.nationalacademies.org/womeninacademe/>.

NOTE

This report was reviewed in draft form by individuals chosen for their technical expertise, in accordance with procedures approved by the National Academies’ Report Review Committee. For a list of those reviewers, refer to the full report.

THE NATIONAL ACADEMIESTM

Advisers to the Nation on Science, Engineering, and Medicine

The nation turns to the National Academies—National Academy of Sciences, National Academy of Engineering, Institute of Medicine, and National Research Council—for independent, objective advice on issues that affect people's lives worldwide.

www.national-academies.org