

WOMEN & SCIENCE

CELEBRATING ACHIEVEMENTS,
CHARTING CHALLENGES



NATIONAL SCIENCE FOUNDATION

Women & Science

*Celebrating Achievements
Charting Challenges*

Conference Report

March 1997



National Science Foundation
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The material presented in this report constitutes a summary of the views and opinions of those who participated in the *Women & Science* conference.

In particular, the summaries of the various breakout sessions and the sidebars containing opinions of individual conference participants do not necessarily reflect the views of the National Science Foundation.

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Executive Summary

This report summarizes the discussions, ideas, and recommendations of the *Women & Science: Celebrating Achievements, Charting Challenges* conference. The purpose of the conference was to take stock of the achievements that women have made, assess what works best in the classroom and workplace, and chart a new course to address the challenges that remain.

The report makes the following seven recommendations:

1. Communicate with women and girls about the importance of being scientifically literate. Increase public understanding of the role that women do and can play in science and engineering while dispelling myths and stereotypes.
2. Rather than relying on quick fixes to local problems, seek to transform the systems of education and the sciences by holding institutions accountable for their performance as employers and places of learning for all people.
3. Recognize and reinforce the importance of mentoring and being mentored at all levels of education and career.
4. Enable women and girls to participate fully in science and engineering by making available a greater variety of resources. These resources include career awareness and career planning assistance and opportunities to interact within and across disciplinary fields and sectors of the economy.
5. Accommodate the needs of women by recognizing a diversity of approaches to learning and the multiple paths women take to becoming literate citizens and career professionals in science and engineering.

6. Strengthen connections between organizations that have a stake in the participation of women in the sciences and engineering, such as the corporate and academic worlds, the formal and informal education sectors, associations of women and associations of sciences, and between higher education and K-12 schools.
7. Place greater emphasis on determining what works best in increasing opportunities for women and girls and how this knowledge can be shared and used by others.

The conference and report are a joint effort of the seven directorates of the National Science Foundation (NSF). Seven hundred women and men from colleges and universities, industry, nonprofit groups, schools, and community groups assembled in Washington, DC, on December 13-15, 1995, to take part in plenary sessions, breakout sessions, and a special showcase of posters and demonstrations.

The report summarizes each of the conference's 12 breakout sessions, which were organized around NSF disciplines and a set of cross-cutting themes in research and education.

The conference breakout sessions examined challenges of women and science and reflected on possible solutions; some tried and some new. Strategies for expanding gender diversity and opportunities for women at all educational levels and throughout the workforce were recommended. The summaries include a brief statistical report on the status of women in each field, findings and recommendations as viewed by the participants, one or more excerpts from the words of the conference participants on a particular discipline or issue, and views of NSF Assistant Directors about the issues concerning women in their respective fields. In addition, the report contains a section devoted to resources for women in science and engineering, excerpts of plenary speeches, and a listing of names and addresses of those who attended the conference.

NSF intends this report to serve several roles:

- It is a complete summary of what transpired at the conference, giving the reader an opportunity to understand the overall flow, mood, and direction of the conference.
- It can be read in independent, self-contained, segments, that is, it enables the reader who is concerned about a particular science or engineering discipline or an issue in research and education to seek information on that subject alone. See the table of contents for a listing of each independent discussion.
- It serves as a resource by providing information on NSF programs and the programs of various professional societies in women and science.
- Finally, the names and addresses of those who participated provide a ready-made network of scientists, engineers, and educators who are concerned about women and science.

Statement from the Deputy Director of the National Science Foundation

Anne C. Petersen

Science and engineering hold unprecedented sway in our personal lives, communities, and nation's future. Today, human beings must accommodate tremendous technological change in the course of a single life span, change that may have previously taken centuries to come about. At the same time, the threads of our national social fabric are left to sustain these changes, adapt, and hopefully seize on them as opportunities. But, while the pace of technological and scientific discovery moves forward, society's ability to transform itself has often lagged behind.

The National Science Foundation conference, *Women & Science: Celebrating Achievements, Charting Challenges*, brought together 700 women and men in December 1995 to celebrate what has been achieved. It was also designed to chart a new course for women to meet the challenges posed by and for science in the next century.

The conference focused on women and the sciences rather than women in the sciences for a deliberate reason: It needed to be made clear that equity and access for women and girls are not problems of women but problems of science and society. Any solutions we identify are going to require that men and women work together to find a better path for science as a social institution and a profession.

Let us talk for a moment about solutions. First, women's roles as conceived by society are embedded in the history of humankind. Their roots are in all professions, not just science and engineering. Change is and will be incremental and sometimes nonlinear in its progression from step A to B, onward. Second, no one organization, individual, or sector of the economy is to blame. Nor will any one organization, individual, or sector bring about a solution for the others.

However, the role of women in science and engineering has its own history and innate features rooted in the social value of science. Just as our economy has grown and changed as a result of increasing world competition, so too must

science struggle to remain relevant to the national good. During the long post-war period, the value of science eluded relevance for most Americans. Priorities were instead determined largely by patterns of government resource allocation for research with a strong and perhaps necessary emphasis on national defense. Now we face a world where science and technology are keystones in global competition and must be measured in terms other than military prowess. The societal value placed on science and engineering has shifted and will continue to shift in ways that provide challenges and opportunities for all of science and engineering and the workforce.

American science has made great contributions to our nation and the world. It must continue to do that in ways that map with current pressures and future hopes. We have tremendous resources, foremost among them is our diversity as a nation and as a people. Diversity adds new ideas, perspectives, and ways of thinking to scientific discovery and its application. It also gives science and engineering new relevance to large portions of our population. The *Women & Science* conference ambitiously aimed to produce new ways to mine the national resource of diversity, in this case women, and to find solutions to some of the research and education problems we face today.

This report discusses the future of women and science in terms of the future of science, women, and trends and pressures of society. Recommendations are offered in a context that recognizes what women have achieved. But more importantly, they focus on what remains to be done and how to do those tasks in ways that reflect reality. They recognize the part that must be played by all individuals, organizations, and sectors of the economy.

At the conference, I listened carefully to the points that were made by the participants in the many plenary and breakout sessions. I listened not only for specific ideas but also for the norms and contexts that were subsumed by those ideas. After the conference, I combed through notes and transcripts. I believe that the following seven overarching recommendations accurately reflect the big picture of what was said.

1. Communicate with women and girls about the importance of being scientifically literate. Increase public understanding of the role that women do and can play in science and engineering while dispelling myths and stereotypes.
2. Rather than relying on quick fixes to local problems, seek to transform the systems of education and the sciences by holding institutions accountable for their performance as employers and places of learning for all people.
3. Recognize and reinforce the importance of mentoring and being mentored at all levels of education and career.

4. Enable women and girls to participate fully in science and engineering by making available a greater variety of resources. These resources include career awareness and career planning assistance and opportunities to interact within and across disciplinary fields and sectors of the economy.
5. Accommodate the needs of women by recognizing a diversity of approaches to learning and the multiple paths women take to becoming literate citizens and career professionals in science and engineering.
6. Strengthen connections between organizations that have a stake in the participation of women in the sciences and engineering, such as the corporate and academic worlds, the formal and informal education sectors, associations of women and associations of sciences, and between higher education and K-12 schools.
7. Place greater emphasis on determining what works best in increasing opportunities for women and girls and how this knowledge can be shared and used by others.

To me, these recommendations are fundamental to the future of not just women and not just science but to the future of women and science. They recognize that all must play a part. Just as one example, every parent in this country – and the world for that matter – is a science and mathematics educator. By our actions we teach our daughters and sons how to look on the sciences, and those of us who are scientists determine how science looks on them. In short, there is a need for society to advance the role of women in science, but we would be remiss not to consider the necessity of women advancing science in our society.

This brings us naturally to the purpose of this report. The report is for us all as scientists and engineers, men and women, researchers and teachers, administrators and policymakers, and, most of all, learners. A major goal of the conference was to seek advice on how we at NSF can best address issues of women and science for the future. The conference was just the first step of many in that process. The report is the second step. I hope that you will find inspiration, strength, and ideas for your own communities and organizations.

To paraphrase from my speech at the conference: As we celebrate our achievements and begin to chart our future challenges, our potential role as leaders should be front and center in our thoughts. We who have climbed the steep slopes by clawing and hanging on should not demand this as initiation for those who follow. Rather, we need to provide a web of support, encouragement, and example. We must nurture, guide, and teach. We must reach down to girls and young women and show them a path paved with encouragement. And most of all, we must do this for the future of science and engineering and for the future of our society.



About the Conference and This Report

The purpose of the *Women & Science: Celebrating Achievements, Charting Challenges* conference was to take stock of the achievements that women have made, assess what works best in the classroom and workplace, and chart a new course to address the challenges that remain.

The conference was a joint effort of the seven directorates of the National Science Foundation (NSF). Seven hundred women and men from colleges and universities, industry, nonprofit groups, schools, and community groups assembled in Washington, DC, on December 13-15, 1995, to take part in plenary sessions, breakout sessions, and a special showcase of posters and demonstrations. Breakout sessions were organized by scientific and engineering disciplines and by cross-cutting themes:

Disciplinary Breakouts

Biological Sciences

Computer and Information
Science and Engineering

Engineering

Geosciences and Polar Programs

Mathematical and Physical Sciences

Social and Behavioral Sciences

Cross-cutting Theme Breakouts

Research-Education Infrastructure

The Impact of Technology

Family Issues

Shattering Preconceptions

Bridging Education and Workforce
Transitions

Changing Curriculum and Instruction

The conference was hosted by Anne C. Petersen, then Deputy Director of NSF. It was co-chaired by Daryl E. Chubin, Division Director for Research, Evaluation and Communication, and Sue V. Rosser, Senior Program Director for Programs for Women and Girls, both of the Directorate for Education and Human Resources. A Planning Committee was established to provide general guidance,

and a Program Steering Committee was formed to construct the conference program. NSF sought and incorporated the advice from a multitude of organizations concerned with women and science.¹

The conference breakout sessions examined the challenges and reflected on possible solutions; some tried and some new. Strategies for increasing participation and opportunities for women at all educational levels and throughout the workforce were recommended. However, due to the backgrounds of conference participants, much of the focus was on women in academia. Prior to the conference, participants were invited to respond to one of three open-ended questions about issues central to the conference. The responses were distributed at the conference and are excerpted in this report. The questions were:

- What single trend – unique or shared with other disciplines – best illustrates the status of opportunities for women in your field (e.g., trends in creating interest, degrees awarded, educational or career transitions, knowledge of opportunities)? In your view, what factors underlie this trend?
- What are some creative ways that the National Science Foundation could increase the participation of and opportunities for women in science, mathematics, engineering, and technology?
- How could this conference be used to stimulate change in local campuses and in communities?

Summary of Breakout Sessions

Each of the 12 breakout sessions is summarized based on notes recorded at the session. The summaries contain the following information:

Status Report: A brief statistical summary of the status of women in each field. These are found in the disciplinary breakout summaries only.

Overview: A summary of the mission and topics covered by the breakout session.

Topical Summaries: A brief summary of what transpired at the breakout session organized by the major challenges and possible solutions suggested by the participants.

Views of the Participants: One or more excerpts from the actual words of the conference participants on a particular discipline or issue. These statements are taken from responses to the conference questions that participants were invited to answer before arriving at the conference.

Views of the Assistant Directors and Post-Conference Reflections: Each Assistant Director was asked to participate in a conference session devoted to what NSF directorates were doing to promote opportunities for women. These statements are reproduced. In addition, each Assistant Director was asked to write a statement 6 months after the conference that reflects on the conference and progress made since.

Other Conferences: Some summaries include a box describing findings from a relevant conference on women in science. These conferences were sponsored by organizations other than NSF.



Biological Sciences

Status Report

In the biological sciences, women are no longer underrepresented at the bachelor's and master's degree levels. They earned slightly more than one-half of all bachelor's and master's degrees that were awarded in 1994. However, women remain underrepresented at the doctoral level where they earned two of every five doctorates awarded. In 1973, women earned about 30 percent of bachelor's and master's degrees and only one in five doctorates.

figure 1

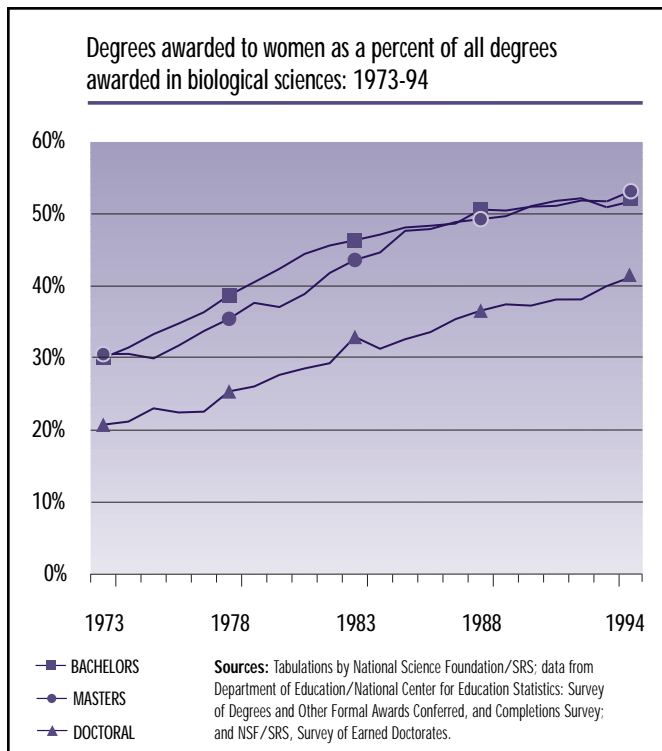
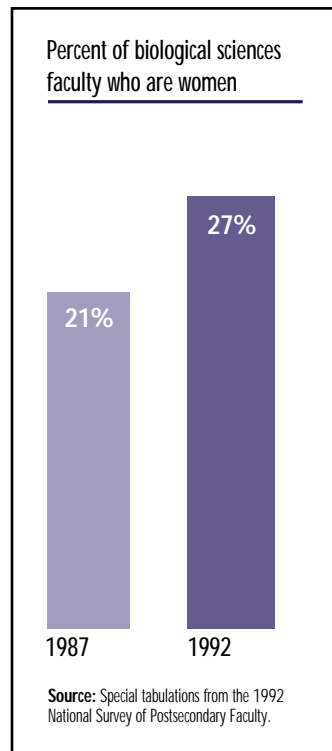


figure 2



Views from the Participants

“With the large number of women now getting their first degree in biology, the chances of more women going on to advanced degrees in biology increase.

As the number of women professors increases, so does the presence of women role models and mentors, which should in turn encourage more women.

I remember only one woman faculty member in the biology department when I was an undergraduate in the early 1960s.

In graduate school, the women faculty were all research faculty and were not in tenure-track positions.

On the other hand, while an undergraduate, my daughter performed independent research with two women faculty members in the biology department and could have chosen from no less than seven women to serve on her Ph.D. committee.”

Of female biology faculty who were newly hired² when surveyed in 1992, 60 percent were hired as part-time employees and more than three-fourths were not on a tenure track or there was no tenure system for their faculty status. In both cases, this was close to or double the proportion of men in these employment situations. At the senior academic ranks, women are still not well represented. Sixteen percent of all female biology faculty were full professors in 1992 compared with 39 percent of male faculty.

Overview

The biological sciences group discussed education from kindergarten through graduate school, transitions of women in biological sciences between education and the workplace and into senior positions, and issues of the family. Because women have reached parity with men in earning bachelor's and master's degrees in the biological sciences, the group chose to focus on problems at the professional level — both in academia and in industry.

Education and the Curriculum

To better prepare the next generation of women biologists, biology curricula at the elementary, secondary, and undergraduate levels should be reexamined to reflect needs of society and the students entering those fields. Learning should emphasize group projects, experiential projects, mentoring, and building self-confidence.

Workshops should be created where teachers and researchers could learn from each other about their respective needs and problems. This would give researchers a greater understanding of the issues facing learners and teachers and would bring understanding of cutting-edge content to teachers of biology.

Leadership

Although women are relatively well represented in the biological sciences, women have not reached important leadership positions in adequate numbers. Based on a national survey of faculty in 1992, women are not confident about opportunities for advancement in their field. Sixty-one percent of women in the biological sciences were very or somewhat dissatisfied with opportunities for advancement compared with 33 percent of men. As a result, particular attention needs to be paid to boosting women into senior ranks. Unfortunately, current

pressures in academia (downsizing, scarcity of research funds) make this difficult. To remedy this, leadership workshops and high visibility awards for senior women faculty could be created. In addition, better communication about the status of opportunities in the biological sciences could provide a more accurate picture to women when deciding on career options.



Views from the Participants

“One of the major problems that has become clear to me through my observations of the job searches conducted by my department is that it is harder to recruit women than men.

Our top group of candidates usually includes as many women as men, if not more, and we have offered jobs to more women than men.

But, we end up hiring many more men than women because women are more apt to turn us down.

Their reasons are diverse, but a common theme is the lack of jobs in our area for their professional spouses.

Male candidates have this constraint less often than women candidates (and are probably less often willing to turn down a good job even if their spouse's professional opportunities are likely to be limited).

We have been unsuccessful, despite good intentions and serious efforts, to increase the number of women on our faculty.”

Views of the Assistant Director Mary E. Clutter

Conference Statement

I am sure that many of you are aware and have heard during this conference that there are many women in the biological sciences. In some institutions, more than 50 percent of undergraduate biology majors are now women! When one thinks about this in the context of the past, even in the context of other disciplines, this is an amazing development. It is even more amazing when one considers that approximately 40 percent of Ph.D.s in the biological sciences are being earned by women! So one might think that there is no real problem with parity, which I understand is a goal discussed at this conference.



Parity, as such, would require equal participation of women in all of NSF's programs. In fact, all of NSF's programs are open to women now. For example, the success rates in the biological sciences for women grant applicants are the same as or better than for male grant applicants. Thus, we might ask, is there, in fact, a real problem for women in the biological sciences? The answer is both no and yes.

The problem is not about numbers of women entering the field. It is about the numbers of women in leadership positions. Despite the increasing numbers of women with appropriate academic and research qualifications, there are too few women in leadership positions. This means that there are too few women sitting at the tables where decisions are being made. To make a difference, women have to be at the table when decisions are being made, when policy is being set. We at NSF have witnessed over and over a strange phenomenon. When more women participate in the review process, more women get grants. This might seem strange to some, but when we regularly see at least 50 percent of proposals as fundable, it surely makes a difference who is sitting at the table and who is directing our programs. Interestingly, our experience is that once women begin to participate, their careers take quantum leaps forward.

Thus, I find it disturbing that we have difficulty in recruiting women for program officer positions and even to sit on review panels. Women will often say no because they have other commitments, they do not think it is a worthwhile use of their time, or their universities do not recognize or reward them for this service. But women must recognize that only if they participate will the system change. Every woman who has ever been a program officer in the biological sciences has advanced in her own career as a direct outcome of her experience in making decisions and developing policy at a national level. Panel service is also a significant step in gaining visibility, gaining experience that will pay off in career development.

Therefore, I extend a personal invitation to women who are interested in working with us to advance science and education in an important and significant way, either as panel members or as program directors, to contact me or anyone in the biological sciences directorate. You will not be sorry.

Finally, I have heard at this conference and at others that the year 2010 is the projected goal for reaching real parity in the sciences. We have made strong progress in the biological sciences, but we are a long way from that 2010 goal. We are even further from the goal of having parity in leadership in the biological sciences throughout our research and education enterprise. Until we have women leaders in significant numbers, the parity goal is unlikely to be reached.

Post-Conference Reflections

The Directorate for Biological Sciences is committed to increasing not only the representation of women but also their status. It is, of course, important for there to be equity in the numbers of women biologists, but it is also important for women to be successful in winning grants and obtaining senior-level positions. There are a number of options for facilitating these necessary changes.

The Directorate for Biological Sciences will perform the following tasks:

- Continue the policy established in 1989 to fund only workshops, conferences, and meetings that include women as speakers.
- Provide training for all program officers to recognize the importance of full participation of all scientists in the scientific enterprise.
- Encourage the advancement of women to senior positions through career advancement awards and visiting professorship for women awards.
- Encourage the advancement of women to tenure-track positions through research planning grants that provide women with the resources to establish independent research programs.
- Provide women with more information on NSF's grant-making process and encourage them to apply not only for NSF grants but also to resubmit if they are turned down. While women may have a higher success rate than men, they submit proportionally fewer proposals and are less likely than men to resubmit proposals.
- Continue to identify women who can fill leadership positions at NSF and serve on review panels, workshops, and advisory committees.
- Urge grantee institutions to promote family-friendly policies by requesting no-cost extension periods on NSF grants to compensate for maternity and family-related leave taken.
- Encourage and recognize mentoring as part of all training programs.

Computer and Information Science and Engineering

Status Report

In contrast to the biological sciences and social and behavioral sciences, women remain underrepresented at all degree levels in the computer sciences, and in recent years, the proportion of degrees awarded to women in this field has dropped. In 1994, women earned about 29 percent of all bachelor's degrees awarded in the computer sciences and 15 percent of doctorates. This is a substantial increase from 1973 when women earned less than 15 percent of computer science degrees at all levels. However, the current proportion represents a decrease from 1986 when women accounted for 36 percent of all bachelor's and 30 percent of master's degrees. The proportion of computer science faculty who are women has also declined in recent years.

figure 3

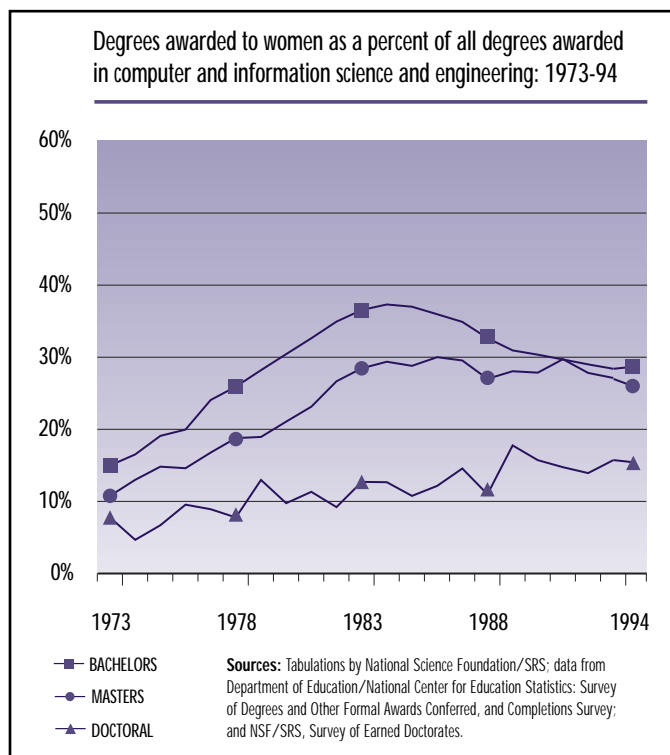
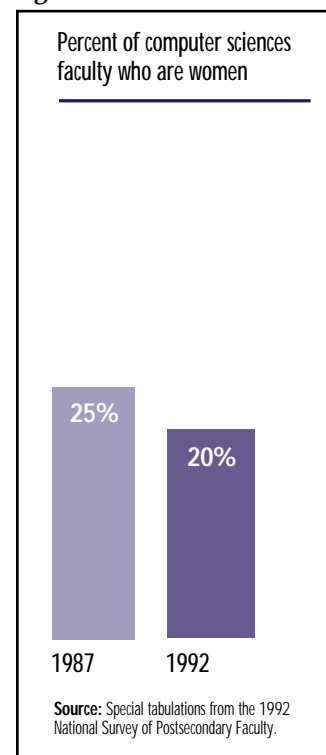


figure 4



Overview

The computer and information science and engineering group focused on past, present, and future challenges. The group emphasized the importance of addressing reasons for and solutions to the decline in the number of women earning bachelor's degrees in computer science.

Galvanizing Support

Because of the decline in the number of undergraduate women studying the computer sciences and the proportion of computer science faculty who are women, solutions must galvanize widespread and coordinated support from the array of organizations, professional societies (such as the Association for Computer Machinery, the Computer Research Association Committee on the Status of Women), and agencies that address computer science. These institutions must work together at the high school and undergraduate levels to attract more women to study in the computer sciences and engineering. As major employers of graduates in computer science, industry leaders could be brought together to form a consortium of corporations to help achieve the goal of equal representation.

Making Connections Through Information Technology

The Internet has vast potential to influence our society, and computer scientists have the capacity to create and use that influence. The Internet and groups such as *Systems* (which is a widely used computer network for women in the computer sciences) are valuable resources for women in the computer sciences. Networks develop a dialogue and raise awareness about the issues and problems of women in computer science. Information on programs that achieve success in encouraging women to enter and remain in the computer sciences could be collected and disseminated via such networks. Support through the Internet could achieve a variety of ends for women from high school through career. Women students could be paired with more senior mentors who would help them to better understand career options and problems for women in computer science fields.

Integrating Cultures

There is currently a mismatch between the cultures of computer science and related disciplines. In computer science and engineering, the majority of professionals are men. In library science (which is increasingly becoming digitized), the majority are women. It is necessary to create better interaction between women and men in computer science, engineering, library science, and related disciplines.

Views from the Participants

“In recent years, there has been a small increase in the number of women Ph.D. recipients in computer science and engineering (CS&E).

Out of 710 women in the [women in computing] database, 235 are Ph.D. students, and 449 already have Ph.Ds.

The fact that more women are going for Ph.Ds is definitely encouraging, since these women are more likely to be in positions to close the gender gap in CS&E by playing leadership roles and by being role models.

A more recent study, however, shows that there is a decrease in the percentages of women who intend to major in CS&E.

In parallel to efforts by NSF and the Computer Research Association (CRA), it is important to have programs directed to students at earlier stages in their education.”

“In my work with high school students, I have seen that there are still serious stereotypes that need to be overcome (e.g., many girls still think that computers are used for number-crunching only).

But I have also seen that it doesn't take very long to change individuals' minds about the field.

What works best is the one-on-one contact between senior and junior computer scientists, especially when both are women.

However, there are still too few senior women in my field to provide this kind of contact to enough younger women without compromising their own careers.”

Grace Hopper Celebration

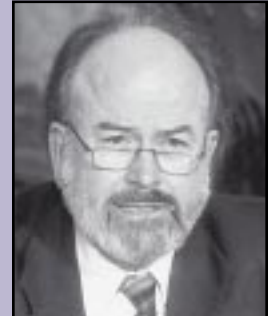
The first *Grace Hopper Celebration of Women in Computing*, held in June 1994, featured speeches about computing by prominent women in industry, academia, and government. The conference focused on technical excellence, collaboration and information exchange, celebrating women's achievements in computing, and the importance of role models, mentors, and professional networking. The 450 participants felt that the conference afforded them an opportunity to make connections with other women in computing fields and to discuss their interests and appreciation for computer science. The second conference will be held in 1997.



Views of Assistant Director Paul Young

Conference Statement

We are particularly concerned with the drop-off of interest in computing and information sciences among women at the undergraduate and K - 12 levels. We are looking for creative ideas for increasing awareness at those levels. Let me mention what we are doing nationally to increase participation of women.



In the late 1980s, Anita Borg, consultant engineer at Digital Equipment Corporation, developed a group of academic and professional women in computer science and engineering called *Systems*. This electronic association has encouraged a particularly active mentor program at several conferences. Computer Research Association has developed an active, on-line database of women speakers and leaders in computer science, useful for academic departments looking for distinguished speakers as well as new faculty members.

At national conferences, the CRA Women's Committee runs career management workshops for women graduate students and faculty each year and provides information on grants, the tenure process, and professional networking. We think this committee is very effective. It also matches female faculty with undergraduate women for summer research work. Because the students are from different institutions than the faculty members, we view this as a model of how information technology is being used and can be used for mentoring undergraduate students across the nation.

In the long run, information technology will transform education. It will have a major impact at the undergraduate level. By transforming education at the undergraduate level, K-12 education will also be positively affected. But beware, there are positive and negative consequences of information technology. On the negative side, this transformation has the potential for depersonalizing communication and human interaction. On the other hand, the positive effects are boundless. Technology has the potential for developing much more personalized, tailored education and can bring people together from all points in the world. The ability to tailor individual experiences can have a beneficial effect for women in computing and will encourage new forms of direct interaction over large geographical distances.

Post-Conference Reflections

For several years, the Directorate for Computer and Information Science and Engineering (CISE) has been concerned about the low representation of women in computer science and computer engineering fields. In 1991, NSF provided support for the Computer Research Association's Committee on the Status of Women in Computer Science and Engineering (CRA-W) with the goal of increasing the number of women participating in fields supported by the Directorate at all levels, as well as providing a forum for addressing problems that fall disproportionately within women's domains. CRA-W provides assistance for travel to meetings and funds for Committee projects such as Career Management Workshops, Distributed Mentor Project, Expanding the Pipeline, and development and maintenance of a database of women in CISE.

The Distributed Mentor Project matches female undergraduates with female professors on summer research projects, thus providing role models for successful research and academic careers. To prepare for graduate school, a *Graduate Information Booklet*, available on the World Wide Web, has been developed describing advantages of pursuing an advanced degree in computer science or computer engineering. Also, a *Careers Booklet* containing biographies of successful women who have chosen interesting and rewarding computer-related careers has been produced to motivate young women at the undergraduate and high school levels to consider a career in computer science. Women professionals distribute the booklet in high schools, give talks, and provide advice and mentoring. CRA-W is also involved in recognizing talent at the undergraduate and faculty levels by presenting awards at various conferences. A CRA-W newsletter column titled, Expanding the Pipeline, addresses problems that women in computing face such as the two-body problem (where only one of two spouses receives tenure, usually the male), high drop-out rates, leave policies, etc.

Few conferences come close to the *Grace Hopper Celebration of Women in Computing* in providing avenues for professional networking and mentoring. The first of these conferences was held in June 1994 and featured technical presentations by prominent women in computing fields. During the EHR-sponsored *Women & Science* conference, plans for the follow-up *Grace Hopper* conference were solidified. The next one will be held in 1997. Another CRA-W project, *Systems Academia*, modeled after the *Systems Network*, serves as an electronic forum to provide an additional venue for mentoring women and graduate students in the field.

Anita Borg's dream, to have equal numbers of women and men in computer and information science and engineering by the year 2010, a project entitled, *50-50 by 2010*, constitutes a significant challenge. The 1995 *Women & Science* conference generated a lively discussion of the project and many useful ideas that can help make Anita's dream a reality.

Engineering

Status Report

Although they have made tremendous progress, women remain more underrepresented in engineering than in any other field. In 1973, women accounted for between 1 and 2 percent of all higher education degrees awarded in engineering. By 1994, the proportion of degrees awarded to women had grown to 17 percent at the bachelor's level, 15 percent at the master's level, and 11 percent at the doctoral level. However, many of these gains were in place by the mid-1980s. Since then, progress has slowed. Within subfields of

figure 5

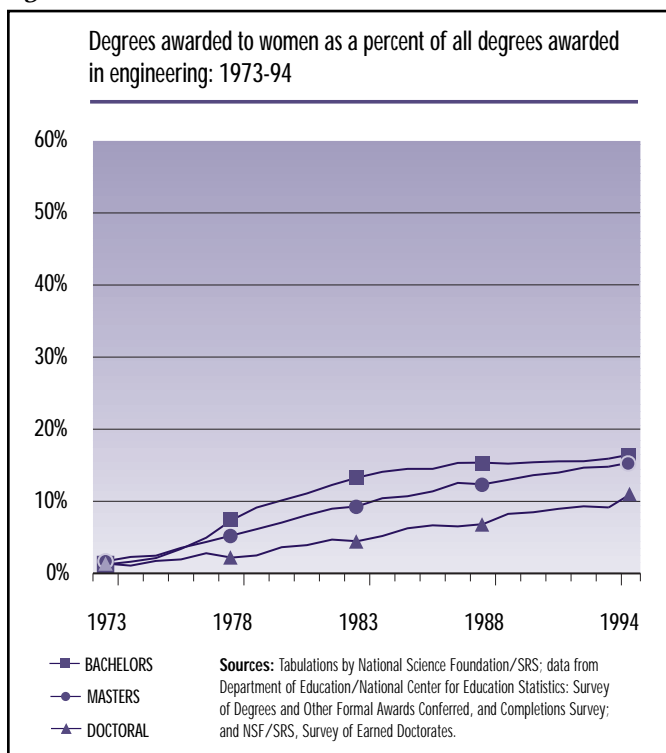


figure 6



Views from the Participants

“During the last 5 years, the College of Engineering at my university has greatly benefited from its participation in NSF’s Engineering Education Coalitions program.

Our coalition has had a significant effect on the transformation of the lower division curriculum.

Our approach has appealed to a diverse set of learning styles rather than only to those students whose learning styles match those encountered in the traditional classroom.

This type of long-term commitment from NSF has been highly successful.

Continuing this approach to the development of the undergraduate curriculum in a broad manner will make engineering a more attractive career choice for a diverse group of students.”

engineering, women are best represented in chemical and industrial engineering where close to a one-third of the bachelor’s degrees are awarded to women. They remain least well represented in electrical and aeronautical engineering, where they account for 11 to 12 percent of bachelor’s degrees.

The proportion of engineering faculty who are women remains alarmingly low, although there has been some progress. However, just 19 percent of women faculty in engineering were full professors in 1992 compared with 33 percent of men. In nonacademic positions, women accounted for 9 percent of engineers in 1990 compared with just 4 percent a decade earlier.

Overview

The engineering group focused on the extreme underrepresentation—at all levels of education and career—of women in engineering and on the changing societal demands on engineering and engineers. Perhaps now more than ever the international competitiveness of the United States requires a well-educated and diverse engineering workforce. At the same time, the definition of well-educated is changing and will continue to change. Telecommunications, biotechnology, and other fields require engineers with diverse perspectives, interdisciplinary talents, and greater communications skills. At the same time, the labor market for engineers has been challenged as a result of the downsizing of the federal budget for defense and space exploration. Women need to view these challenges as opportunities and capitalize on them as such.

Change the Perceptions

Societal images of engineers and engineering are hampering efforts to attract women to the profession. Women (and all) engineers need to address the public about who engineers are and what they do. Images that are damaging to women’s progress in engineering must be counteracted with positive images and role models. Perceptions of the capability of women held by those in the profession of engineering must also change. Women must make clear that intended and unintended acts that result in their exclusion will not be tolerated.

Monitoring Progress

Because women are woefully underrepresented in engineering at all levels, benchmarks need to be developed so that the progress of women can be monitored and evaluated over time. Best practices need to be identified and duplicated in all areas of education and career—from kindergarten to postdoctoral levels, industry, and academia.

Nurturing and Networking

To promote the progress of women within engineering, opportunities for nurturing and mentoring must be made available so that more experienced women can pass on what they have learned to students and young professionals. Women engineers need to reach out to young girls through schools and community organizations such as the Girl Scouts and other groups. A network of women engineers at all ranks of industry and academia would complement these efforts.



Views from the Participants

“As an engineer and researcher, my experience of the climate in engineering is that it is very uncomfortable for women.

The problems are due to many cultural behaviors that could change if the men in power chose to recognize those behaviors and change them.

Because the men in power have no motivation to give up some of their power, the problems remain.

Voluntary desire to be politically correct is not going to become a pervasive part of the white male structure in engineering.

With our government in fiscal crisis, it is imperative that efforts by NSF be directed to programs that will force those in power to replace the system with one that works for everyone.

I am calling for programs that require lasting paradigm shifts among university administrators and educators.”

Views of Assistant Director Joseph Bordogna

Conference Statement

We in the Engineering Directorate are embracing a strategy that will enable women to succeed. We have an early career development program (called CAREER) that is intended to integrate research and education as a strategy over time. CAREER is an excellent venue to make good use of that special talent.



We have the GOALI Program (Grant Opportunities for Academic Liaison with Industry). GOALI gives professors and students the chance to spend extended periods of time in industry collaborating on research projects of mutual interest. It also has a component that enables engineers from industry to serve for extended periods in academic research labs, in classrooms, and even on curriculum committees. This gives women the opportunity to influence both cultures and expand their own horizons.

I think we should embrace women enablement tactics within the true meaning of affirmative action. One-half of the advisory committees should be women. Women should be on all the panels. Action groups at NSF should include women. We have an engineering education coalitions program, and it's funded very handsomely from NSF to change all engineering schools' undergraduate programs. Women are taking leadership here because the coalitions program requires research-education integration. We should fast track women graduate students into the professoriate. If there are more women there, we solve a lot of the problems of academe.

Finally, none of this happens without leadership, and we should be pushed to make sure we lead well.

Post-Conference Reflections

Today's engineering students will spend most of their careers in the twenty-first century coping with challenges and opportunities vastly different from those experienced by engineers of the last one-half century. The intellectual skills of tomorrow's engineers will extend well beyond the traditional science-focused preparation that has characterized engineering education since World War II. Underlying this trend is a number of factors, including global commercial competition as a major driver for industrial organization and engineering employment; opportunities offered by intelligent technology to be more creative and work smarter; an expanding social infrastructure that demands a talent for complexity; an eclectic, constantly-changing work environment calling for astute interpersonal skills; and massively integrated populations placing environment, health, and safety at the front end of design.

The Engineering Directorate is crafting its education and research programs and its internal management strategy to enable the nation's engineers to take advantage of these opportunities and contribute fully to society's cultural progress and quality of life. Toward this end, the Directorate is emphasizing the broad concept of acting affirmatively in all interactions with its constituencies. For example, program officers' success in achieving diversity in all aspects of their professional duties is explicitly noticed and rewarded. All professional staff appointments are made through the Directorate's Personnel Search Committee, which seeks out excellent women candidates for every position. As a result, the number of women program officers in engineering has increased dramatically over the past several years. The Directorate's external advisory committee is composed of approximately equal numbers of men and women, all with stature in the engineering community.

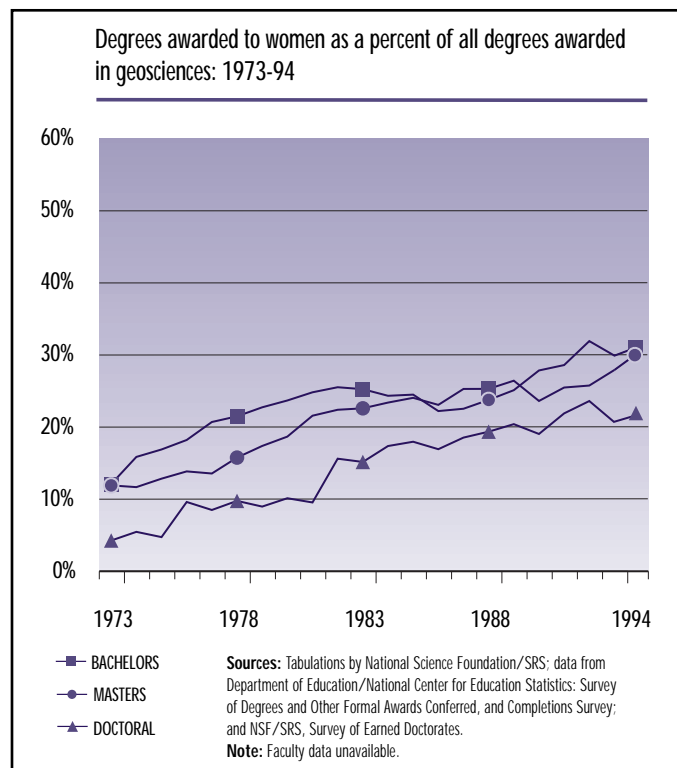
NSF's high profile in the academic community brings with it the responsibility to lead by working continuously, sensitively, and comprehensively to increase the diversity of the pool of proposers, reviewers, and candidates for NSF staff positions. The heads of the various divisions in the Engineering Directorate are expected to be proactive in addressing this issue when they travel to conferences and universities, especially in talks they present on NSF programs and priorities.

Geosciences and Polar Programs

Status Report

In 1994, women in the geosciences (earth, atmospheric, and oceanographic sciences) accounted for 31 percent of bachelor's degrees awarded, 30 percent of master's and 22 percent of doctorates. This compares favorably with the situation in 1973, when women earned 12 percent of bachelor's and master's degrees awarded and just 4 percent of doctorates. Within the subfields of the geosciences, there is considerable variation in terms of the participation of women. Women remain least well represented in the atmospheric sciences where they earned just 19 percent of bachelor's degrees and most well represented in earth science where they earned 33 percent of bachelor's degrees in 1994.

figure 7



Overview

The geosciences group discussed methods to attract and retain girls and women at the elementary, secondary, and undergraduate levels; those at the graduate and postdoctoral education levels; and those who have entered geoscience careers. The participants felt that much progress has been made by women in the geosciences over the last several decades, however, barriers still exist to the entry and retention of women. It was noted that improving the climate for women will require collaborative efforts among individuals, professional societies, academic institutions, industry, and state and federal governments.

Benchmarking

To monitor the progress of women, the availability and accuracy of relevant data in the geosciences disciplines needs to be ensured.

Education, Curriculum, and Teacher Development

Studies indicate that women show more interest in problems set in a real-world context and approach problems in a holistic manner. By integrating geosciences education with instruction in other sciences (as recommended by the *National Science Education Standards*), rather than teaching each subject separately, girls and women may find the sciences more appealing. Instruction in the geosciences should also make use of more hands-on, cooperative projects (methods believed to be more relevant to female learners than the more traditional competitive approaches). In addition, the community should recognize that increasing the participation of a more diverse population requires that schools and colleges make use of curricula that are more gender-neutral, much of which is already available but not widely disseminated. Teachers (particularly at the elementary level) should receive better training to teach subjects in the geosciences in a manner that incorporates these ideas.

Integration of Research and Education

Bridging the gap between research and education is important at all levels. Methods that could be promoted to encourage collaboration between science educators at the K-12 level and scientists at colleges, universities, and in industry include electronic bridges, industry mentorships for teachers, and summer internships. At colleges and

Views from the Participants

“A clear and dramatic increase has occurred over the past decade in the number of professional women in the field of oceanography/marine sciences.

A combination of the awareness of the problem on the part of institutions, equal employment opportunity and other programs, and the increasing acceptance by male oceanographers have played a role in this.

I have noticed a bias toward women candidates in our recent recruiting because they are often overachievers and very competitive.

On the other hand, their proportion in the labor pool remains low.”

Views from the Participants

“A growing trend, at least in academic geoscience departments, is toward flexible hiring arrangements for women to enable them to have both a career and a family.

The situation I am most familiar with is the split, or shared, position.

A husband and wife team share one salaried position between them in addition to household/child rearing duties.

There is no inherent reason why this arrangement should only be available to married couples.

The arrangement may become more inclusive over time.”

universities, the reward system should be redesigned to encourage faculty to engage in education and K-12 curriculum development as well as research. Opportunities should be provided for women to be involved in research as early as possible in their academic careers.

Networking, Mentoring, and Capacity Building

Women in the geosciences suffer from a lack of visibility. A number of mechanisms can counter this by providing for increased interaction among students and faculty across institutions. These include the expansion of NSF’s visiting professorships for women; the provision of travel grants for students to attend professional meetings; the development and dissemination of speakers’ lists; and the establishment of summer institutes for women that focus on skills, leadership, career planning, and mentoring. Mentoring programs, which provide women students with longer-term, one-on-one contact with role models, should be strongly supported.

Career Advancement

At a time when funds for science are shrinking and the number of women entering science professions is increasing, it is particularly important to ensure that women are not squeezed out. Although their numbers in the field have increased, women in the geosciences are seldom found in the senior ranks. Institutions need to promote more favorable climates for women to succeed. For instance, the promotion/advancement reward structure must be revised to assign value to education, service, and outreach activities (areas that are equally important to the scientific enterprise and in which women often excel) relative to research. Women also face the issue of balancing family life with education-to-workplace transitions; these two issues are inextricably intertwined in women’s lives and affect their retention in the field. Policies and programs should be implemented that would allow for greater career flexibility. For example, the problem of reentry after parental leave needs to be addressed so it does not become an irreversible setback in a woman’s career progress. In addition, more information about career ladders and career alternatives to academe needs to be made available.

Views of Assistant Director Robert Corell

Conference Statement

I see this as a unique conference, a starting point, a nest within which new strategies and approaches can be developed, nurtured, and ultimately implemented. We in the geosciences care about this, and we've made some progress. We've put a great deal of effort into this issue over the past decade or more and developed partnerships to implement new programs and activities that we hope will make a difference. But we have a long way to go.



Our fields are fields that historically have not attracted women in the ranks of scholarship as well as industry. However, over the past 25 years, baccalaureate degrees have gone up by a factor of 3, master's degrees have gone up by a factor of 4, Ph.Ds have gone up by a factor of 7. So, while the overall proportions are in the 25 to 30 percent range for these various degrees, that's a dramatic change from single-digit participation in the 1960s and 1970s. It is my pleasure to be here with you today to hear your questions and seek a mutual understanding about how we take the next steps.

Post-Conference Reflections

Attending the *Women & Science* conference was a powerful experience. I was struck by the enthusiasm with which the conference was received. It offered a valuable opportunity to recognize and celebrate the tremendous achievements made by women in all areas of science, as well as an opportunity to identify the challenges that remain.

There is considerable reason to celebrate the successes women have made in the geosciences. Only a few decades ago women were not permitted to participate in most research cruises, were discouraged from participating in fieldwork and, until 1969, U.S. women scientists were not allowed to conduct research in Antarctica. These barriers have since been eliminated. Statistics presented at the conference demonstrated that the numbers of women receiving undergraduate and graduate degrees in the geosciences has dramatically increased over the last several decades. Within the Geosciences Directorate, the women's success rate (the number of awards divided by the number of proposals submitted) for peer-reviewed proposals has equaled or exceeded that of their male counterparts for the last several years.

I am committed to seeing that this trend continues. The Directorate participates in a range of activities, working with other government agencies as well as professional societies, designed to enhance diversity. We are continuing to work to integrate human resources development in our ongoing programs. In addition, the Directorate has made a concerted effort to ensure that there is broad

representation of all groups on our scientific and professional staffs; in our advisory panels and committees; in our pool of reviewers; in our K-12 outreach programs; and in our undergraduate, graduate, and postdoctoral research programs. Our efforts are reviewed on a biennial basis by a committee of representatives of the scientific community that we serve.

Much work remains to be done if we are to achieve parity in the geosciences. While the barriers that exist today may not be as egregious as the ones of decades ago, their results are equally detrimental if they inhibit the participation of women. However, it was clear, both from the poster and breakout sessions, that many exciting programs have been undertaken by the scientific community to address this issue. During the geosciences session at the conference, some excellent strategies, many of which resurfaced in other sessions, were identified for enhancing the participation of women.

We must capitalize on the momentum that this conference has generated. I have requested that a team of program officers, representative of our respective divisions, work with the senior management of the Directorate to carefully review the recommendations made at the *Women & Science* conference. This process is underway and will ultimately result in a strategic plan for the Directorate.

The success of any strategy will require the full participation of the scientific community, including government agencies, academic institutions, industry and individuals. During this period of flat or potentially declining research budgets, we must increase our vigilance to see that the number and prominence of women in our discipline continues to increase — not simply because it's the right thing to do, but because enhancing diversity will improve our science.

Mathematical and Physical Sciences

Status Report

Women in the mathematical and physical sciences (MPS) report substantial progress in the past 21 years. Women earned 40 percent of the bachelor's degrees awarded in 1994 in MPS, 34 percent of the master's, and 21 percent of doctorates. In 1973, women earned 30 percent of bachelor's, 22 percent of master's, and 8 percent of doctorates. Within the disciplinary fields of MPS, women were best represented in the mathematical sciences, where nearly one-half (46 percent) of bachelor's degrees were earned by women in 1994.

figure 8

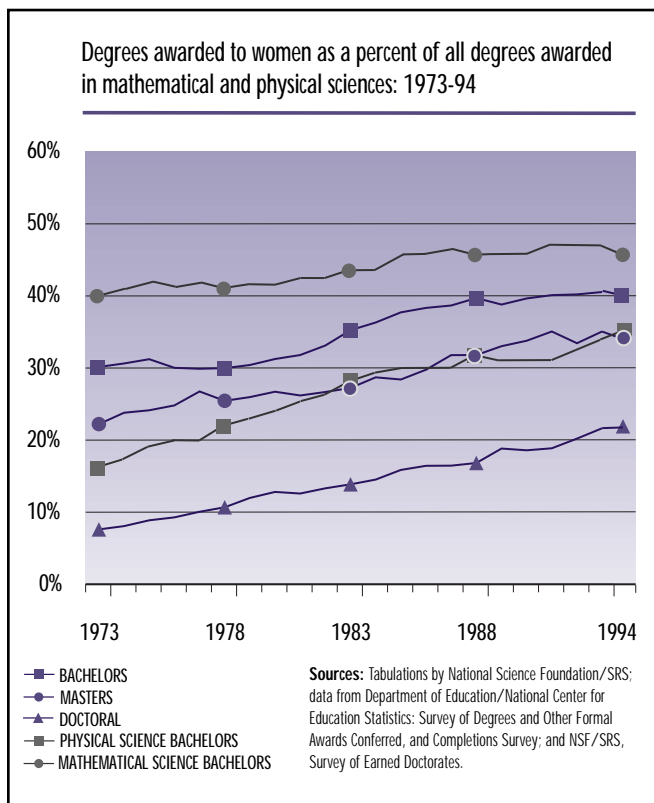
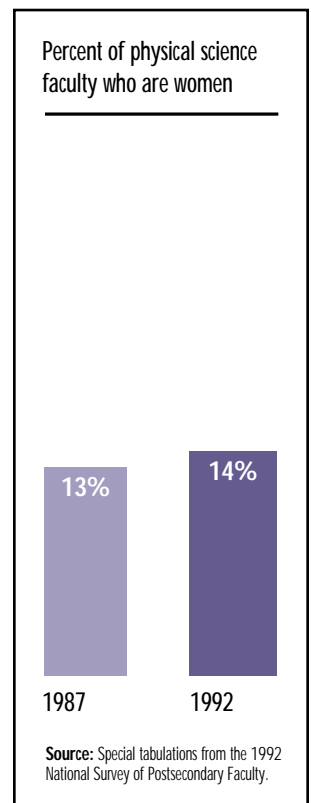


figure 9



figure 10



Views from the Participants

“Creating interest among women in the physical sciences is crucial to increasing the number of women educated in the area.

This interest is best created at an early age through successful encounters and hands-on experience with the materials.

The perception that physical sciences are “too hard for a girl” can only be overcome when girls believe they can do the work.”

“The single most important trend that creates, improves, and supports opportunities for women in the physical sciences is the presence of other successful women in the field.

Increasing the number of women in science decreases the solitude of the struggle.

Most importantly, the infrastructure necessary to support women in science will not be built without a representative number of women in the field.”

“A significant trend that is reshaping the status of opportunities for women in mathematics—both in mathematics education and in careers that rely heavily on mathematics—is the increased awareness that women possess the analytical thinking skills to do mathematics and that women can excel in mathematics-related careers.”

They were most underrepresented in physics, where just 18 percent of bachelor’s degrees awarded went to women.

However, at the faculty level women can report virtually no progress in MPS in recent years. Moreover, comparatively few women (6 percent) in mathematics were full professors in 1992 compared with men (28 percent).

Overview

The mathematical and physical sciences (MPS) group discussed issues within the whole of the MPS fields as well as in specific fields such as astronomy, chemistry, mathematics, materials science, and physics. Much of the discussion focused on changing the culture within the education and research institutions and renewing attention to increasing the participation of women at all levels and within all fields of MPS.

Nurturing

Women in MPS need mentoring experiences and role models. Although important at all levels of education and career, this is especially important for students and young professionals, particularly in fields of MPS where women are most underrepresented (e.g., physics). Nurturing could take a variety of forms such as support for young women students to working with faculty on real world research projects, quality academic and career advisement, and financial support.

Networking

Opportunities must be made for increased networking among women across disciplines, geographic distances, institutions, and levels of the education system. Connections between women’s studies and science and women scientists could be very beneficial. Young women need to be informed of the importance of mentoring in building and sustaining careers in MPS. Additional support could also be made available for a small cadre of women to serve as role models by bringing their messages, advice, and stories to women on a national scale.

Transform the System

Many of the problems of women in MPS are endemic to the culture of the education and research system itself. Therefore, attention should be paid to the system as a whole rather than to isolated parts. Institutions should be held accountable for the success of women and other underrepresented groups as students and career professionals. Support for women throughout the entire system would enable women to make successful transitions from high school to college to career. Family-friendly policies would enable women to concentrate on their professional endeavors while knowing that their familial obligations will be more easily met. Service and teaching activities must be better rewarded by institutions of higher education.

Value Contributions of Education Institutions

Elementary and secondary schools, 2-year colleges, and 4-year colleges all provide the foundation for women and girls to achieve excellence as MPS professionals. The importance of this must be recognized at all levels. Colleges, universities, and industry should play a more active, collaborative role in improving K-16 education and scientific literacy in MPS fields.



Views of Assistant Director William Harris

Conference Statement

In competing for grants in MPS, women principal investigators do, by and large, better than men. The success rate is approximately 38 percent. Women have been very successful in the CAREER program for young faculty members, earning 28 percent of the awards.

We have changed, rather significantly, the participation of women in the program officer's corps in MPS over the last few years; it has more than doubled. Women now represent almost 25 percent of the MPS program officer's corps. Their presence changes the way the Directorate does business. MPS intends to continue to emphasize the participation of women.



Post-Conference Reflections

Women should be involved in every aspect of professional scientific life. On a practical basis, MPS can help to influence change at universities and other institutions in a variety of ways through proposal submission policies, procedures, and related activities.

Recently MPS revised its staff memorandum, Policies to Promote the Full Participation of Women, Minorities, and Disabled Persons in Science, to more clearly define responsibilities of senior managers and program staff. An annual report from each MPS division summarizing its activities in each of several important areas is required. These areas include staffing and staff orientation, inclusion of underrepresented minorities and women on review committees and their use as ad hoc reviewers, encouragement of and help with proposals through information dissemination with respect to programs and proposal preparation, site visits, and technical assistance. Program officers are expected to ensure that funded conference proposals provide appropriately for participation by women and for child care.

Supplements for projects that extend integrated research and education goals are now part of the CAREER program and suggest a possible mode of support for encouraging research-based education projects. Also, supplements for personal computers or equipment that allow expectant or new mothers to continue their research at home could be considered.

NSF could support grant writing workshops to focus attention on advising women on successful proposal preparation. Funding rates, averaged over the period from FY92 through FY95, have been at least as good for women as for men. However, the number of proposals from women remain small, reflecting in part the dominance of males in the universities submitting proposals. Fortunately, opportunities for women will increase, assuming no dramatic downsizing in faculty numbers, in the next few years since the average age of faculty in some disciplines is in the 50s.

Social and Behavioral Sciences

Status Report

Women are not underrepresented in the social and behavioral sciences as a whole. Women earned more than one-half of bachelor's degrees (58 percent) and master's degrees (56 percent) that were awarded in 1994 and nearly one-half (49 percent) of doctorates. This was not the case in 1973 when

figure 11

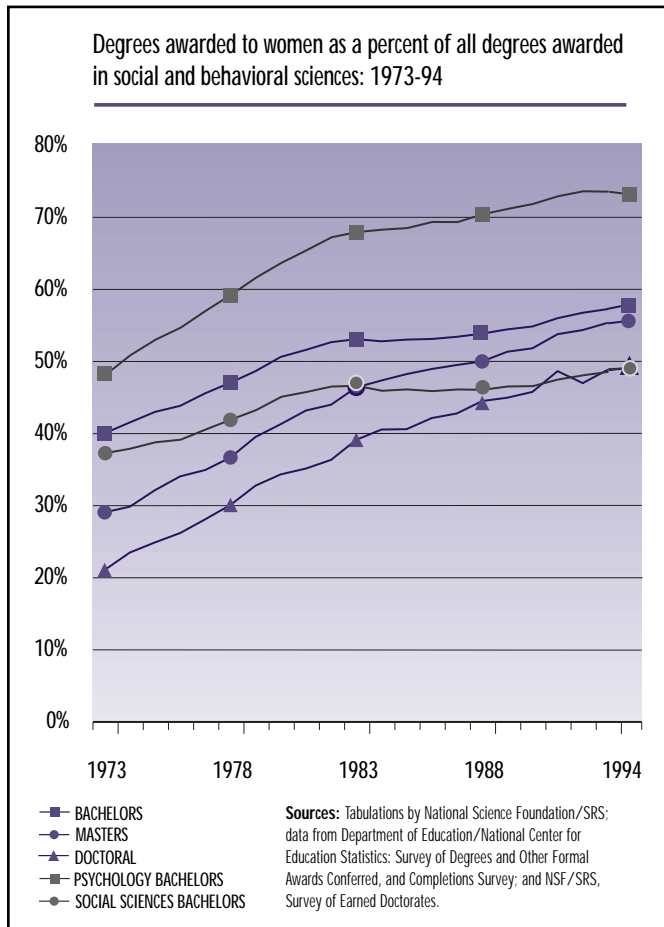


figure 12

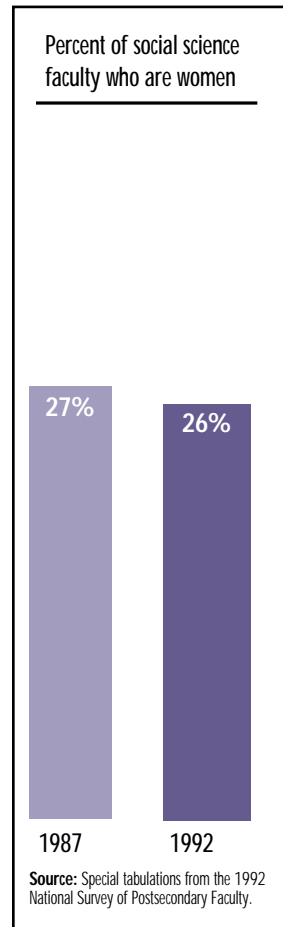
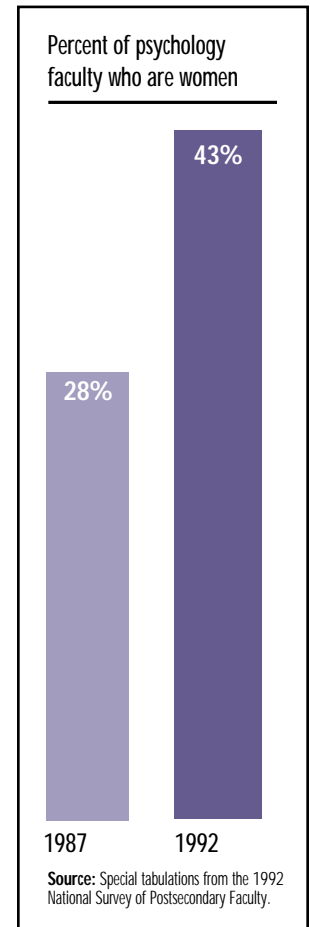


figure 13



women earned 40 percent of bachelor's, 29 percent of master's, and 21 percent of doctoral degrees. Within the social and behavioral sciences, however, women are still underrepresented in economics, where they earn just 29 percent of bachelor's degrees and political science where they earned 45 percent of bachelor's degrees.

At faculty levels, women are most well represented in psychology. Indeed, women have made tremendous progress in psychology from 1987 to 1992. However, in the social sciences, no progress has been made recently.

Overview

The representation of women has increased dramatically in the social and behavioral sciences as a whole in the last 21 years. As a result, the social and behavioral sciences group chose to focus on problems that are associated with the high rates of female participation—such as gaining tenure and promotion and the “feminization” of the field. However, not all subfields in the social and behavioral sciences are without problems of underrepresentation. In economics and political science, women continue to be underrepresented, receiving less than one-third of the doctorates in these fields.



Feminization

Psychology, anthropology, and sociology have become “feminized” because of a simultaneous drop in the number of men entering the field and an increase in the number of women. Men became less interested in these fields because of low salaries relative to other fields. The influx of women, because women’s work tends to be devalued, contributed to the declining status of these fields and was reinforced by low salaries and the drop in the number of men. Although women’s earnings are approaching those of men, women are less willing to fight for higher salaries. Men are now choosing sociology in larger numbers; however, there are no indications why they are returning to the field or what effect this will have on the status of women.

Promotion and Advancement

Women often lack opportunities for promotion and advancement within the social sciences. In some fields, such as psychology, women are well represented in the lower ranks; in other fields, such as economics, geography, and political science, women remain underrepresented at all levels. Because there are few women faculty role models, there are greater time demands on women faculty as mentors for female students. Women of color continue to face even greater challenges. The changing academic market with fewer tenure-track positions and more temporary assignments exacerbates the problems faced by women.

Disproportionately, women serve as part-time and temporary faculty and are often found in 2- and 4-year schools rather than research institutions. Women need to aggressively promote their professional activities as well as apply more frequently for research grants, mentor junior staff and students, and enlist the support of their male colleagues. NSF needs to encourage women to apply for grants, thereby increasing their visibility and productivity and facilitating their movement into senior positions.

Views from the Participants

“The single most dramatic trend in academic sociology since the 1970s has been the feminization of the discipline’s recruitment pool.

Contrary to conventional wisdom that feminization leads to occupational decline, data strongly suggest that as the field declined in prestige and earnings, men moved to other training programs.

This opened up additional graduate slots for women, who were themselves newly interested in the field.

Signs of renewal have once again surfaced.

Median annual salaries of sociologists are once again on the increase, and women sociologists have narrowed the gender gap in earnings.”

Views from the Participants

“Although women and men are earning an equal number of sociology doctoral degrees — as measured in a variety of ways — women are not achieving parity in the discipline.

Women earn significantly lower salaries than men.

Women reported fewer experiences serving as peer reviewers, making public appearances as experts, working as primary researchers, or publishing in academic journals.”

The CURIES Conference: Gender, Research, Practice, and Policy

The Cross University Research in Engineering and Science (CURIES) group on women and gender in science, engineering, and mathematics sponsored a conference in May 1994 to assess current knowledge and set an agenda for future research, practice, and policy. The goal of this agenda was to ensure equitable opportunities for women in scientific and technical fields. The key recommendations included:

- Focus on institutional change to achieve gender equity in science, mathematics, and engineering;
- Move from an emphasis on research to a focus on action and accountability;
- Reframe problems and solutions to recognize the issue of diversity of people in science, mathematics, and engineering;
- Revise our view of the standard linear pipeline of science and engineering education and allow numerous possible entry points; and
- Give top priority to sustainable improvements that become integral to institutional operations. This is especially important given the limited resources of time, energy, and funding available.

Source: The Equity Agenda: Women in Science, Mathematics and Engineering. Copies of this report can be ordered from: The Center for the Education of Women, University of Michigan, 330 E. Liberty St., Ann Arbor, MI 48104-2289. E-mail request to mtrumble@umich.edu.

Views of Assistant Director Cora Marrett

Conference Statement

There are three reasons why all scientists and engineers should be interested in the status of women in the social, behavioral, and economic sciences. The first is that many of the issues call for greater knowledge about programs and their effects, family influences, and social processes that social and behavioral scientists study. The second reason is that many of the concerns of women in science and engineering span disciplines. Third, there are higher rates of participation for women in at least some of the social and behavioral sciences compared to the other sciences.



Let me note at the outset that the participation rate for women varies across the social and behavioral sciences. Perhaps something can be learned from the variety of experiences across disciplines.

On the disturbing side, some of the fields that are experiencing increasing numbers of women have not seen a similar increase in the rates of participation in influential positions. Efforts to change numbers must be accompanied by efforts to improve retention, promotion, and advancement.

The other disturbing sign is the “feminization” of those fields in which the numbers of women have been growing. There is a long-term tendency for areas dominated by women to suffer lower compensation and prestige. No necessary connection exists, but clearly that is an issue that we all must be concerned about.

The Directorate for Social, Behavioral, and Economic Sciences is responsible for collecting data on the status of women, minorities, and persons with disabilities. We produce a report of which we are very proud: The Foundation’s biennial report to Congress, *Women, Minorities, and Persons with Disabilities in Science and Engineering*. We also fund research, especially on the status of women in the social and behavioral sciences, and hold conferences and activities, especially on the subject of women in economics. We provide support wherever we can in connection with our colleagues across the rest of the Foundation.

Post-Conference Reflections

The Directorate for Social, Behavioral, and Economic Sciences (SBE) is continuing its efforts to enhance the status of women in the social, behavioral, and economic sciences by supporting research by and on women in the sciences,

collecting data on the participation of women in the sciences, and promoting programs for women. Consider the following tasks:

- The Social, Behavioral and Economic Research Division (SBER) developed three new initiatives that are of particular interest to women: the Human Capital Initiative, which is a program of research aimed at improving the human resources of America's citizens; the National Consortium for Research on Violence; and the Learning and Intelligent Systems Initiative. These activities will support women's research in many areas of science and engineering.
- SBE funds research on the status of women in the social and behavioral sciences. At the *Women & Science* conference, Shulamit Kahn presented an overview of research on the participation of women in economics. Her presentation, based on research supported largely by NSF, subsequently appeared as an article in the prestigious *Journal of Economic Perspectives*. In addition, three new proposals for research on careers of women were funded this year.
- As a result of the Conference, the American Economic Association's Committee on the Status of Women in the Economics Profession submitted a proposal to the Economics Program for a workshop that will create ongoing mentoring relationships between successful senior women economists and promising junior women economists.
- NSF is expanding the Alliances for Minority Participation (AMP) program to the social and behavioral sciences. The AMP program is a national effort to increase the number of minority students (men and women) receiving baccalaureate degrees in science and the number going on to graduate study.
- SBER is funding a national conference titled *The Role of Social and Behavioral Science Careers in the 21st Century* that should be of broad interest to women thinking of science as a career.
- SBE continues to collect and disseminate data on the status of women. Our new report, *Women, Minorities, and Persons with Disabilities in Science and Engineering: 1996*, was recently published, and new data from our education and personnel surveys will be released this fall. We are also actively pursuing means for broader dissemination of our data — all of our statistical reports as well as an interactive data analysis system are now on the World Wide Web.
- Finally, considerable efforts have been made to ensure that the composition of the staff, advisory committees, workshops and conferences, and committees of visitors reflects the gender and racial diversity of the social and behavioral sciences.

Views of Assistant Director Luther S. Williams

Conference Statement

In our strategic plan, NSF in a Changing World, one of three goals is the provision for excellent science, mathematics, engineering, and technology education for all students at all educational levels. What I would like to do is to take a few minutes to point out some issues and opportunities offered by the Directorate for Education and Human Resources.



First, there is the quality advice that we garner from the broad community. We need individuals with a wide range of views and backgrounds to participate as members of a national advisory committee to guide the Directorate's planning.

Second, there is the diversity issue not only at the program officer level but also in leadership roles throughout the various programs of the Directorate. We need program officers and division directors who shape programs and define their components.

Third, there is the issue of balancing priorities. We must effectively ensure substantial participation of women in our mainstream programs in addition to offering targeted, highly specific programs designed to achieve highly specific goals in a finite time period.

Along with these issues, we must make sure that the broad diversity of the scientific and technical enterprise is represented at all levels of education and career. This involves monitoring who receives NSF awards, who assumes leadership roles, and who directs the broad educational agenda independent of its level, whether it is K to 12, undergraduate, graduate, and obviously, science and engineering professionals.

Post-Conference Reflections

The *Women & Science* conference was a milestone in NSF's history of furthering research and education in science and engineering. The conference was the first of its kind where women from all areas of science and education came together to formulate an agenda for the future. It was also the first conference that actively incorporated the views and ideas of all parts of the National Science Foundation in the planning stage. In my view, the conference provided an important platform for us to reexamine our programs and policies in order to ensure we can meet the challenges posed in the future.

I would like to tell you a little about what the Directorate for Education and Human Resources is doing to promote diversity in science and engineering particularly as it affects women.

- We continue to fund research on issues pertaining to women and girls in science, mathematics, engineering, and technology at all levels of education and career. This research serves as an input into our program planning and as a foundation for innovation in instruction and learning in the educational and scientific communities.
- We support a program for women and girls that is intended to increase the number of women who are full participants in the mainstream of education and research in science and engineering. This program includes some emphasis on women's careers, but more importantly, targets the K-graduate school levels in order to encourage interest in the sciences while removing barriers to participation.
- We view all of our programs as vehicles to address our goals of equity and diversity and all our funded projects are required to do their share in meeting these goals. For example, our instructional materials development program and our informal science education program require that science and mathematics content be free from stereotypes, be presented in gender fair and equitable ways, and encourage the participation of young women and members of other underrepresented groups. Similarly, all of our systemic initiative projects are required to promote the full involvement of all students regardless of race, ethnicity, sex, or disability status.
- Most importantly, the *Women & Science* conference inspired us to reexamine our visiting professorships and faculty awards programs for women. We are currently assessing a number of possibilities to strengthen these activities. No matter what form they may finally take, I am convinced that, through these efforts, NSF will play a national role in the furthering of women's careers in the sciences and engineering.

Finally, I wish to point out that all of our programs undergo a rigorous process of evaluation and all projects are expected to evaluate their outcomes and disseminate the best of their results and findings. Only through this systematic examination can we hope to learn what works and how we can best share this with the community.

Research-Education Infrastructure

Overview

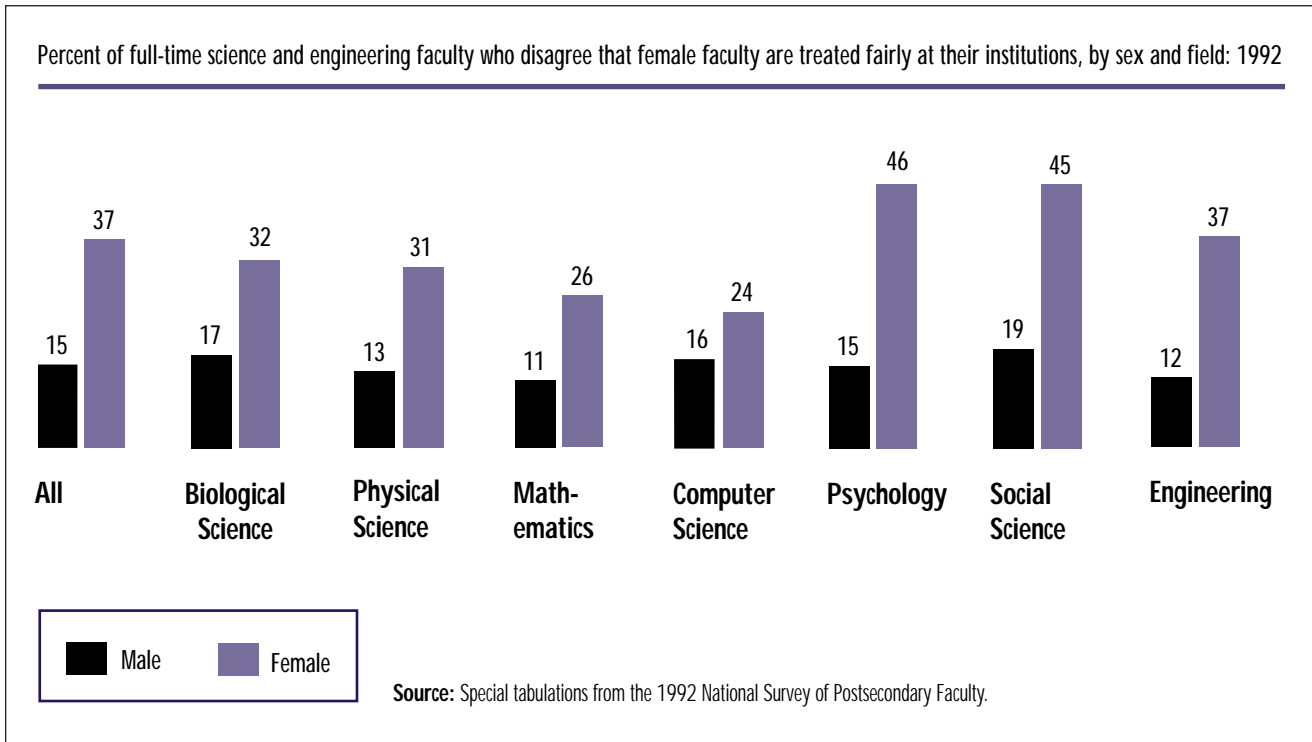
The research-education infrastructure group examined the climate for women in the sciences from the elementary and secondary level, to higher education and the workplace. Its goal was to determine factors in education and workplace environments that affect women's participation in the sciences and engineering.

Challenges

The research-education environment is often a chilly one for women students and scientists. While blatant forms of sexism are now uncommon, more subtle forms remain, such as not being invited to meetings or not being treated in a collegial fashion. The results of a 1992 survey demonstrate that men and women faculty have differing perceptions about the extent to which women are treated fairly at their institutions. Although most faculty of both sexes felt that women were treated fairly, 37 percent of women, full-time faculty in science and engineering disagreed, while just 15 percent of men disagreed (*see figure 14*).

Funding is shrinking just as women are entering scientific fields in larger numbers. Nineteen percent of all women faculty surveyed in 1992 were recent hires (hired between 1989 and 1992) compared with 10 percent of men. As universities restructure and downsize, vacant faculty positions are being replaced with nontenure-track instructor positions that pay less and come with little or no job security and benefits. Disproportionately, women fill these positions or serve as part-time and temporary faculty. Almost one-half (48 percent) of all recently hired women were hired in part-time positions compared with 35 percent of men. Nearly two-thirds of these women took these part-time jobs because no full-time positions were available.

figure 14

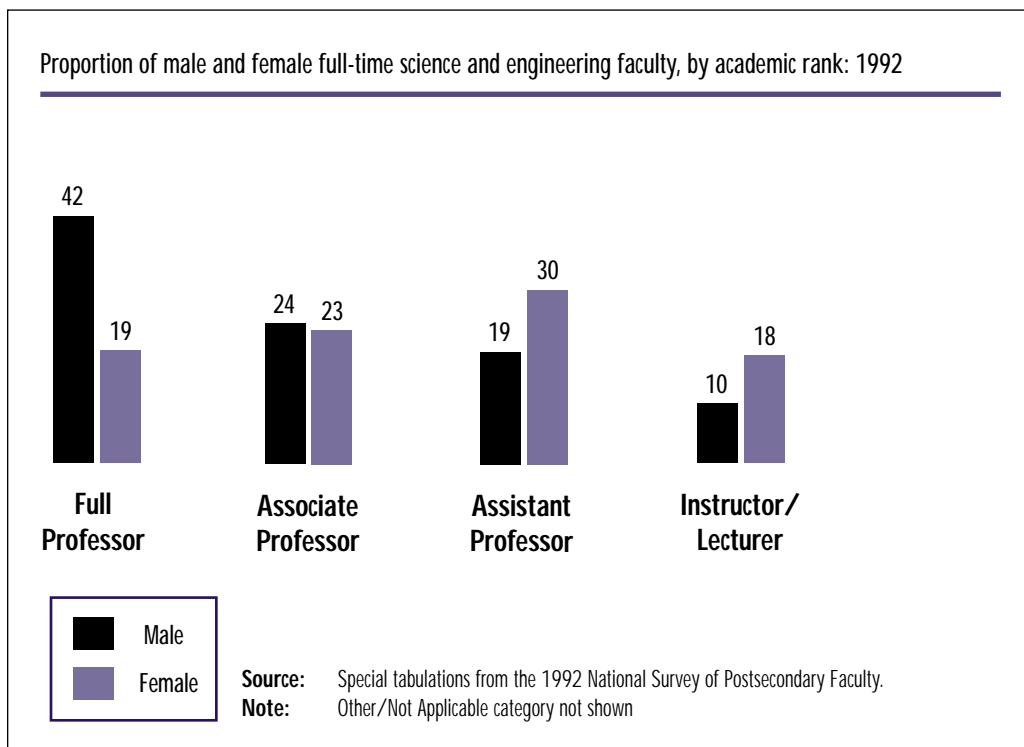


As in many professional fields, women in science and engineering experience the barrier of the glass ceiling. Thirty-six percent of women, full-time science and engineering faculty who were surveyed in 1992 were very or somewhat dissatisfied with the opportunity for advancement compared with 26 percent of men. Women advance to a certain level, but as the prestige and importance of the ranks increase, fewer and fewer women can be found. In academia, for example, women are overrepresented as instructors, lecturers, and assistant professors and underrepresented as full professors (*See figure 15*). Few women are department heads or have executive positions in industry and government.

Related to this glass ceiling is the problem of isolation. In some fields, particularly those that are dominated by men, women often feel isolated, unable to make the informal, casual connections like their male counterparts. Networking is still an “old boys” phenomenon, more exclusive than inclusive.

There are many reasons for the attrition of women from science and engineering fields (Suter, 1996). At the undergraduate level, women point to a lack of self-confidence or a damaged self-esteem, stereotypes of science and engineering as “male” fields, experiences of gender bias, a distaste for the competitive nature of science and engineering education, psychological alienation, a lack of adequate academic guidance or advice, and low faculty expectations.

figure 15



Recommendations

Many programs have addressed the problems in the research-education infrastructure. However, dissemination of these programs is limited, and evidence of their success is not readily available or accessible.

Graduate schools need to do a better job advising women on alternative career routes. The current perception that nonacademic careers are inferior should change. Resources on these career options need to be made more available. Administrators should not assess Ph.D. programs based solely on the number of graduates in academic careers.

Peer mentoring should also be encouraged. This task involves senior graduate students mentoring new graduate students and graduate students mentoring undergraduates. Publications from groups such as the Association for Women in Science (AWIS) can be used as resources.

Opportunities should also be available to women at the midcareer level. Women need to be trained in leadership skills to prepare for deanships and comparable senior positions outside academe. Similarly, networking opportunities must be made available to promote advancement and reduce isolation. Good networking opportunities should advance the notion that science is a multicareer enterprise. Internships and apprenticeships should be available at various levels—undergraduate, graduate, and postdoctoral.

Views from the Participants

“We have trained women but have given them few opportunities to excel.

This situation is demoralizing and a social injustice. There is a glass ceiling both in industry and in academia for women scientists and engineers.

NSF could easily implement certain measures to hold institutions accountable if they have not been active and sensitive to recruitment and retention of women.

This could be done quantitatively by comparing statistics on women doctoral students graduated in the last 10 years nationwide in a particular discipline of science and engineering to the number of tenured women faculty members in the same discipline of an institution under scrutiny.

Special attention should be paid to institutions that give tenured titles to women faculty members but do not actually grant them tenure.”

Membership on important tenure, promotion, and research funding review panels should be examined, and explicit and implicit criteria should be reviewed to ensure the inclusion of women. This restructuring will effect the executive level, where decisions on hiring and promotion are made. Universities and federal agencies need to reexamine their value systems for promotion and award decisions, too (e.g., value given to service, teaching, and outreach activities relative to research).



Mentoring

The Association for Women in Science (AWIS) launched its Mentoring Project in 1990, with a goal of increasing the number of women who become science professionals. The project was designed to inform, promote, and support mentoring at every development stage. AWIS identified many ways and means of mentoring—going well beyond the traditional model where senior professionals mentor junior professionals. The study also focused on the traditional conflicts between the images society assigns to “women” versus “scientists,” experimented with group mentoring methods and network creation, and explored the special concerns of women of color.

The project was co-funded by AWIS and the Alfred P. Sloan Foundation. Two products are available from the project, *A Hand Up: Women Mentoring Women in Science*, updated in 1995, contains interviews with women in science, common threads regarding challenges, reflections and suggestion from noted scientists, and a resource guide to nearly 100 groups that support women in the sciences. It provides excellent guidance on job searches and letters of recommendation (350 pages).

Mentoring Means Future Scientists: A Guide to Developing Mentoring Programs Based on the AWIS Mentoring Project is the full report on the 3-year project. It includes a discussion of what was effective and what was not in mentoring programs targeted at specific fields and age groups, sample materials, and the survey data that resulted from the study. It also contains an extensive bibliography (160 pages).

For current prices and listings of AWIS publications, write to AWIS, 1201 New York Avenue N.W., Washington, DC 20005, or call (202) 326-8940.

Views from the Participants

“Climate issues for women faculty in these disciplines are the most critical.

Several institutions (perhaps through multiyear postdocs) should become hosts to female-dominant departments in these areas.

Although mentor programs exist all over, few are actually working.

In a female-dominant department, there will be less mystery about the tenure and review process, an openness about expectations, an immediate acceptance of an individual’s worth, an understanding of external and familial responsibilities, and an overall attitude of continual growth.

After being in such a department for several years, a woman should have developed enough self-esteem and knowledge of the system to seek and gain a tenure-track position elsewhere.

This suggestion may garner considerable criticism as “women need a helping hand.”

I contend that this helping hand, understanding ear, and invisible mentoring is precisely what men have been constantly receiving in their education and careers.

This would not be a “helping hand” situation but a leveling of the playing field.”

Impact of Technology

Overview

The impact of technology group focused on technological literacy issues of girls and women, the participation of women in technology-intensive fields, and the promise and dangers the information revolution holds for education.

Challenges

In elementary and secondary school, girls and young women do not participate as often as boys and young men in activities designed to promote the use of or the learning about technology and computing. In a 1992 study, Anderson (1993) found that girls in 5th, 8th, and 11th grades were slightly less likely to have taken a computer course and have a computer in the home as boys, but scored as well as boys on a test of computer knowledge and skills. Girls with limited experience about technology, particularly information technologies, are at a disadvantage when they reach the undergraduate level and beyond. In general, it is less likely that those who are socialized to shun technology at the K-12 level will pursue science and engineering—much less the technology-intensive studies within these fields—at the undergraduate level and beyond.

Historically, middle school courses in the study of technology (i.e., the study of the nature of technology and its societal implications) and computer technology, in particular, have had a distinctly masculine tone and have drawn from a primarily male participant pool. From their roots in the 1950s and 1960s, computers have had the image of being “complex, number crunching machines that are staffed by men in white lab coats.” Computer jargon such as “computer jock” and “hacker” usually conjures images of (white) young men (Sanders, 1995).

At the same time, women in science and engineering fields are least well represented in technology-intensive fields such as engineering, computer science, and physics. Even within the biological sciences (where women are comparatively well represented), women congregate in subfields that are relatively instrumentation free. However, the use of educational technology in teaching does not vary by sex. A 1992 NSF study (1992) revealed that the frequency of use of computational tools and software and computer-aided instruction in postsecondary teaching was much more clearly associated with the particular science or engineering field than with the instructor's sex. That is, women and men were about equally likely to make use of these educational technologies in instruction.

Furthermore, the input of women into the creation of technology is something that has always been perceived to be minimal. Whether or not this is true (and in many cases it is certainly not), there is a common perception that many technologies used in science and engineering were developed by and for men.

Recommendations

The crisis in computer science (see the summary on the computer and information sciences and engineering breakout session) must be stemmed. Recent declines in the proportion of computer science degrees awarded to women must be reversed, and the public perception of computers as a male-dominated endeavor corrected. This affects not only computer science but also all other sciences that are relying more often on people who have high levels of expertise in their own fields as well as computing.

There are a number of well-conceived activities taking place across the country that focus on girls and technology. However, to focus on any one age group or educational level would be a mistake. Any policy that aims to increase the technological literacy of girls and women must be inclusive and encourage well-measured programs so that we can understand what works and use those results to create still better programs.

Much of the literature confirms that technology-intensive projects that bridge all boundaries may be particularly important in promoting the involvement of girls and women. Bridges between computing technology and fields that are historically women dominated have the possibility of bringing more women into technology and should be aggressively pursued.

In addition to making bridges to nonscience and engineering fields, girls and women seem to be drawn to programs that are factually

Views from the Participants

“One of the best ways NSF might enhance the participation of women in science-based careers is to avail itself of current technology to the fullest extent possible.

NSF should exploit the Internet in order to publicize the programs that are effective in recruiting and retaining women in science and engineering education and employment.

NSF should provide the funding to put on the Internet information about effective interventions and model projects, scholarships and fellowships, data about the status of women in science and engineering education, and research about women in science-based careers, particularly those financial aid programs, interventions, and research projects funded by the Foundation.”

Views from the Participants

“On our campus we have developed a valuable model that could be used by NSF to support and increase the involvement of women in technology.

Women, Information Technology, and Scholarships (WITS) colloquium, an interdisciplinary group of faculty and academic professionals at the University of Illinois, Urbana-Champaign campus, is working to help ensure that new communications technologies will be structured and used in ways that are beneficial and equitable to all.

While initially we planned for one year of programs, the participants from disciplines across campus requested that WITS continue.

We have published a WITS book, sponsored dozens of workshops, hosted many speakers, and have become an organization well known to many administrators.

The interdisciplinary nature of the WITS has provided a depth to our organization that has provided women graduate students and faculty support unequalled anywhere else on campus.

We have recently published Global Alert for potential strategic partners concerned about gender equity in global communication networks.

We are preparing a handbook so that groups elsewhere can use some of the materials and perspectives from our first 4 years.”

grounded. In the educational realm, this means communicating that technology is a means or foundation for something that has societal impact, not just a foundation in the abstract.

Finally, the information revolution, of unforeseeable scope and magnitude, holds danger as well as promise. The danger is that it can cause disenfranchisement; it can separate men from women, black from white, rich from poor. On the other hand, it holds tremendous promise for doing exactly the opposite — more can be done with less money and isolation can be reduced. Support networks for women such as *Systems* embody this promise. This issue deserves more deliberate and systematic examination in order to avoid the dangers and identify the promises.



Family Issues

Overview

The family issues group focused on changing workplace policies so that women (and men) scientists and engineers will be better able to balance career and family responsibilities. The group considered incentives and disincentives that could be put in place at the institutional level that would lead to more productive scientists and engineers. This would benefit women as well as men, the institution, and the enterprise of science and engineering in general.

Challenges

Women scientists and engineers face a host of challenges to their careers that result from family responsibilities. Family issues are those responsibilities in one's personal life that conflict with or pose challenges to the rhythms of academia and science or vice versa. These challenges are often disproportionately shouldered by women. The way that employers respond to these issues can either lessen or intensify their effects and lead to greater or less productivity and career satisfaction. Frequently cited family issues include child rearing and child care, the care of elderly parents, family leave policies, dual-career families, commuter marriages, trailing spouses, the double-body problem (the problem when only one spouse receives tenure) and career retention and reentry issues. All of these issues affect women as well as men. However, historically women have taken a greater role in managing family and household.

In their study of the career paths of men and women in science, Sonnert and Holton (1995) found that women (21 percent) more often pointed to family demands as a career obstacle than men (3 percent). Women and men placed equally high importance on their careers as compared with family, but women more often reported some tension between their various roles.

Women scientists are more often married to scientists than are men. Sonnert and Holton (1995) found that about 62 percent of the married women in their

Views from the Participants

“I envision a society where productive years for women (scientifically and physiologically speaking) are not mutually exclusive, where raising children is a continuation, not an interruption of life.

This would be a society where young women who are serious in their studies are not constantly asked if they would ever get married, where a woman’s dedication to science is not questioned if she chooses to have children (as it is not for men).”

“While I am not offering solutions and I also acknowledge other factors, I see this issue as a major factor in the participation of women in science.

I see self-imposed selection not as the survival of the fittest but as an unwritten rule of society that deprives many fields of science in academia of a considerable pool of talent and young science-oriented women of role models.

It also depletes high-ranking positions in industry and national labs of highly qualified women.

While having a family and pursuing a career is a personal choice, too much of the burden is placed on the individuals for creating a situation by which they can do both.

I believe that women quietly and sometimes desperately try to hold on to both worlds of science and family.

A huge leap has been made by sensitizing men as life partners; however society as a whole, and employers specifically, have yet to pick up their share of the responsibility.”

sample had a spouse who held a doctorate compared with 19 percent of married men in the sample. On the positive side, women scientists who marry male scientists share similar lifestyles with their spouse. However, because women are more often married to doctorate holders than men are, women more often face the career problems of this phenomena. It is often difficult for both members of a dual-career couple to find satisfactory jobs in the same geographic area, particularly when they are both college faculty. It also difficult when one spouse is offered a job in a distant geographical location or when only one spouse receives tenure.

In addition, studies of undergraduate women who switched out of science and engineering majors have revealed that these decisions are often made because of the perception that the lifestyle commonly associated with science is not one that many women believe is compatible with their plans for marriage and family (Rosser, 1995).

Almost all of the women with children in the Sonnert and Holton study felt that child rearing had somehow affected their career compared with only two-thirds of men with children. The period of life most often associated with child rearing also happens to be associated with periods of career-building and, for academic professionals, seeking tenure status in particular. However, both men and women also cited advantages of marriage and child rearing, including the emotional satisfaction they provided.

Recommendations

For many of the challenges posed by issues of the family, institutions that employ scientists and engineers need to examine how they can transform the climate, policies, and practices of their institutions as a whole in order to provide a more balanced, family-friendly atmosphere for women and men. The onus for change must remain on employing organizations (e.g., colleges, universities, and corporations) rather than on employees or outside organizations.

Two studies were recommended on family-issues policies of institutions. First, institutions that are examining their family policies could be studied to inventory what works and what does not. A second study could examine best practices in family policies. These two studies would provide more information and serve as a baseline for other institutions.

A synthesis of the current authoritative research on family issues could be completed and made available to institutions and individual scientists. Some female university professors are finding a more supportive environment because of the growth in women faculty, women's courses, support groups, and funding for gender/women's studies. As more and more women enter the sciences, the sheer number may provide greater support for changing institutional policies on family issues.

Lessons can be learned from other sectors such as industry. Large corporations more often offer family-friendly benefits and policies, such as child care services, sensitivity training, and family leave, than many universities.

Finally, the availability of professional development programs, such as career advancement awards, visiting professorships, and other programs, offers greater professional flexibility to women's careers in ways that result in greater flexibility in women's personal lives.



Views from the Participants

“Women must become convinced that good child care outside the home is a positive experience for their children, and somehow women must shed the load of guilt that often accompanies having a career.

Perhaps the most positive contribution to be made at conferences such as this one is to begin to help women come to grips with this problem.

Let's develop support groups for women in science and make them aware of the data indicating the positive aspects of learning experiences for children in good child care programs; let's establish a national dialog about the necessity of providing such programs; let's publicize the stories of successful women scientists who've chosen not to choose between family and career but are satisfied that they've excelled in both.

Let our goal for the twenty-first century be to create a society in which our daughters and granddaughters will not have to choose between science and family!”

Shattering Preconceptions

Overview

The shattering preconceptions group focused on myths and stereotypes of women and science as portrayed in the popular media and as commonly accepted by the public in a variety of social settings (family, schools, peer groups, the workplace, etc.). These myths and stereotypes have a tremendous impact particularly on young women. Of special concern to the group was the issue of the so-called “double bind,” that is, the effect of being both a woman and a member of a racial or ethnic minority group. Preconceptions lead to barriers that are deeply embedded in society and require widespread, grassroots solutions.

Challenges

There are many negative stereotypes about women in science. They include the perceptions that women should not be scientists, that women lack certain analytic and cognitive abilities that are essential to working in the sciences, that girls need not learn as much higher level mathematics as boys; and that girls are innately more interested in the arts and humanities, whereas boys’ interests take them to more technical pursuits. There is also a belief that science and mathematics are rare, innate abilities. Simply put, some people believe that only some can do science and others cannot.

While many of these stereotypes were more widely accepted by the public in prior years, they are still present in many aspects of life. They have detrimental effects on young women’s perceptions of their own technical abilities and their interests in education and career.

These stereotypes often start in the home when children are very young and are carried through early schooling, high school, college, and into career, constantly reinforced by cues from society. Girls often receive subtle feedback from parents, teachers, friends, and the community that steers them away from the

sciences and, especially, engineering. Some young women receive the message that there is a mismatch between being feminine and pursuing interests in technical areas. In reality, a larger proportion of high school girls take challenging science and mathematics courses than boys. The exceptions are physics and calculus. About 32 percent of male high school graduates in 1993 had earned credits in physics compared with about 27 percent of females. (Suter, 1996) These numbers may suggest why women are so underrepresented in engineering, which relies heavily on an understanding of physics and its principles.

Several studies have demonstrated that young women receive higher grades than men in high school and college science and mathematics courses. Despite this, women tend to think that they are not performing well; the opposite is true with men. This lack of self-confidence (or overconfidence in the case of men) is carried throughout life. In a sample of academic scientists and engineers surveyed by Sonnert and Holton (1995), 70 percent of male scientists reported that they had above-average scientific abilities, whereas only 52 percent of female scientists reported such an attitude.

Women of color who pursue science and engineering studies and career face an even more formidable array of barriers. They are affected by gender as well as racial bias — thus, the double bind. To exacerbate the

figure 16

Examining the double bind: Measuring progress over five years

Science and engineering doctorates awarded to women who are U.S. citizens or permanent residents, by race/ethnicity: 1989-1994

TABLE

	1989	1994	Percent Increase
Total	4,921	6,493	32
White	4,288	5,159	20
Asian American	241	820	240
Hispanic American	155	230	48
African American	153	214	40
Native American	20	24	20

Source: National Science Foundation, Survey of Earned Doctorates
 Notes: Details may not add to totals. Persons of unknown race are included in total.

Views from the Participants

“Girls and boys have very firm ideas about what roles they should take in the sciences.”

Girls who are “A” students often view themselves as poor science students.

We have found that all-girl clubs allow girls to try new, unfamiliar activities without fear of failure.

The success of these experiences carries over into their classes. The middle school years are a crucial time for girls.

This is the age when girls start falling behind boys in academic areas (especially math and science) and begin losing self-esteem.

Projects that expose girls to positive role models make them aware of their opportunities and options for the future and give them new experiences that have a tremendous impact on their decisions and self-perception.”

Views from the Participants

“The negative image of scientists presented in the media is a major obstacle to exciting young people about science.

Scientists are presented as bumbling, absent-minded, out of touch, and, often, dangerous.

Even when presented in less negative ways, the image is almost exclusively male and “hard,” divorced from human concerns, and devoid of social skills and interests.

Further, media coverage of science itself often has a negative twist.

NSF, possibly in collaboration with AAAS, could undertake several initiatives to counter these problems.”

situation, many of the remedies to the underrepresentation of minorities in science and engineering are kept intellectually and programmatically distinct from the remedies for the underrepresentation of women.

At the career level in science and engineering, it is common for women to feel they are assumed to be professionally incompetent until they prove otherwise. Women of color face this barrier more frequently. The opposite is true for men, whose competency is assumed until demonstrated otherwise.



Recommendations

Methods to overcome the underrepresentation of women in the sciences and engineering must attend to the social factors, such as stereotypes and preconceptions, that contributed to lopsided participation rates. In addition to promoting public understanding of scientific concepts, public understanding of science as an enterprise and the role of science and scientists should be promoted. Parents, school teachers, and faculty need to be reminded to set their expectations very high for all children, not just those who are stereotypically ordained to succeed.

Changing public attitudes toward women requires working at the grassroots level. Changing attitudes is the responsibility of scientists and many scientific and women's organizations. NSF has a history of using its resources to galvanize action. NSF could fund public awareness supplements or extensions to standard NSF grants.

Mentoring and outreach are essential to overcoming the damage inflicted by negative images, preconceptions, and stereotypes. Mentoring and outreach are by nature confidence-boosting activities. Without such nurturing, students may fall victim to society's stereotypes. Most scientists, particularly women, should be encouraged to visit elementary and junior high schools to explain their professions and interests. Good models for mentoring and outreach programs should be shared among industry, academia, and federal agencies. Organizations that employ scientists and engineers should offer incentives for volunteering in mentoring, outreach, and other capacities that encourage persistence and participation. Scientific professional societies should take the lead in organizing community outreach opportunities for scientists from various workplaces.

To deal with the issue of the double bind, federal science funding agencies should give priority to grants that demonstrate diversity as a goal. They can hold grantees accountable for showing that they are achieving results. Of particular concern to NSF, the makeup of grant proposal review panels needs to be examined to ensure that diverse backgrounds and perspectives are represented.



Views from the Participants

“It has been my experience as my children have gone through grade school that teachers’ attitudes can have an influence on the participation of women in science.

One second grade teacher remarked to me, “boys always have more fun with science fairs than girls.”

Children pick up this kind of attitude and can develop preconceptions without ever experiencing failure in these areas.

They are discouraged before they begin by preconceptions that it will be hard or not fun because they are girls.

The attitudes of male peers can also discourage females from wanting to participate in science and technology fields.”

“The single greatest impediment to attracting members of underrepresented groups is the perception of science as a white, masculine enterprise.

The history of science is replete with Caucasian male success stories.

The collection of these individual portraits serves as the photo album of the profession.

There have not been enough men of color and women valorized to create an impression of a diverse community.

We look around and see more women colleagues and there seem to be more people of color gaining recognition for their accomplishments.

Is enough being done to promote the idea of a difference in the composition of the scientific workforce?”

Bridging Education and Workforce Transitions

Overview

The bridging transitions group emphasized a new way of looking at education and workforce transitions. Traditionally, “bridging transitions” means transitions between various education levels and career, such as high school to college, college to graduate school, education to the workplace, etc. The group felt that focusing only on these transitions limits creative thinking (and therefore policy choices) of the real transitions women must make to move from the role of student to the role of science and engineering knowledge worker.

The group offered three basic transitions beyond the traditional hierarchical conception: educational, structural, and relationship. These transitions often serve as barriers to women entering and progressing through the stages of study and career in science and engineering.

Challenges

The major challenge for understanding how to bridge transitions is to recognize that research, policy, and practice must address more than the linear transitions between educational levels. It must address interconnections between women and science that portend their success or failure. Each of these three transition areas requires a new way of thinking about both achievements and challenges. Each must be addressed at a variety of organizational levels: local institutions, public and private foundations, and state and federal government.

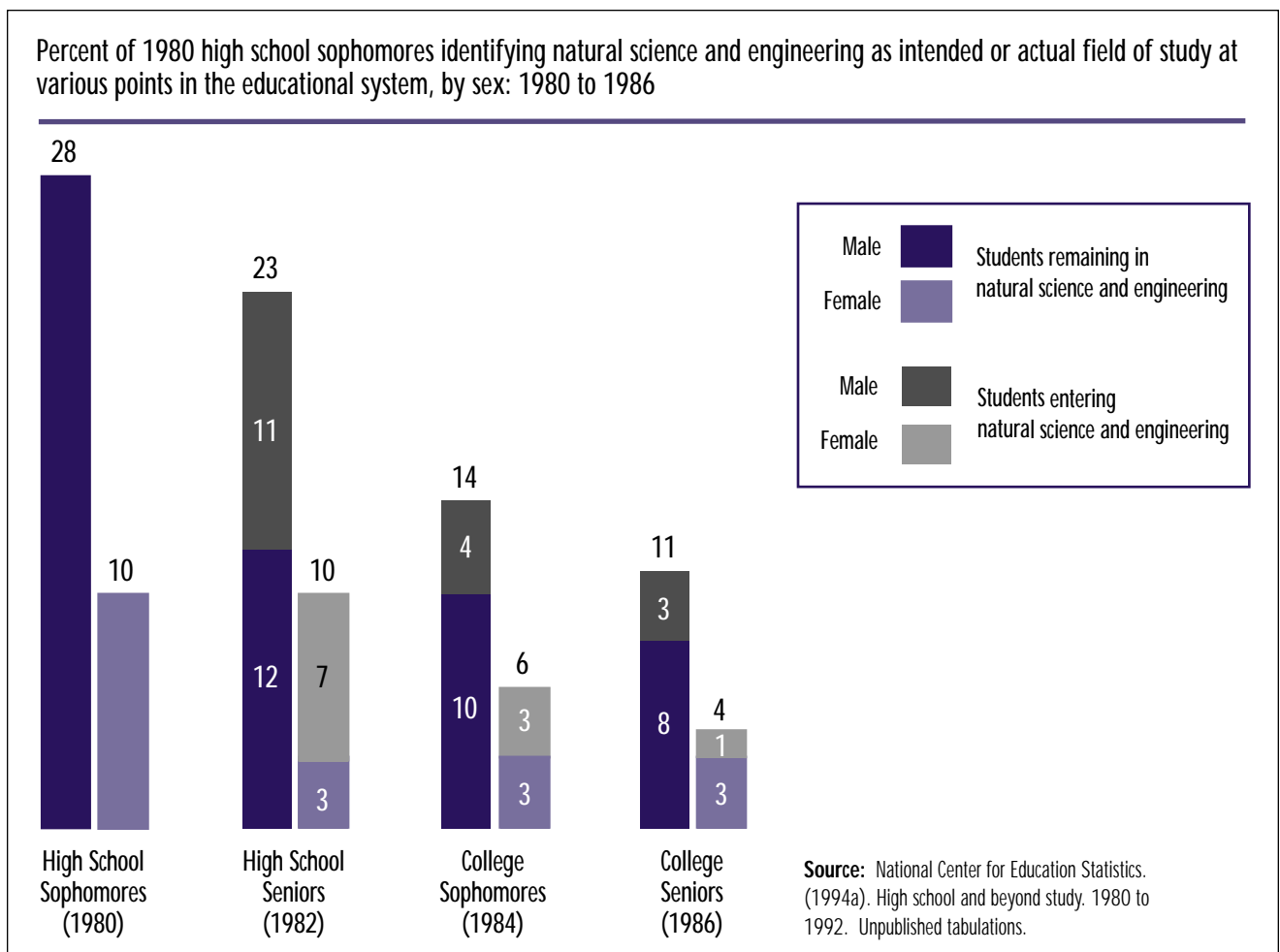
Educational Transitions. The proportion of women in science and engineering diminishes at each successive stage in the science and engineering education and research enterprise. For example, all elementary school girls receive at least some science education. As young women receive more and more options in science and engineering studies, fewer and fewer women are found pursuing those studies. Because women are underrepresented in many fields of science

and engineering, and particularly at higher status levels (full professors, department chairs, deans, etc.), interventions must be tried that will help to smooth the transition from one level to the next.

The High School and Beyond Study (discussed in Suter, 1996) traced the intended or actual major of students who were high school sophomores in 1980 through 1986 (a time when those pursuing college had reached their senior year). The now somewhat dated study found that men and women leave natural science and engineering majors in about the same overall proportion. After 6 years, just 40 percent of the male and female high school sophomores who had originally intended to major in natural science and engineering, had done so. However, at each transition point (high school sophomore to senior, high school senior to college sophomore, college sophomore to college senior) proportionally more women entered the science and engineering pipeline than men, but proportionally more were lost. In effect, a greater supply of women made up for the greater rate of female attrition (*see figure 17*).

Structural Transitions. These are transitions that women must make in acclimating themselves to new science and engineering environments. As women move

figure 17



Views from the Participants

“Support aimed at the critical junctions in a faculty member’s career can help her cross the junctions without casualty.

These junctions are getting her first academic job, publishing her thesis results, and starting her first major research project.

All faculty need help at these points, but underrepresented minorities need more assistance.

Support can come in a variety of forms — money as grants is seen as the most prestigious.

A conference for women to network is another strong possibility.”

“Once women with scientific training have stepped out of the labor force for a few years to care for young children, it is difficult to move back in, especially with the rate of technology change. In order to return to the workforce in scientific or technical positions and/or to higher education, these women would benefit by the work-study program.

A combination of opportunities for internships or practice with opportunity to complete or update prior study would be an attractive option.”

from the undergraduate to the graduate level, their role changes (e.g., from generalist to specialist) along with the demands and expectations placed on them by the academic environment. The same kind of structural change between role and environment must take place in making graduate student and workplace transitions (i.e., learner to doer). In many instances, these environments are “chilly” ones (see section on Research-Education Infrastructure) that require a more systematic and concerted change effort on the part of the individual than one might expect.

Relationship Transitions. When girls (like boys) are young, their primary mentoring relationship is child to parent or caregiver. As girls enter school, a relationship transition takes place: student to teacher is added. In high school, peer relations play a large role in young women’s academic decisions. Finally, as women enter college, graduate school, and beyond, two new relationships develop: mentee to mentor and colleague to colleague. These transitions offer peril and potential for growth.

Recommendations

Educational Transitions. There needs to be a change in the way that science and mathematics is taught and learned—kindergarten through undergraduate. The middle and high school curriculum is fragmented, making transitions from one level of education to the next intellectually difficult. Subject-matter content must be articulated across the grades K-16 in order to take a system-wide approach to educating students in science and mathematics.

Using real-world problems, examples, and projects help smooth transitions to the workplace. Although beneficial to all learners, current emphasis on authentic projects and assessments in secondary schools is particularly valuable for those women who do not go on to college or pursue technical training. Many believe that women are particularly comfortable in learning science and mathematics when connections are made between subject areas and the real world.

Structural Transitions. At early educational levels, proper academic and career advisement is important for alerting women students to the structural transitions that they will have to make in their educational and career experiences. For example, young women need to be informed in high school that they will need to take precalculus, calculus, and physics before they can major in engineering in college. Likewise, women need to be informed of career opportunities and barriers in science and engineering throughout their educational experience.

Research experience during the first 2 years of college is a valuable bridge between the roles of learner and doer (a role that becomes

increasingly important at higher levels of learning), helping to smooth this critical role transition. In a similar way, academic and industry collaboration in shaping education and training can help smooth transitions from college to the workplace.

Relationship Transitions. To strengthen relationship transitions, the role and place of mentoring must be emphasized. Research findings must be disseminated to parents, teachers, and faculty on the potentially important effects that role models and mentors have on young women. For example, first- and second-year high school teachers are critically important to young women staying in science and mathematics. The effect of gender socialization on preservice teachers (undergraduate and graduate education majors) and the effects that student teaching has on their eventual teaching beliefs and behaviors should be examined.

The Mills College Conference: Women and Leadership

In 1994, the Mills College Women's Leadership Institute sponsored a national *Women in Science Summit*, inviting 52 prominent women scientists to create an action plan that would advance women's leadership in science. The participants represented the spectrum of biological, social, and physical sciences as well as college, university, government, and industry perspectives. The participants made the following recommendations:

- Initiate new recruitment and retention efforts for senior science positions;
- Ensure comparable salaries;
- Promote effective mentoring systems;
- Improve work environments;
- Support career flexibility;
- Heighten visibility at top levels;
- Enhance funding to increase the number of full professorships for women; and
- Increase accountability at national and institutional levels.

Source: Advancing Women's Leadership in Science: An Action Plan to the Year 2000. Mills College, Women's Leadership Institute, Mills Hall, 500 MacArthur Boulevard, Oakland, CA 94613, (510) 430-2019.

Views from the Participants

“A recent survey indicated that a least 50 percent of students plan to stop taking math and science as soon as they can, although many express interest in study or careers in areas that require a good deal of mathematics.

In addition to ignorance of the need for math/science in many careers, there is ignorance of what one really does in a given career.

This affects males as well as females but may impact females more.

In addition, women tend to be more concerned about balancing career and family life and also more concerned about working with people.”

“I propose the development of a career awareness program involving classroom interaction of students, teachers, counselors, and parents (at all levels, at least through undergraduate work) with people engaged in careers requiring a math/science background.

Women need to know that a math/science background is a critical filter for many careers, that many women are successfully pursuing scientific careers, that there are many math/science careers that involve working with people, and that one can balance career and family life.”

Changing Curriculum and Instruction

Overview

The changing curriculum and instruction group addressed issues of how curricula and instructional techniques affect women's participation in science and engineering studies from kindergarten through the undergraduate level. The group examined the issue of why women find curriculum or coursework content and instruction less attractive in some fields than in others. Curricula and instruction are and will likely continue to change in ways that are more inclusive of women. Specifically, the group addressed four main areas of this change: change within institutions, changing curricular content, changing the culture, and changing curricular and instructional policies.

Challenges

Historically, curricular content and teaching techniques in the sciences and engineering not only have done little to encourage girls and women to pursue their interests in these fields but also have done damage, affecting girls and women negatively.

Attitudes are influenced early—in elementary and middle school for example. Textbooks and curricula materials have historically transmitted masculine stereotypes of science. Sometimes these cues were overt, often they were subtle and unintentional. For example, the field of engineering (and other physical sciences to a lesser extent) has developmental roots in military projects. As a result, many of the examples in earlier engineering textbooks were taken from military applications. These types of examples often had less connection and familiarity to the lives of women.

Researchers have often pointed to unintentional favoritism toward boys and men in classroom instruction. Examples often cited include teachers calling on male students more often, making more frequent eye contact with male students,

asking male students more higher order questions, and assigning higher value to responses from male students (Rosser, 1995). Moreover, often due to lower enrollments of women in some courses, women often do not get adequate opportunity to interact with other women on group projects involving substantive course-related projects.

Finally, many scholars feel that current reforms in curriculum and teaching map particularly well with the learning styles of girls and women. Connections between coursework and real-world issues, hands-on activities, cooperative learning, and group projects are believed to benefit all learners, regardless of sex. Some research concludes that old instructional styles were detrimental to efforts to attract and retain women in science and engineering fields. The function of introductory courses in particular was meant to “weed out” those who were not “capable” of scientific study — often resulting in the exodus of women and people of color.



Recommendations

The overall recommendation of the group is that vestiges of bias in curriculum materials and instructional techniques should be actively eradicated while developing and implementing curricula and instructional techniques that are relevant to all students, reflect their needs, and acknowledge a diversity of learning styles.

Making changes in how teachers teach will require making changes in how teachers are prepared for the classroom and ongoing professional development. Such changes often run counter to established and more familiar instructional practices and require time to implement. Special emphasis should be placed on professional development in diversity issues and equitable instructional practices for all prospective and current teachers at the elementary, secondary, and undergraduate levels.

Views from the Participants

“Creating interest among women in the sciences is crucial to increasing the number of women educated in the area.

This interest is best created at an early age through successful encounters and physical manipulation of materials.

The interrelationship between the concrete manipulation of objects and the abstract development of quantitative relationships needs to happen early in a child’s learning experience, not as seniors in high school in a strictly abstract environment.

The relevance of the activities and connections to objects and experiences in everyday life are other essential components necessary to develop a positive outlook among female students toward the sciences.

The interest has to be sustained over several years and has to be backed up by thoughtful and rigorous learning experiences through the high school and college years.”

Views from the Participants

“Our academic institutions and funding agencies must recognize and reward faculty for the development and use of science curricula and instructional methods based on cognitive theories, which take into account individual preferences in learning and teaching.

Educational research must be supported so that we can learn more about why women abandon science majors and careers, whether specific teaching and learning strategies can increase the academic success of women, and how best to sustain women’s interest in science.”

“A finding that struck me in my research is that girls (even very young girls) do not see the relevance of science for their future.

They think this way well before they start seeing themselves as not being good in science and before their test scores and course taking start declining.

NSF has been active in promoting images of women in science, but I think much more is needed. Here are a few suggestions:

■ *Provide awards for math and science books that show both boys and girls using math in diverse ways.*

■ *Publish a magazine (like the old Weekly Reader) that goes to every school child and shows men and women scientists and their wonderful discoveries.*

■ *Fund television spots showing women doing science with a powerful message to the young girls who have no good role models provided on TV.*

■ *Sponsor visiting scientist programs at the schools so that men and women scientists can come to talk to classes about science.*

My daughter is in 4th grade, and she has never had a scientist come to her school to talk. The closest thing was a ‘weather man.’”

Classrooms need to provide ample opportunity for both male and female students to participate fully in the learning activities available. The content of curricula must be connected with process skills—teaching, pedagogy, and assessment — in order to spur the complementary changes in practice that are necessary for sustaining reform. However, these curriculum and instructional changes must also show that science and engineering are relevant and interesting to girls and women. For example, women’s impact and role in the history of science and engineering should be reflected accurately in instructional materials and practices.

Finally, there is a need for further research and evaluation on issues of gender and curriculum and instruction. Studies that trace the impact of various reforms in teaching and the use of new materials could provide beneficial feedback to teachers, administrators, and policymakers and would expand the knowledge base in these important areas.



Views from the Participants

Dear Dave:

Just a quick note to let you know of the success of a program I put on at Vassar on June 8, 1996, that was inspired by the December 1995 NSF conference on women and science. After visiting numerous posters at the December meeting that describe successful NSF-sponsored projects to encourage girls in science, I decided to put on a program here at Vassar.

Sister/Scientist Day at the Vassar College Farm involved 50 girls (5th-11th grade) and 20 parents from the Poughkeepsie and mid-Hudson region. These participants spent the day at the Collins Field Station on the farm working on hands-on science projects led by female scientists (many of them Vassar College professors). Each girl participated in three different workshops that they chose from a list of 22. Most of the workshops were hands-on workshops but some were career and guidance workshops. The adults attended guidance workshops only.

In addition to the workshops, all participants enjoyed a keynote speech by Peggy Shephard, co-founder and executive director of West Harlem Environmental Action titled, "Science and Social Justice." The participants were welcomed at the opening of the conference by the Vassar College Dean of Faculty and me. There was a high proportion of students of color among the participants since I recruited heavily from Poughkeepsie High School. A lovely article appeared (and was spotlighted) in the *Poughkeepsie Journal* that discussed the conference and its goal of encouraging girls to engage with science.

Thank you and all of your colleagues at NSF for putting on the December conference on *Women & Science*. Were it not for that, I might not have had the idea or the energy for Sister/Scientist Day at the Vassar College Farm.

Best Regards,

Jill S. Schneiderman
Associate Professor of Geology
Vassar College

Views from the Participants

“Our academic institutions and funding agencies must recognize and reward faculty for the development and use of science curricula and instructional methods based on cognitive theories, which take into account individual preferences in learning and teaching.

Educational research must be supported so that we can learn more about why women abandon science majors and careers, whether specific teaching and learning strategies can increase the academic success of women, and how best to sustain women’s interest in science.”

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Notes

¹ A complete listing of individuals involved in organizing the conference and conference program can be found on the World Wide Web as described on p. 64.

² They were hired between 1989 and 1992. The survey was conducted in 1992.

About NSF

The National Science Foundation (NSF) is an independent federal agency established in 1950 to promote and advance scientific progress in the United States. NSF accomplishes its mission primarily by competitively awarding grants to educational institutions for research and education in the sciences, mathematics, and engineering.

NSF's annual budget currently exceeds \$3 billion, more than 96 percent of which goes directly to institutions for research and education programs. The agency actively collaborates with universities, state governments, and other federal agencies, businesses, private foundations, community and civic groups, and international agencies on a broad range of research and education projects in science, mathematics, and engineering.



Neal F. Lane
Director
National Science
Foundation

NSF Opportunities for Women and Girls

NSF's mandate to ensure the vitality of the nation's scientific enterprise includes concern for the composition, distribution, and effectiveness of the human resource base in the sciences, engineering, and mathematics (SEM). Within this context, the foundation is committed to enhancing the current rate of participation of women and girls in science, mathematics, and engineering education and careers, in general, and as active participants in all of its programs. NSF considers unsolicited research proposals from qualified investigators for support of research in any NSF-supported field of science, mathematics, engineering, and education and strongly encourages applications from women. NSF offers the following opportunities in addition to its disciplinary programs.

Comprehensive Focus

(grade school through graduate school):

- *Implementation and Development Projects (IDP)* funds projects that build on existing research about gender and the SEM infrastructure in order to create positive, permanent change in academic, social, and scientific climates. Awards will be granted for up to 3 years and with budgets up to \$300,000 per year. Proposals with budgets over \$100,000 must be collaborative efforts; have multiple target populations; effect permanent change; include strategic leverage plans connecting the project with other initiatives; and reflect significant commitment, including cost-sharing from the collaborating institutions. Contact the program officer for women's programs in the Division of Human Resource Development. Program Guide, NSF 96-131.
- *Information Dissemination Activities (IDA)* ensure that there is widespread dissemination of strategies, research results, and resources that will accelerate efforts to increase women's involvement in SEM. IDA awards provide a mechanism for individuals to interact and exchange both strategies and information related to the participation. Contact the Division of Human Resource Development. Program Guide, NSF 96-131.

Graduate Student Focus:

- *Graduate Research Fellowships*, with a special component, *Women in Engineering and Computer and Information Science*, are awarded to individuals wishing to pursue master's or doctoral study in science, mathematics, or engineering. For forms and additional information, contact the NSF Graduate Research Fellowship Program, Oak Ridge Associated Universities, P.O. Box 3010, Oak Ridge, TN 37831-3010, (615) 483-3344. Flyer, NSF 94-112.

Faculty Research and Development Focus:

- *Research Planning Grants* provide funding for women scientists and engineers (who have not had prior federal support) in all NSF-funded disciplines for preliminary studies and other activities related to the development of more comprehensive research projects. Contact the appropriate disciplinary program officer or the cross-directorate coordinator for the relevant division or directorate. Program Guide, NSF 93-130.
- *Career Advancement Awards* support activities of experienced women investigators for the purpose of expanding their research potential and capability. Contact the appropriate disciplinary program officer or the cross-directorate coordinator for the relevant division or directorate. Program Guide, NSF 93-130.

Contacting NSF

World Wide Web:

- The World Wide Web makes it possible to view text material as well as graphics, video, and sound. The URL (Uniform Resource Locator) for the NSF Home Page is <http://www.nsf.gov/>. The URL for the *Women & Science* conference is <http://www.ehr.nsf.gov/conferences/women95.htm>.

Internet Gopher, Anonymous FTP, and On-line STIS:

- The Internet Gopher provides access to information on NSF's Science and Technology Information System (STIS) through a series of menus. The NSF Gopher server is on port 70 of stis.nsf.gov.
- Internet users who are familiar with File Transfer Program (FTP) can easily transfer NSF documents to their local system for browsing and printing. FTP instructions are: FTP to stis.nsf.gov. Enter *anonymous* for the username and your E-mail address for the password.
- NSF's STIS is an electronic publications dissemination system available via the Internet (telenet to stis.nsf.gov). Login as *public* and follow the instructions on the screen.

How to Request Printed NSF Publications:

- You may request printed publications in the following ways:
- Send and E-mail request to: pubs@nsf.gov.
- Fax request to (703) 644-4278.
- For phone request, call (703) 306-1130 or Telephonic Device for the Deaf (TDD (703) 306-0090).

- Send written request to:
NSF Forms and Publications
4201 Wilson Boulevard, Room P-15
Arlington, VA 22230

When making a request, please include NSF publication number, number of copies, and your complete mailing address.

Questions About NSF Publications, Programs, Etc.:

- Contact the NSF Information Center at (703) 306-1234 (TDD (703) 306-0090), or send your E-mail message to info@nsf.gov.

Questions About Electronic Systems:

- Send specific, system-related questions about NSF electronic systems to webmaster@nsf.gov or call (703) 306-0214 (voice mail).

Additional Resources for Women in Science, Mathematics, Engineering, and Technology

American Association for the Advancement of Science (AAAS)

1200 New York Avenue, NW
Washington, DC 20005-3920
(202) 326-6670
<http://www.aaas.org/>

Since 1973, AAAS has initiated research, seminars, workshops, and publications to enhance the status and accelerate the advancement of women in science, mathematics, engineering, and technology fields. Much work is collaborative and includes international cooperation with U.N. advisory groups and educators in other countries. This program has also emphasized the special issues facing minority women in science. A major current effort is Collaboration for Equity, a 3-year, NSF-funded initiative with the Education Development Center, Girls, Inc., and others. The focus of Collaboration for Equity is on processes and materials to support systemic reform for education leaders in schools and community settings relating to gender and science.

AAAS is a nonprofit corporation whose membership includes leading professional societies, corporations, institutions, and individuals concerned with advancing public understanding of professionals in science and technology, their roles, education, and employment.

American Association of University Women (AAUW)

1111 16th Street
Washington, DC 20036-4873
(202) 785-7700
<http://www.aauw.org/>

A nationwide grassroots organization of 150,000 college graduates dedicated to promoting equity and education for all women and girls, AAUW consists of three corporations: the Education Foundation, the Association, and the Legal

Advocacy Fund. Each was founded to remove obstacles—financial, legal, and social—faced by women and girls.

The AAUW Education Foundation provides fellowships and grants. For 1996-97, approximately \$2.6 million was awarded to 274 women. Outreach to minority women is a priority. The Foundation operates the Eleanor Roosevelt Fund to create a more equitable education system for girls. The Fund supports public policy research, fellowships for public school teachers, and community action projects.

The Association is an advocate for greater equity and a catalyst for change. The Legal Advocacy Fund is the nation's only legal fund to specifically address sex discrimination and harassment issues in higher education. It offers financial assistance to women faculty, staff, and students who have grievances against colleges and universities; it supports sex discrimination lawsuits; and it recognizes innovative equity programs through its Progress in Equity Award.

American Chemical Society (ACS)

1155 16th Street, N.W.
Washington, DC 20036
(202) 872-4590
<http://www.acs.org/>

The American Chemical Society was founded in 1876 and is a not-for-profit organization. It is the world's largest scientific society and has a membership of over 151,000 chemists and chemical engineers. The ACS Women Chemists Committee is charged with helping women become leaders in chemical sciences and attracting younger women to this field. ACS publishes its Women Chemists Newsletter twice per year.

American Geological Institute (AGI)

4220 King Street
Alexandria, VA 22301-1507
(703) 379-2480
<http://www.agiweb.org/>

AGI, a federation of geoscientific and professional organizations, serves its member societies and the geoscience community by coordinating and consolidating the common interests and influence of geoscientists on behalf of the geosciences. The Institute provides information services, such as the GeoRef database and *GEOTIMES*, for its member societies and the geoscience community; provides a focused and effective voice for the interests of the geoscience community on national science policy issues; strengthens earth science education by leading efforts with its member societies and others to develop K-16 curriculum materials; and increases public

awareness of the role that geoscience plays in our lives and in the environment. As of 1994, AGI's affiliations had grown to include 26 member societies that collectively represent more than 80,000 geologists, geophysicists, and other earth and environmental scientists; more than 100 colleges and universities; more than 30 corporations; and hundreds of individuals.

American Mathematical Society (AMS)

P.O. Box 6248
Providence, RI 02940-6248
(800) 321-4AMS (4267)
<http://www.ams.org/>

AMS was created to further mathematical research and scholarship. Founded in 1888, it now has over 30,000 members, including mathematicians throughout the United States and around the world. It continues to fulfill its mission with programs that promote mathematical research, increase the awareness of its value to society, and foster excellence in mathematics education.

The American Physical Society (APS)

One Physics Ellipse
College Park, MD 20740-3844
(301) 209-3200
<http://www.aps.org/>

APS is an organization of more than 41,000 physicists worldwide. Since its formation in 1899, it has been dedicated to the advancement and diffusion of the knowledge of physics. The APS organizes scientific meetings and has programs in areas such as education, international affairs, public affairs, and public information. APS operates a Committee on the Status of Women in Physics that is charged to address the production, retention, and career development of women physicists and to gather and maintain data on women in physics in support of these objectives.

American Physiological Society (APS)

9650 Rockville Pike
Bethesda, MD 20814-3991
(301) 571-0693
<http://www.faseb.org/aps/>

APS is devoted to fostering scientific research, education, and the dissemination of scientific information. By providing a spectrum of physiological information, APS strives to play an important role in the progress of science and the advancement of knowledge. Providing current, usable information to the scientific community is the Society's primary focus. APS actively promotes the participation of women and minorities in physiology at the precollege through

professional levels via a set of coordinated programs. These include a mentoring program for women in physiology; a project to develop and disseminate curricular modules on women role models in life sciences for middle and high school classrooms; undergraduate and graduate research fellowships for minority students; travel fellowships for minority students; and summer research fellowships for minority teachers and teachers of minority students.

American Society for Microbiology (ASM)

1325 Massachusetts Avenue, N.W.
Washington D.C. 20036
(202) 942-9319
<http://www.asmtusa.org/>

ASM is the oldest and largest single life science membership organization in the world. Membership has grown from 59 scientists in 1899 to over 40,000 members today located throughout the world. ASM represents 23 disciplines of microbiological specialization plus a division for microbiology educators.

The Association for Women in Mathematics (AWM)

4114 Computer and Space Sciences Building
University of Maryland
College Park, Maryland 20724-2461
(301) 405-7892
<http://www.math.neu.edu/awm/>

AWM was founded in 1971 at the Joint Meetings in Atlantic City. The purpose of the association is to encourage women to study and to have active careers in the mathematical sciences. Equal opportunity and the equal treatment of women in the mathematical sciences are promoted.

Association for Women in Science (AWIS)

1200 New York Avenue, NW
Washington, DC 20005
(202) 326-8940
<http://www.awis.org/>

AWIS is the largest multidisciplinary science organization for women in the United States. It has more than 5,000 members and 74 chapters nationwide. Founded in 1971, AWIS is a nonprofit organization committed to the achievement of equity and full participation of women in all areas of science and technology, including the life and physical sciences, mathematics, social sciences, and engineering.

Serving as a national voice, AWIS has made a lasting impact on the accessibility of science education and careers for women. Two current AWIS programs are

Women Scientists in Academia: Warming Up a Chilly Climate, funded by the Alfred P. Sloan Foundation, and *The Association for Women in Science Mentoring Project*, funded by NSF. The Sloan project will develop a model program offering workable options for institutions committed to enhancing the academic climate for women scientific faculty. The NSF project established community-based mentoring programs at 12 locations nationwide.

AWIS also offers a number of resources for women in the scientific community. *Mentoring Means Future Scientists: A Guide to Developing Mentoring Programs Based on the AWIS Mentoring Project* is AWIS's full report on its initial 3-year Mentoring Project for undergraduate and graduate students, upon which the current NSF project builds. *Mentoring Means Future Scientists* identifies the most and least effective aspects of the earlier project and includes an extensive bibliography listing resources on women in science and on mentoring. *A Hand Up: Women Mentoring in Science*, now in its second printing, was also produced as part of the first AWIS mentoring project. This "paper mentor" consists of four sections including interviews with women in science, mathematics, and engineering; a discussion of personal and professional challenges faced by women in the scientific community; educational and professional advice; and an extensive listing of scientific, feminist, and educational organizations that support women in the sciences. A third publication, *Grants at a Glance*, is a 100-page book of funding information, listing more than 400 awards, fellowships, and scholarships for women at all levels in a wide variety of fields.

Commission on Professionals in Science & Technology (CPST)

1200 New York Avenue NW
Washington, DC 20005
(202) 326-7080
<http://www.aaas.org/cpst/>

CPST compiles, interprets, and disseminates data on the education and employment of scientists including a document on women and minorities. CPST works collaboratively with institutions and professional groups to improve all aspects of data collection and use and generates both scheduled and special publications. Membership in CPST is open to professional societies, corporations, institutions, and individuals.

Committee on Women in Science and Engineering (CWSE)

National Research Council (NRC)
2101 Constitution Avenue
Washington, DC 20418
(202) 334-1372
<http://www.nas.edu/cwse/>

Since its beginning in 1991, CWSE has engaged in activities to encourage greater participation of women in science and engineering careers. This has

included: 1) collecting, examining, and disseminating data about women's participation throughout academe, government, and industry; 2) monitoring efforts to increase participation, particularly intervention programs; 3) conducting symposia, workshops, and other meetings of experts to explore policy, stimulate initiatives, and evaluate progress; and 4) conducting special studies relevant to women scientists and engineers.

CWSE has undertaken numerous activities to fulfill its mandate. In particular, it has held conferences and conducted research resulting in the following National Academy Press reports:

- *Science and Engineering Programs: On Target for Women?* (1992) contains findings based on the Committee's first national conference to examine the infrastructure of postsecondary science and engineering education. This report identifies educational programs that have been effective in facilitating the recruitment and retention of women in science and engineering careers, emphasizing not only programs at the undergraduate and graduate levels but also programs within the federal Government, academe, and industry.
- *Organizations Encouraging Women in Science and Engineering* (1993) has served primarily as a resource for women seeking financial support for study and for professional societies seeking greater interaction. It lists science and engineering professional societies as well as organizations focusing on postsecondary education and racial and ethnic minorities with pertinent information.
- *Gender Differences in the Career Outcomes of Ph.D. Scientists and Engineers* (forthcoming) is the result of a 2-year study based on the annual Survey of Doctorate Recipients administered by NRC. The study panel examined nine career outcomes, such as employment status and research productivity. This volume contains comparisons of career outcomes for women of different racial and ethnic backgrounds.
- *Databook on Female Engineering Faculty* includes a directory of such faculty at U.S. institutions as well as demographic information on them compiled in useful tables.
- *Diversity in Science: Perspectives on the Retention of Minority Women in Science, Engineering, and Health-Care Professions* was developed from the Committee's third national conference. CWSE believes that society as a whole benefits when the most talented individuals are recruited, used effectively, and retained in all employment sectors. As a result, CWSE convened a January 1995 planning group, leading to this report designed to inform the policy community of the status of minority women in these fields and the necessity of family-friendly work environments.

Computing Research Association (CRA)

1875 Connecticut Avenue NW
Suite 718
Washington, DC 20009-5728
(202) 234-2111
<http://www.cra.org/>

CRA is an association of more than 150 North American academic departments of computer science and computer engineering, industrial and government laboratories engaging in basic computing research and affiliated professional societies. CRA's mission is to represent and inform the computing research community and to support and promote its interests. CRA seeks to strengthen research and education in the computing fields, expand opportunities for women and minorities and improve public and policy maker understanding of the importance of computing and computing research in our society.

CRA established the Committee on the Status of Women in Computer Science and Engineering (CRA-W) to take positive action to increase the number of women participating in Computer Science and Engineering (CSE) research and education at all levels. In addition to increasing the number of women involved, it also seeks to increase the degree of success they experience and to provide a forum for addressing problems that often fall disproportionately within women's domain.

National Council of Teachers of Mathematics

1906 Association Drive
Herndon, VA 20190
703-620-9840
<http://www.nctm.org/>

NCTM, founded in 1920, is a nonprofit professional association dedicated to the improvement of mathematics education for all students at all levels in the United States and Canada. With more than 117,000 members, it is the largest mathematics education organization in the world.

National Sciences Resources Center (NSRC)

600 Maryland Avenue SW
Washington, DC 20024
(202) 287-2063
<http://www.si.edu/nsrc/>

NSRC is an educational research and development, information dissemination, and outreach organization operated by the Smithsonian Institution and the National Academy of Sciences. Established in 1985, it contributes to improving K-12 science education by designing programs built on national resources. All

NSRC programs place special emphasis on stimulating an interest in science among women and minorities, and on helping school districts serving these populations to improve their science programs.

National Science Teachers Association (NSTA)

1840 Wilson Boulevard
Arlington, Virginia 22201-3000
(703)243-7100
<http://www.nsta.org/>

NSTA was founded in 1944 and is the largest organization in the world committed to the improvement of science education at all levels preschool through college. NSTA's current membership of more than 53,000 includes science teachers, science supervisors, administrators, scientists, business and industry representatives, and others involved in science education.

Society for Women Engineers (SWE)

120 Wall Street
New York, NY 10005-3902
(212) 509-9577
<http://www.swe.org/>

SWE stimulates women to achieve full potential in careers as engineers and leaders, expands the image of the engineering profession as a positive force in improving the quality of life, and demonstrates the value of diversity. Founded in 1950, it has an international membership of more than 14,000 women engineers in 79 local sections and 277 student sections.

Women's College Coalition

125 Michigan Avenue, NE
Washington, DC 20017
(202) 234-0443
<http://www.academic.org/>

Founded in 1972 as a project of the Association of American Colleges, the Coalition represents the 84 women's colleges in the United States and Canada. The Coalition makes the case for single-sex education for women to the higher education community, policymakers, the media, and the public. Additionally, the Coalition collects and disseminates information and sponsors research in areas relating to the education of women and to gender equity in higher education. Other priority areas identified for attention by Coalition members are the issues of retention and recruitment of women into mathematics, science, and engineering and the development of women's leadership in society.

Women in Engineering Program Advocates Network (WEPAN)

Purdue University
1284 Civil Bldg.
West LaFayette, IN 47907-1284
(317) 494-5387
<http://web.mit.edu/wepan/www/>

WEPAN was founded in 1990 to effect a positive change in the engineering infrastructure so that the climate becomes conducive to women. Technical assistance and training are offered to colleges and universities to initiate or expand Women in Engineering and Science programs focused on recruitment and retention at the precollege, undergraduate, and graduate levels. WEPAN has a membership of more than 500 and operates three regional centers at Purdue University, Stevens Institute of Technology, and the University of Washington. WEPAN offers publications and videos covering data, resources, research and engineering practice, as well as newsletters and conferences.

WebSites and Networks

Argonne National Laboratory. Clearinghouse for women in science through the Women in Science and Technology Program (WIST) at Argonne.
<http://www.anl.gov/WIST/Wist.html>

Systemers. An organization and on-line discussion group for computing women.
<http://www.systemers.org/>

Women and Computer Science. Writings about women and computer science, including survival skills and Internet resources.
<http://www.ai.mit.edu/people/ellens/gender.html>

Women's Home Page. The site of note for feminists and all who study women's issues, this home page offers a good collection of papers and articles on women and science.
<http://www.mit.edu:8001/people/sorokin/women/>

The Women's Professional Directory
(Formerly the Women in Technology Directory)
<http://www.womensdirectory.com/>

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Notes

*Adapted from Chadwell, Faye A. (1995). Bibliography in Sue V. Rosser (ed.) *Teaching the majority: Breaking the gender barrier in science, mathematics, and engineering*. New York: Teachers College Press.

France A. Córdoba

Featured Speaker

Opening Night Celebration: Reaching into the Future

December 15, 1995

I am an astronomer. I look at the stars. Everywhere I look in astrophysics, I see women working behind the stars. I see a picture of Jupiter, bruised by the infall of two dozen pieces of a comet, and behind the image I see the face of young MIT researcher Heidi Hammel. I see the countenance of the universe change to a much younger entity of only 8 billion years, and behind this, the handiwork of Carnegie Institution's Wendy Freedman, who is systematically detecting and measuring Cepheid variables in distant galaxies. I see in evidence of planetary systems around distant suns the possibility of life outside our solar system; behind this is the painstaking observational work at millimeter wavelengths by Anneila Sargent of Caltech. I see in the birth of a mechanical rover that will take its first halting steps on Mars 2 years from now the tenacity and the vision of JPL's Donna Shirley. When I look at Saturn and admire its rings, I know that my graduate school buddy Carolyn Porco is developing the first imager that will reach and orbit Saturn and image its rings in the year 2004. When I look at the Northern Cross, I imagine that I see — once again after 20 years — the nova I discovered while looking up at night from the floor of the Grand Canyon. I was not the first to see and report Nova Cygni 1975, but for me it was my discovery all the same. Everywhere I look in astrophysics, I see women working behind the stars.

In Washington I see women engaged in setting science policy at the highest levels. I see the remarkable job women are doing at the federal agencies: NIH, DOE, Education, DoD, NOAA, NSF, NIST, and NASA. I hear shining through those acronyms the strong, articulate voices of Florence Haseltine, Martha Krebs, Eve Bither, Anita Jones, Kathy Sullivan, Cora Marrett, Anne Petersen, Mary Clutter, Arati Prabhakar, Nancy Maynard, and many, many others who are changing the face of science and the course of science policy. One recent nova event for science policy was the Administration's release of *Science in the National Interest*. This visionary document, spearheaded by MRC Greenwood when she was at OSTP, is remarkable for the way it celebrates science and its common-envelope star, technology; it embraces change and lifts from the ragged edges of that change a new attitude that articulates wider goals for science, goals that put science in contact with its benefactor and beneficiary, the public.



France A. Córdoba

Chief Scientist,
National Aeronautics
and Space
Administration

Another nascent star is the 1991 Women's Health Initiative. The birth of this enterprise required a new attitude, one which came from an active women's health movement around the country that drew attention to the failure of health policy with respect to serving women. Florence Haseltine, director of the National Institutes of Health's Center for Population Research, was well-placed to take leadership in this effort. She founded the Society for the Advancement of Women's Health Research. Her efforts were supported by NIH's first woman director, Bernadine Healy. This effort became institutionalized with the advocacy of congresswomen who have strong interests in women's health issues. The bipartisan team of Barbara Mikulski, Pat Schroeder, and Connie Morella worked with NIH to found the Office of Women's Health Research in 1990.

I've painted an optimistic picture, a picture of positive change in the landscape of science discovery and science policy with the infusion of women. Yet, there are signs that we may be looking at the brief, jubilant flare of the middle-age main-sequence star that is the culture of science as we know it today. Such stars emit flares from time to time, increasing in brightness tenfold, but in the end they are what they have always been — dim stars that will be on their evolutionary track for a long time.

What are the signs that temper my optimism? Here was the scene in 1991 at one of the nation's top research institutions of higher learning: Fully one-half of the department heads in that institution's College of Science were women, a splendid moment that was revealed in by the college, the university, and women in science organizations. Today, only 4 years later, there are *no* women department heads in that college. Did they die untimely or unseemly deaths? No, one rotated off in the usual time period, two went on to higher administrative positions at other institutions, and one saw her department subsumed into another college so she returned to the rank of professor. All of this is pretty normal activity among department heads in general. So why were no women promoted to their places, or to any of the other possible headships in the college? The truth is there *are* no other women at the rank of professor in any of the departments and only a very few at the lower ranks of associate or assistant. The veneer of success for women in science leadership was very thin indeed.

Another example: Last weekend I flew to Cape Canaveral to participate in the launch of a long-awaited satellite to perform observations of stars that emit X-rays. As I sat for hours in front of a console in the mission control room, I looked around me at the people sitting in front of the two dozen other consoles. The scene looked like the world of Apollo 13, except that the monitors were spiffier. All consoles, save one, were "manned." We have not come a long way in the 25 years since Apollo 13 was rescued.

From these examples of women in science and women still outside of science, you can see that the report card is mixed. Progress depends on which field you are considering: The numbers of women are increasing in psychology,

biomedical engineering, biology, anthropology, primatology, and history. Yet they are not increasing in other areas, like physics, math, computer sciences, and mechanical and electrical engineering. The latter may be the areas that have reached saturation and have overproduced in recent years. As the numbers of women in the workplace have increased, women may be choosing growth areas, areas where they see opportunity. This could account for some of the differences we see in the proportionate increase of women in selected fields.

The feminist critique of science has lately focused on a popular concept that frames our dialog, and some of our actions, on increasing the number of women in science: They call this The Pipeline Myth, AKA The Myth of Steady Progress. How often have we heard that all we need to change this institution or that one is to get more women into the pipeline?

“We thought all you had to do was get more women into the pool —into graduate schools and tenure-track positions —and automatically they would move into the faculty and into industry, and so on. We were naive.” Neurobiologist Neena Schwartz

Historian Londa Schiebinger says, “There is no greater myth in respect to women in science than that of inevitable progress.” History, she notes, shows otherwise. For example, after women gained admittance to graduate schools at the beginning of the century, they flooded Ph.D. programs in many fields. By the 1920s their numbers were at a historic high, with women earning 14 percent of doctorates in the physical and biological science. But during the cold war years, the proportion of women Ph.D.s plummeted. They did not regain this level of participation until the 1970s. Filling the pipeline doesn’t necessarily help. Historian Margaret Rossiter says that women in science suffer from “hierarchical discrimination,” that as they move up the ladder of power and prestige, their number drops off much faster than does the number of men. The higher one goes in the scientific hierarchy, the fewer women one finds. This concept is one that deserves historical research and scholarly analysis.

My own view, drawn not on scholarship but on personal observation, is that there are several ways for contemporary women to get into the “top” echelons — and interestingly they all involve sudden events, rather than steady progress.

(1) Enter new growth fields that have a lot of resources being poured into them. These fields by nature are open to the best and brightest and, especially, the most aggressive — it happened 2 decades ago in computer science and is happening now in biomedicine. If a field blossoms during periods when women are trying to get into research in increasing numbers, there is opportunity.

(2) Use new facilities. The workforce of even relatively stagnant fields can be suddenly changed with the infusion of new facilities or technologies. Growth of new facilities can welcome new users as long as the policies governing use favor the most capable (e.g., the Hubble Space Telescope and the opportunities it has created for the entry of women in astrophysics).

(3) Introduce women from outside an organization as “agents of change.” The Clinton White House has appointed many women to significant positions. Left to their own devices, established institutions, especially ones in which the top positions are prestigious and therefore competitive, will not readily propel people with new or different approaches to the top, especially if the institution is comfortable with itself. It may have little interest in rocking the boat. The very notion of “nonlinear moves” signifies that a social revolution is being mandated from a force that has leverage over the institution.

Questions we might ask are: Why is it so difficult for institutions to reform in a slow, steady way? Why are social “mutations” or upheavals, rather than gentle evolution, generally more successful in changing culture? My view is that rules, many of them unwritten, form the basis of a culture. These rules are predominantly rules of conduct and, thus, behavioral in character. The struggle to change a culture introduces new behavior that may be unwelcome because of its unfamiliarity. The phrase “Old Boys Club” sounds trite and a little incredible in this day and age — until you realize firsthand how strongly behavioral and social much of our policy, planning, and management activities is. Our social history reveals that we have been effective in acquiring territory, food, and goods by being clannish.

One aspect of this conference is about identifying the challenges and taking practical steps to confront them. So I put together a list of challenges. The first few are my own; they are drawn from my academic, research background, and approach. The second group is from my female colleagues outside of NASA and my male colleagues within the Agency.

My own:

(1) The literature on women and the origins of science shows that western science culture is historically highly gendered (look at any issue of *Physics Today*, which still focuses on the white male history of physics). Knowing where we have been — our history in science — is the first step in making a plan for where we need to go. A study of other cultures is part and parcel of this approach.

This understanding should lead us to appreciate that a diversity of approaches benefits the generation and communication of new knowledge, both of these being vital to the success of science. But we need to go deeper than this; we need to change the culture of science itself to root out that which discourages women from continuing, once starting in this field, to wanting to continue. We cannot do this without a solid understanding of where we have been.

(2) Our view of what is “prestigious” affects our choices, including our career choices. We are affected by the definitions and trappings of success. By definition, anything prestigious is a limited resource: only a few can have titles, be the head, the Chair, the boss, the prize winner. There are often elaborate rituals

that accompany prestige, and these rituals can be strongly gendered. Involved in prestige, of course, is a society's notion of self-worth. If a group is excluded from attaining the prestigious positions, it sends the message that that group is not worthy. I think we need to examine how exclusivity is related to prestige and examine how we can move to a more democratic science.

(3) There is the problem of isolation. Isolation is different than being alone. On a dark night, under the stars and looking up, you may be truly alone. But rather than feeling isolated from the cosmos, you probably would feel closer to it, more in touch with the pulse of the universe. Alone is something active, something you choose. Isolated is what is done to you; it is being left out and kept out. We need to identify the processes that isolate us and work on changing them. One of the Washington women I mentioned earlier told me that often she is not invited to the table for important meetings, so, she invites herself; she simply appears at the table and is never asked to leave. In this way she becomes more aware of what is going on, becomes more participatory, and eventually gains the credibility she needs to get people to take her ideas seriously. Information is key to keeping isolation at bay. Information leads to smart involvement, and, for those who desire it, leadership.

(4) The agents of change themselves have to resist becoming part of the processes that once excluded them. This includes recognizing the need for mentoring and support groups; it includes embracing diverse approaches to the study of women in science itself. The field of women in science includes different approaches, which often work in isolation from each other:

- Statistical literature (leads to appreciation of current status, number of women in science);
- Historical/sociological study of women in science (leads to better understanding of the current number of women in science);
- Studies of the structure of knowledge crafted within institutions historically designed to exclude women — how to develop practical ways to create a science that is open and comfortable to all, what has been called a “sustainable science.” This emphasizes an objective approach that requires that the critique of science be joined to the generation of knowledge.

These three cultures need to come together in harmony to set a course for the future of women in science. A meeting such as this one is a good place to begin.

(5) There are still great challenges on the homefront. We need enabling processes that address domestic concerns: child care, parental leave and benefits, the promotion and tenure clock, shared responsibilities of dual career families. Enlightened policies will benefit both women and men.

(6) We need a chant like the Navy, you know, Hua! Hua! Hey, it builds solidarity throughout the ranks. Perhaps the right chant can lift our spirits when we need the bonding.

I asked the NASA Administrator how he would frame the challenges for women in science. He had his own list:

Reform peer review panels. Include more women and minorities and young people on the panels so that the goods are more widely distributed and the overall quality enhanced.

Reform peer review itself to be more embracing of new, innovative ideas and more critical of stagnant ideas that should be eliminated. This will improve the situation for young people in general, men and women.

Mentor better. Women need to feel less isolated and be better prepared to succeed.

Don't be meek.

A young woman astronomer colleague who has been on the forefront of women in science issues had this observation: "There are three kinds of women scientists today: senior women, many of whom grew into significant positions by emulating the characteristics of the majority male scientist and who are not interested in change; the middle group of women who may have tried at one point to make things better; and the younger cadre which doesn't see the problem clearly, but recognizes some disadvantages wrought by affirmative action programs." She says the challenge is to find a shared vision among these groups, acknowledging the difficulties but determined to plan an optimistic future.

A superachieving, action-oriented, woman planetary astronomer confided to me that she believes that the strategic battles have been won. But in the tactical arena, women are still at a disadvantage. She sees the challenge as how to gain acceptance by men in "hand-to-hand combat." She apologizes for that metaphor, claiming that she is not a battle freak, but, rather, battle weary. She says that women need to be listened to and respected. The problem is how to gain acceptance, without sacrificing ideals. An essential ingredient of the tactical approach is consistency: Be there, speak up, don't be angry (it turns everyone off, she notes), do what you have to do with grace and style.

Her observation is corroborated by some of my male colleagues at NASA, who offered that they see women's greatest challenge as needing to be taken seriously.

In the conference invitation letter, I was asked to draw on my own life experiences and my role as NASA's Chief Scientist. I have put novae, cataclysmic variable stars, pulsars, quasars — the exotic stuff of the cosmos — the stuff that had taken hold of my imagination since I was a student, on hold for a few years. I accepted the NASA Administrator's invitation to come to Washington for 3 years to work on integrating science in an Agency that does many kinds of science —

the physics of the universe, remote sensing of the Earth, in situ sampling of particles and fields in space, exploration of the solar system, gravitational biology and exobiology, the physics of fluids, materials and living tissue in altered gravity.

I was asked to help construct a vision for the future that would combine in new ways essential aspects of these fields. It would be necessary to break down the stove pipe nature of the old disciplines, areas of research that had grown mature and insular, and develop, instead, cross-cutting initiatives that would yield new discoveries and understandings of the universe, our solar system, and especially our planet Earth. I was asked to look at the science we do from the unique platform of space in full view of the public that funds the investment. How to set a course that was rich in its scientific goals, meaningful to the public, and, of course, cheap. That was the challenge.

The first thing I did was to lead an all-Agency effort to write a guide that laid out the conduct of our research. This policy document serves as the framework within which our programs are managed, from developing the concepts for new missions to finally disseminating the data broadly. The three concepts that were the underpinnings of the guide are quality, participation, and responsibility. We do not shy from the need to develop human resources to enrich our research programs. We do not shy from advocating open competition, peer review, and immediate dissemination of all the data that are taken. We redefine the roles of all the participants in a changed playing field. We encourage partnerships to leverage the science investment. We recognize the shared responsibility of the Agency and all its stakeholders in fostering education and public literacy in science and technology.

A similar approach might be applied to the questions posed by this conference. We need to develop a vision of where we are going, a clear sense of mission and goals. We need to frame the conduct of the new world of science that we envision: what are the policies we could aspire to, live by. And then, develop a roadmap for the future, a roadmap with metrics and evaluation points, a roadmap that sees the world in 10, 15 years as a different place for women in science.

My daughter, who is in the fourth grade, said that the worst talk is a humorless talk. So I will end with a joke, which I first heard from my Hubble Telescope buddy Anne Kinney.

Q: How many psychiatrists does it take to change a light bulb?

A: It only takes one, but the light bulb has to really want to change.

Lynda M. Jordan

Speaker

Opening Night Celebration: Reaching into the Future

December 13, 1995



Lynda M. Jordan

Associate Professor
of Chemistry,
North Carolina Agricultural and Technical
State University

Giving honor to God, I would like to thank the organizers and the National Science Foundation for inviting me to give remarks at this auspicious occasion. As a child of a teenage pregnancy, in a family who was on welfare, and raised in a single family home, I know that my presence here today is based on the grace of God.

Before we go any further, I would like everyone do something for me. Let's strip away our degrees: we all know we are accomplished. If we were not accomplished, we would not be in this room. Let's communicate with each other on a humanistic level. During these next few minutes I would like to address the subject, "The Role of Women in Science."

What is a woman? Women are different from men. Just on the basis of our daily activities we play a variety of roles. We are nurturers, creative, efficient, resourceful. We are mothers, grandmothers, daughters, sisters, wives, aunts, teachers and WE ARE SCIENTISTS!

In a publication entitled, *Who Succeeds in Science: The Gender Dimension*, by Dr. Gearhard Sonnert, documentation of the obstacles confronting women in science includes: family influence, the lack of early institutional support at the high school, college and graduate school levels, professional career choices, and family matters.

At a time that we are questioning the validity of affirmative action, I know the significance of affirmative action. Had it not been for affirmative action or the civil rights movement I would not be here talking to you today. I am living proof that a brain has no gender; a brain has no color nor does a brain have a socioeconomic level attached to it.

I recently read a book by Jeremiah Wright; he discussed the topic of assimilation. Many people think when we talk about assimilation that we are discussing the assimilation of going from a black to a white environment or a white to a

black environment. However, assimilation is when you abstract from anything that is not yourself. Yet, there are problems associated with assimilation. If one continues to assimilate, eventually you will forget who you are. When you forget who you are, you forget what your role is in any given situation. Assimilation totally destroys who you are. And the sad thing is that you don't even realize what is happening to you, because when you assimilate, you forget who you are.

I recently was invited and participated in an initiative to South Africa organized by the Citizen Ambassador Program. The purpose of this delegation was to discuss plans for the reconstruction and development of the new South Africa. One of the major points that I came home with was that the South Africans know that the progression of their country is directly proportional to the education of their women! The struggles that the South Africans are experiencing are similar to struggles of blacks in this country prior to the civil rights movement.

Two things happened to me while in South Africa. First, for the first time in my life, I felt totally accepted just as I am. This experience was one which I wish everyone in this room could experience. Second, I realized that my struggles are an asset; that every struggle that I had encountered in my life has a meaning, and there is a reason for these struggles. A benefit of these struggles is the fact that other peoples can benefit from them.

The first thing that we must do is heal. We have to heal. The PBS documentary, "Discovering Women," gave me and my family the opportunity to heal. My participation in this project was a family decision. We had many conversations about this documentary, and we decided that we will allow it to air. Believe me, I was kicking and screaming throughout the preparation of the show. Judith Vecchione and Yvoone Smith could attest to that. To answer so many people's questions, we are not getting paid for the participation in this series. Many people have asked me if we are getting paid, and we are not. However, our (the six women scientists) participation in this endeavor is based on our intense commitment to the education of the youth. If one person is inspired to pursue a terminal degree in chemistry because of this film, then it was worth it. I do what I do because I want more individuals to go to school and pursue a degree in science. I believe the nurturing of a person to pursue a higher life is just as important as a scientific research journal article. In fact, I think it is more important.

According to the *New College Course and Transcript Files* published by the U.S. Department of Education, people are interested in technological advancement. An example of this is computer technology. I do not know about you, but I rely on my students to help me keep up with the new technology in computers.

As women, we need to define ourselves for ourselves. Our contributions should be based upon where we can make a difference. We have a contribution to make. Our contribution is unique and is needed for the progression of not only the American society but also the world. Throughout my international travels, it has become apparent to me that the whole world is looking to

America to solve some of these problems, we have to find a solution. The world is waiting for us. As women, we have the capacity to look at all aspects of the problems we face and the needs of our children.

Be yourself, rejoice in you, and allow yourself to evolve into that well-rounded, beautiful, unique, intelligent creature that you were created to be. God bless you all and Merry Christmas.

Shirley M. Malcom

Plenary Session Speaker

Policy Implications

December 15, 1995

I must confess that I feel under a lot of pressure. I came to the talk the other night, and I heard France (Córdova) stand here and very eloquently talk about a lot of issues. Then I had to sit there and listen to Linda (Wilson) and Lydia (Villa-Komaroff) give everyone good advice in elegant language. And here I stand at 8:30 in the morning to talk about policy. This is a topic that everybody thinks of as being boring, and so I really have a job in front of me.

Luther kind of gave you a biosketch of what I do, my day job and my night job, but he really did not tell you, even though he knows, who I am. In a way, I stand here as an impostor. You hear the degrees, and the committees, and the boards, and the access to policy levels. But I look in the mirror, and I see something that is very different. I see the accumulated experiences that span a cultural and generational divide. The leading front of the baby boom, the forcing edge of the civil rights and women's rights movements, a child of Sputnik, a child of Birmingham, Alabama, the 1960s, and Earth Day. A person who still has problems getting a cab. A person who gets asked if she is with housekeeping and can open a hotel room for someone who forgot his or her key, even when I am dressed up. A person mistaken as a clerk in the store but invisible to the clerk in the store.

So I just want to tell you that even if I ever thought about getting a swelled head because of the opportunities that I have had to participate in the policy world, there is always something there to remind me otherwise.

While some of you might find all of this an unsuitable combination for the policy world, I think that it gives me a kind of interesting place to stand. That, plus being the mother of two teenage daughters, one of whom, thankfully, just finished all of her college applications. We did not want to take that into the holidays.

Now, all of these things really teach you a lot. And I said, policy has a way of being boring, but I think that it is very exciting. It is exciting when you basically



Shirley M. Malcom

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American Association
for the Advancement
of Science

have had a chance of experiencing policy up close and personal. And I had a chance of experiencing policy up close and personal.

I was born and raised in Birmingham, Alabama. I went to segregated schools, schools that were segregated by law. I know that sounds weird right now, but that's what I experienced. Even though Brown versus the Board of Education was settled in 1954, when I graduated in 1963, I had never gone to a school that had been integrated. I really thought about this a lot. I thought about policy, and the fact that it was policy that we did not have schools that were segregated. But the reality was that we did. I realized that policy lets things happen, but it doesn't necessarily make things happen. That was a good lesson to learn, and to learn it early.

One of the other lessons that I learned was that benign-looking structures can be barriers. A lot of you might think, well, there is good and sufficient reason to have things like literacy tests. People who vote ought to be able to read and write, have some things, and know things about our country and our democratic processes. There are a lot of good reasons for that. There is a good reason for thinking that we ought to be able to pay for the structures that allow us to vote — you know, poll taxes.

But, in fact, we know that for many years that these were ways of holding members of a group to different and higher standards because they were not implemented the same way across the board. They were used as mechanisms for discrimination.

So the benign-looking structures can have other than benign consequences. I want to point this out in terms of women. I want to give you a lesson on that with regard to the use of certain kinds of defining and discriminating criteria, in things like admissions, and in the award of fellowships.

We can use the GRE as the primary way of screening, and get one set of results. Or we can use the GPA as the primary mechanism of screening, and get a totally different set of results. We know of cases of where, when universities basically have flipped the way that they made decisions, that they ended up not liking the results. Because they got "too many women."

To those who have these kinds of arguments, do you want a measure of a morning's activity, or measures of many years of effort? These are the kinds of things that we really have to look at — structures that otherwise look benign.

One of the other things that Birmingham taught me was how to recognize the lesser of two evils and to make an active choice for the lesser of the evils, rather than just getting out of the game. Sometimes I think that we let the perfect be the enemy of the good; that we have to be careful that in seeking the perfection, that we let something that is even worse come into play because we do not make an active choice for the lesser of the two evils.

The third issue that Birmingham taught me was how policy can let things happen, but that people have to make things change. The other thing that I learned was how much easier it is to get change when money is involved.

Margaret Rossiter reinforced that for me in her work when she talked about what was done by the women who contributed to the establishment of the Johns Hopkins Medical School. By conditional philanthropy, Johns Hopkins — the number one medical program in the country — always admitted women to the medical programs, and it did not hurt them.

But, in fact, strings were attached. The golden rule was exercised. Those who have the gold, make the rules.

So this notion of incentives, and sanctions, and rewards, and punishments, and carrots, and sticks, and all of these kinds of things, I learned very early. I learned another thing very early, too, that I think is always important for us to remember: We have to be satisfied with changing behavior first and letting hearts and minds follow. People are always talking about how their heart is not in it. Forget their heart. Change their behavior.

But let's talk about policy. This is going to be Policy 101 because, quite frankly, I think that some of us have a mistaken view of what it is.

Let us get the first definition. This is a dictionary, and some of you may actually be kind of surprised by this definition — I was. The first meaning of policy is prudence or wisdom in the management of affairs. Isn't that amazing. Yes.

The second definition gets a little bit more down to the kind of nitty gritty of it, basically where there is material interest that is involved. It is only the third definition that gave us this thing that we tend to think of as being policy, a definite course or method of action.

Action is the first idea. Selected from among alternatives, that means you can do a lot of different things — it is the thing that you choose to do that is the issue and, in light of giving conditions to guide and determine present and future decisions.

And this is a critical point. What we do now will have consequences in the future. They may not be the consequences that we want. So we always must be prepared to modify and tweak our policies. The very fact of having them in place changes the conditions in which they are operating.

I will give you an example of where this has had negative, unintended consequences, namely, Title I. A lot of us will argue that in the Great Society days when Title I was put in place, it was put in place for really terrific and wonderful reasons. Those reasons were to make up for some differences that were being made on kids based on the amount of resources that were going toward their

education. Over the years it was used to try to give those kids a leg up. What ended up happening is that it was used only in those remedial kinds of ways. You can never catch up by only having things remediated.

You will never catch up because the rest of the world doesn't stop. It requires a major modification in the way that we think about Title I, so that we can remove the unintended results of truncating the educational experiences in favor of what we now understand as being better practice. That is an example of where we're always having to tweak the policy environment.

We must remember that policy actually involves a number of different kinds of pieces. It is, first of all, figuring out what we want, what is most desirable, what we want out of the system. And then, there is the issue of establishing the rules so that we can achieve what is desirable and minimize what is not. But one of the things that we must remember is that it is an imperfect process. Not all policy is good for all time. So there is this question about constant adjustment. As the environment changes, the context of the policy has to change. So we have to reexamine.

I wanted to distinguish policy from practice. Or maybe I should have called it implementation. That is, how the game is played, once the rules have been established. There are lots of parts about practice that, in fact, are very important.

First of all, do all the players understand the rules, and what the rules really mean? Are the referees doing their job? Are they playing favorites, or are they really being impartial judges as to whether or not the rules are being followed?

Policy is not just something that is done in DC, or in Albany, or in Harrisburg, or Trenton, or Sacramento, or Annapolis, or wherever. It is also how every institution that is a part of the system sets its rules.

If your university has students wait until their junior year to declare a major; if it has no mechanism set in the departments for bonding students to the field, identifying the students, bringing them to science, keeping up with them; having a way for them to explore career options; if there is no opportunity for undergraduate research because they do not show up until they are juniors, not declared, for meeting and interacting with role models, then you are part of the problem. The research says that we have to be attentive to what happens to women and to minority students when they hit the door.

We have found, when Marsha Matyas and I actually did some work looking at these kinds of issues, we found that most institutions did not even have any coherent sense about what retention rates were. They for sure did not know theirs — and do not ask for any level of disaggregation.

We can find retention rates and graduation rates for basketball players because it is now required by NCAA rules that they tell us. But we do not necessarily

know if students come to us as a major, whether they finish in science or what happens to them. You have to look inside your own institution and find out if anybody is keeping score. That is a part of policy.

One of the other issues that France Córdova brought up was this notion about the difference between strategies and tactics. Strategies are kind of longer term things. Tactics are what you can refer to as hand-to-hand combat. Essentially, I want to give you a couple of tactics to use in the next meeting that you're in when somebody says something that's a little bit off-the-wall. Ask them for their data. They almost never have it. Or for the citation of the research paper that has caused them to say whatever it is that they said.

It is those kinds of issues where people are basically allowed to get away with statements that are just full of it, that I think that we have to basically challenge people. We have to stop being polite. We have to challenge people when they say something that is not really supported by the evidence.

One of the important issues is this last piece down here, that is, indicators. How do we know what has happened? Okay, we have the policy, we had practice or implementation. Now, how do we figure out what happened as a result of this? The only way we can do this is to have some kind of indicator in place that can help us figure this out. That's the only way.

We have to look and see if any change happened and then be ready to make the change in the policy if it is, in fact, not giving us what we need. Document the problem — it's absolutely essential that we do this. If anyone starts to tell you that they don't think we need to collect these data anymore, I want you to become very attentive.

We have to have data disaggregated in ways that allow us to understand what is happening within the system. I want to talk about one example of this where it is absolutely crucial — you see, this is what happens when you don't count. That's a play on words. It's absolutely a critical issue internationally.

In a lot of cases people just didn't keep the data that would allow us to understand whether women were going into scientific careers in other countries. Based on the experience that we have had before Beijing, in Beijing, and after Beijing, a lot of us are coming to understand the absolutely critical role that science and technology play in development.

There are millions — no, there are billions of women who are out there whom aid money never really reaches, because they're not sitting at the policy tables. You only get to the policy tables if you are elected or if you have "expertise" and credentials, whatever that means.

We have to be concerned about the women who are in science and technology in those other countries. We have to be concerned about the way that aid monies are used in those other countries, whether they are basically used to put

in technology that really doesn't fit into the context of those countries, and who is being served and what are the results and the effects on women. We've got to do this. And that's just one example of where data really make a difference.

A lot of us have fought this battle of strategies for many, many years. One of the battles that we have fought is this notion of targeting versus mainstreaming, and I think the biggest battle that we have fought is the versus. These things have been held up as being basically separate kinds of alternatives, or separate options for us in the policy arena. That somehow the issues of women get focused on, or somehow that they get mainstreamed, as though they're basically choices that have to be made. We must have both.

We are not to the point in time where we can do away with targeted programming. We will need targeted programming for some time to come. We need to fold the lessons of targeted programming, though, into structural reform. That is the challenge that is before us. We have to figure out what has worked for groups that are underrepresented and figure out how to build that into the transformation that is now occurring within systems. The systems are transforming because they have to. We're going to have less money than ever before, and more work that we have to do with that less money. You cannot do that unless you reengineer the system.

The issue is that, rather than all of us working all the time on our targeted efforts, some of us are going to have to transfer some of our energies in time, to taking those lessons and putting them into structural reform. The "systemic-ness" needs to include inclusion.

What we have right now is very small money in targeted efforts, trying to overcome the inertia of a massive system that is trying to maintain the status quo. That's what we have. So we must affect that massive system.

That means that every rule that people have exercised within that system must be on the table for reexamination: peer review, the criteria for awarding grants, the way money is used, what we ask PIs to do. We ought to be able to ask them and expect that they can walk and chew gum at the same time.

In our broad policy document within the National Science Foundation, *NSF and a Changing World*, the integration of research and education is held up as a goal. In order to make that goal a reality, every person has to do his or her part. One PI at a time, one grant at a time, one center at a time. Every person must do his or her part.

As we are developing this reengineered system, quality, equity, access, and inclusion must all be design specifications, at the same time. We've got to figure out how to make all of these things happen, not one or the other. All of them.

I wrote a chapter on policy in *Investing in Human Potential*. The chapter was called "More Than Market Forces." We have a lot of faith in market forces, and

my contention in that chapter was that it will take more than market forces to make these kinds of changes. If we are going to strive for structural change, which is what is the topmost part of this triangle, we have all of these other things that are currently in vogue: isolated projects.

I have gone onto university campuses and met people who were involved in projects and they didn't even know about each other. They all had programs to try to bring people to science or to engineering, and they were not even aware of each other. This is a lot of what is going on.

Until hard dollars get spent to bring all people to the enterprise equally, it is not real. The rest of this stuff can go away. Soft dollars can go away. The volunteers can leave or get tired, or get sick, and try to do too much, and I think that is the thing that we have to try to ask. How are people admitted? How are they counseled? How are the dollars spent? Who's doing what?

It is great to have goals, and we need to express them, but at some point we have to get down to the nitty-gritty of what actions can move us toward those goals. And that's really where we are right now. They have to be do-able. They have to be things that can lead to change.

Change is not going to be easy for any of us. A lot of you have heard me say this little expression: Nobody likes change but a wet baby. It's not in our nature to like it, but if there is a silver lining to the cloud of the budget reductions, the silver lining is that it will force us to look at our systems again. The opportunity for change is therefore greater than ever before. Life is handing us lemons. It is up to us to make the lemonade.

Anne C. Petersen

Plenary Speaker: Achievements & Challenges

Women and Science: Promoting Leadership for National Progress

December 14, 1995



Anne C. Petersen
Vice President for
Programs,
W.K. Kellogg
Foundation
Formerly Deputy
Director of the National
Science Foundation

Good morning. I can't tell you how exciting I find it to join Linda (Wilson) and all of you as we launch into the first full day of this pathbreaking conference.

As you know from your agenda, this promises to be a very full day. But our agenda is only as ambitious as the goals we have set for ourselves. This is a watershed event, looking backward and forward, and its potential impact extends beyond each of us and the institutions we represent.

My remarks this morning are entitled, "Women and Science: Promoting Leadership for National Progress." In particular, I want to talk about the need for greater leadership from all of us in advancing science in our society. As we celebrate our past achievements and begin to chart our future challenges, our potential role as leaders should be front and center in our thoughts. In particular, we need each of you to advise us at NSF about how we can best address issues of women and science for the future.

Leadership is complicated. We often make the mistake of assuming that leading is simply a matter of being first or occupying the top spot. It's really much more than that. There's an old saying that leadership is the only ship that doesn't pull into a safe port in a storm.

In this same way, our role as leaders involves more than just sitting in the same chairs and occupying the same offices as those who came before us. We should strive to provide a new vision and direction for science in America. I believe each of us can help to craft a vital and vibrant, dynamic and diverse, scientific enterprise for the twenty-first century.

This is a challenge that several organizations like the Association for Women in Science have been addressing for over 20 years, and we have made progress on many fronts. For example, if you were to review the telephone directory for the Clinton/Gore Administration, you'd see that women hold some 40 percent of the presidential appointments, a percentage that also holds for the key science and technology posts.

It's been a very pleasant surprise for me to hardly ever be the only woman in the room at policy meetings. I'm almost always able to see people like France Cordova, Laura Tyson, Alice Rivlin, Sheila Widnall, Mary Good, Martha Krebs, Anita Jones, Arati Prabhakar, Jane Wales, and until a few months ago, MRC Greenwood, among others.

When we look outside government, there are also many signs of progress. We'll hear about industry at lunch today from Lilian Wu of IBM. At private foundations and societies like the Carnegie Institution and the AAAS, we see more and more names like Maxine Singer and Rita Colwell topping the masthead.

It's interesting to note — but perhaps not surprising — that leadership in academe has been slower to change. The Linda Wilsons of the world remain the exception and not the rule. In fact, aside from Judith Rodin at Penn, the presidencies of the top 20 research universities remain an all male enclave. To repeat, that's 1 in 20 or 5 percent. Percentages that low don't cut it even when you grade on the curve. And it's hard to explain that percentage as sampling error.

This makes clear what achievements we should celebrate and what challenges we must still chart. We want this conference to help us work toward that long-sought critical mass for women in science. Also, ask how our leadership can enhance the contribution of science and engineering to our society. What can we do to make a difference?

This challenge has taken on an increased sense of urgency in recent weeks and months. I know that many of you have been following the political machinations on the budget and what the future holds for research and development in the latest federal budget scenario.

The appropriation for the National Science Foundation has not been resolved as yet. Although the House has approved the conference committee's agreement on our bill and the Senate is expected to do the same, there is strong likelihood that the President will veto it — not due to any disagreement about NSF but because of other issues.

Of more long-term concern is the bleak outlook for federal R&D funding in the current balanced budget projections. In addition to the grave damage this can cause to the nation's economic and social progress, we cannot ignore the reality that opportunities for women in science will be cut short if science and technology are cut short. It is therefore our responsibility to speak out for R&D generally and to provide greater leadership for science and technology in our society.

In the historical record, we find many discussions of the roles and responsibilities of men and women, for example in the writings of Socrates in the fourth century B.C. In the early 1900s, many centuries after Socrates, Susan B. Anthony, the American suffragist, stated the case quite wryly. She said, "The only question left to be settled now is, are women persons?"

The constant irony has been that women have possessed the fundamental qualities of leadership, but their traditional place in society has typically denied them opportunities to exercise that role beyond the home. Many women of my generation did not have mothers who worked outside the home. Breaking away from that traditional role-model with a sense of exhilaration and authority, rather than a sense of guilt, was not always easy.

I grew up in a small town in Minnesota. I was very interested in mathematics and at some point got the message that this was not something that should interest a girl. I really had to fight for my place, and I will never forget the many experiences of exclusion. In many respects, I am leading the life my mother would have wanted to lead.

It saddens me that she could not use her talents in the same way. It makes me all the more conscious of the terrible “national loss” we have experienced, and continue to experience, when women are not able to become leaders in fields in which they can excel. American science continues to suffer from such a deficit, and this has negative implications for our long-term economic prosperity.

Evelyn Fox Keller, physicist and noted historian of science, has focused on questions of masculinity in the language and values of science.

In documenting the powerful male view she says, “We see it at the very beginning of modern science with the scientific revolution of the seventeenth century. The Royal Society of London, one of the first modern scientific societies, was founded in order to ‘raise a masculine philosophy.’ In the most general sense, science meant ‘thinking like a man.’” Incidentally, the Royal Society was established in 1662 and did not admit a woman until 1945. Thus, attitudes about science as masculine seem to accompany behaviors that excluded women.

Those definitions do not belong solely to past centuries. In 1966, the year I received my baccalaureate degree in mathematics, the stereotypes were alive and well, as evidenced by a compilation of essays on science and national goals from the National Academy of Sciences. One essay was able to state unabashedly, “The level of federal support should always be adequate to provide research opportunities for all those men who give promise of true originality.”

In a sense, this statement exemplifies what we each have had to overcome. The road ahead may not be much easier, but the prospects for success and the opportunity for leadership are, I hope, greater now.

Let us be clear. As we work to advance women’s leadership in science, we must also remain focused on the larger goal of advancing women in leadership roles across the broad spectrum of the society. Leadership in science will be but one component of that broader agenda.

Consider, for example, one area where our contributions can extend well beyond the laboratory. A recent study completed by the Johnson Graduate School of

Management at Cornell University sheds light on an issue that directly affects our industrial prowess as a nation.

The Cornell survey found that fewer than one-half of the managers in 1000 companies were viewed as technologically literate by their colleagues. It's hard to believe in this day and age that a corporate manager could get away without knowing the difference between quantum mechanics and auto mechanics, or between a potato chip and a computer chip. Then again, that might explain our R&D cuts in the federal budget.

This fact provides just one more reminder that we cannot let history repeat itself and allow anyone to define too narrow a role for women in our society. By 2010, an NSF study estimates that 25 percent of all jobs will require technological expertise. We need to ensure that women have the opportunities to attain such expertise, whether their careers take them to science, to corporate America, or to government.

I am proud to say that the National Science Foundation has taken serious steps to advance diversity and inclusiveness.

For many years, NSF has been aggressively engaged in remedying the underrepresentation of women and minorities and persons with disabilities in science and engineering professions. We are required by law to do so. We have no intention of wavering from that goal. But we are nevertheless taking a new look at our efforts in keeping with the recent Supreme Court decision that, as the President said in June, "raised the hurdle" for federal affirmative action programs.

It's best to describe the potential changes in our programs as a change in emphasis, rather than a sea change. We have stepped up our assessments of the effectiveness of targeted programs at reaching their goals. We are also assigning higher priority to developing nonexclusive alternatives for our targeted programs and will implement any appropriate alternatives.

An NSF task force is currently examining these issues on a program-by-program basis, and we should be able to provide more specific information in coming months about how all of this affects specific programs, like the Visiting Professorships for Women and the Program for Women and Girls.

Despite all of this legal and policy uncertainty, there can be little doubt about the impact of specific projects NSF has supported. If you wander through the showcase hall, you can see a number of the success stories that have emerged from various NSF programs. For example, our support helped to start the project known as WISE, for Women in Science Excel, at SUNY-Stony Brook.

This project focuses on six crucial years in the educational pipeline — 9th grade through sophomore year in college. From a large body of research, we know that these are the years when a disproportionate number of well-qualified

girls and women change their minds and give up on potential careers in science and engineering.

We now know that grades and ability are rarely the cause of their decisions to leave science. In fact, one recent study found that across the country, women undergraduates outperform men in mathematics courses. Role models, mentoring, and attitudes are key factors influencing dropout from science and math. WISE is one of many projects that is seeking to make a difference in these factors.

Your tax dollars are also at work through the project known as Bridging the Gap, led by Marilynn Sikes and Discovery Place of Charlotte, North Carolina. This project helps us get an early start because its goal is to make science, engineering, and mathematics a part of Girl Scout activities. It's an ambitious program with the potential to reach the nation's 2.6 million Girl Scouts. While this project may never achieve the fame of cookie sales, it will undoubtedly contribute more to science and less to our waistlines and cholesterol levels.

All of the projects on display bode well for the future of women in science and for the nation's future. Indeed, the increasing infusion of women in the sciences and engineering may well change the nature of our national science agenda. For example, the greater numbers of women in the life sciences, now about 40 percent of the total life sciences workforce, will surely increase our knowledge about women's health and perhaps preventive approaches. We cannot predict what new discoveries will emerge, only that we will surely benefit from the pursuit of new questions.

Returning to Evelyn Fox Keller, she wisely instructs: "Science gives us a description of nature. Science gives us scientific theories of nature. [But] There is no magic lens that will enable us to see nature uncolored by the values, hopes, fears, anxieties, desires, goals that we bring to it."

This is important guidance as we move more aggressively to diversify the science and engineering workforce not just by gender but by ethnicity. As this workforce changes, there are likely to be observable differences in the direction within disciplines as well as in the development of the larger body of knowledge.

Not long ago, I heard somebody ask, "What good is diversity?" In biology, if we don't have diversity within a species, we begin to see that species die out. The same may be said of science: Extreme orthodoxy of theory and perspective stifles debate and experimentation. We need the richness of many ideas from many different perspectives. Unquestionably, that's one of the important contributions increasing numbers of women can make to science.

The challenges that lie ahead for women's leadership in general, and in science in particular, are formidable. I am sure most of you have gone hiking and mountain climbing on occasion and are familiar with the phenomenon known as the false summit. You are hiking up a hill, and you think you are approaching

the summit. You're hungry and thirsty, and the kids are ready to break out the chocolate bars.

Then you reach what you thought was the top, only to find that it was just a false summit, with the true summit still a few hundred feet above you. That's when the kids let you know that they have had more than enough and begin to accuse their parents of playing a cruel joke on them.

When we look at the statistics about women in science and engineering, it's easy to be misled by a few false summits. Women have made progress in virtually every area of science and engineering. Recent data show that women have made major gains in employment in many of the sciences: They now account for 40 percent of the biologists and 30 percent of the chemists. But perhaps you can help us understand the increase of women in computer science to 30 percent and then the sharp fall off more recently. Was it a false summit?

Like the false summit, this progress often reveals an even greater set of challenges. For example, women now earn nearly one-half (44 percent) of the bachelor's degrees in science and engineering. Unfortunately, there is a steep drop off at the Ph.D. level, as women earn fewer than one-third of the doctorates. This looks like a classic case of stopping — or being stopped — short of one's goal and never getting to enjoy the view from the summit.

Other trends reinforce this phenomenon. NSF's surveys show that women scientists and engineers holding the Ph.D. are less well off than men with respect to unemployment or underemployment, salary, academic rank, and tenure, even after accounting for differences in years of experience.

There remain other areas where even the false summit lies far off in the distance.

Dr. Mary Good, Under Secretary for Technology at the Department of Commerce, has made a special plea for more women engineers and technologists. She notes that there are many more women in science than in the technological fields. The numbers for women in engineering sometimes seem stuck in time — women earn only 15 percent of all baccalaureates and only 9 percent of the doctorates. Percentages that low make you think we were talking about the 1950s, not the 1990s.

None of these trends bodes well for leadership. Furthermore, these statistics also tell only one small part of the story. A 1991 study by Judy Dubas and Julie Graber found that despite education attainments, women aspire to lower status jobs. Our society is also only beginning to appreciate the true complexity surrounding issues of family and child rearing. In a report I co-authored with Phame Camarena and Mark Stemmler, we found that young women still expect to play a larger role in family responsibilities than do young men.

If we went around the room today, we'd undoubtedly find a few hundred stories that each shed new light on this issue. I recall a friend telling me that we kid

ourselves into believing that child care duties can be split 50/50. They really require 110 percent from each parent.

My husband and I were determined to do it all and not slow down after our daughter was born. We went so far as to develop an elaborate changing of the guards system of child care. Every day, we would meet at the train station — the “IC” as its known on Chicago’s South Side. One of us would carry Christy in a tummy pack, and we would hand off the pack as we passed each other at the turnstiles. I’m sure we were quite a sight.

As unique as our system was, I’ve realized that being a woman scientist is no different from being a women in any professional field. When I compare notes with friends who are in law or business, the issues are the same; they just use different terms. Instead of worrying about how having a family will affect their chances at getting tenure, they worry about how it will affect making partner. We worry about publish or perish; they worry about billable hours. We need to get our proposal in; they need to meet their sales quotas or their court deadlines.

In the end, the solution to our leadership lies within ourselves for ourselves. We who have climbed the steep slopes by clawing and hanging-on, should not demand this as initiation for those that follow. Rather, we need to provide a web of support, encouragement, and example. We must nurture, guide, and teach. We must reach down to girls and young women and show them a path paved with encouragement. And this effort will only be enhanced by the participation of our male colleagues.

This conference is working on several creative ways to do this. We must also take steps as simple as submitting names to nominating committees and search committees for top honors and positions. Other steps might be more complicated, as we explore new ways to organize ourselves and expand our influence and contributions. It is extremely important that each of us sees this as a personal and professional responsibility.

We should also think big. For example, we know that the life sciences are growing rapidly and that women comprise a large and growing share of researchers in the field. Thus, it is not unrealistic to suggest the possibility of major female leadership in the next decade in the fastest growing science discipline. What we know about goals and dreams is that if you set your sights high, you tend to reach high.

The writer and social commentator, John Gardner, tells us of the importance of leadership and leaders. He says, “Leaders have a significant role in creating the state of mind that is society.” There is much that women can teach science, the nation, and our culture. It has to do first with thinking of ourselves as leaders, and that will take us where we want to go.

We at NSF thank you leaders for being here to work on this important agenda.

The talk last night and this morning about the importance of cheers to bonding and inspiration in the military have led me to conclude, not with a joke but with a cheer. Like many girls and women with frustrated athletic aspirations, I was a cheerleader in high school and college. I will end with an adapted University of Chicago cheer. I'll bet most of you didn't even know Chicago had teams, much less cheerleaders! It goes:

Thucydides, Demosthenes, Peloponnesian Wars

X^2 , Y^2 , H_2SO_4

Who for, What for, What are we for?

Women in Science!

Lydia Villa-Komaroff

Speaker

Opening Night Celebration: Reaching into the Future

December 13, 1995



Lydia Villa-Komaroff

Associate Vice President for
Research, Northwestern
University

We're here tonight to celebrate, and we're here tonight to talk about challenges. What I'd like to do is to issue one. We've been talking and we've heard about some of the challenges that women face as we move into positions of — we hope — influence.

We've heard that institutions haven't really responded to the fact that there are many talented women, only a small fraction of whom are here tonight, from which to draw into these positions.

I think one of the things I would like to tell you tonight, because we are a privileged group — no matter what our background, or where we came from — the fact that we are in this room tonight makes us very privileged. And I think we mustn't forget that. The other thing we mustn't forget is that power is not given. It must be taken. Women are at a substantial advantage. After all, we're not X-chromosome-deprived.

The other thing that I think we have to keep in mind is that life is not fair. You will not necessarily get what you deserve unless you're quite aggressive about demanding it, and that can be done with grace and skill, and in fact must be, since if it is done clumsily it is likely to backfire, and then you'll just be one of those troublemakers.

And so tonight as we sit here, we all have to decide in which direction we will go. The very sad fact is that very few women are moving up into the hierarchies of academics, or of business, or of law, or of just about anything else that you can think of.

We're particularly concerned tonight with science and the doing of science, and I would like to say that those of you who are here have a responsibility. And it's not easy. It never has been easy. It's not easy for the men. It won't be easy.

You will have to make choices. You will have to make decisions. You will make sacrifices. And it will be worth it, because then you will be in a position not only to control your own life but also to help control and to advocate for those who come behind. We will hope that the next generation will be easier. My generation's experience has been made easier because of the women who have come before us.

Yesterday there was a small reception given at Harvard Medical School for three of us who are leaving — by happenstance all at the same time. I'm going to Northwestern to assume the position you just heard about (Associate Vice-President for Research Administration). Priscilla Shaeffer is going to assume a chairmanship at Pennsylvania, and Jean Patterson is going to assume a chairmanship in San Antonio. So we figure we're doing double-digit subtraction of the women faculty at Harvard Medical School.

And some of the women there said, you know, it's kind of too bad. And we said, well, you know, it just so happened that we all happened to leave at the same time. There was no plot. And they should think about where they will go, too.

Priscilla was telling us about the first time that she went to a faculty meeting at Harvard, and one of the professors there asked her if she was the dean's secretary. That doesn't happen anymore. You will get funny looks, but you don't get the question. That's progress. And that's how we measure progress.

As we stand here today in this room, this room would not have been possible 15, 20 years ago. It would have been difficult to amass an interest and a group of such power as we have here tonight.

So, yes, there's an awful lot to do, and there are a lot of positions that we need to fill. It is a challenge, and it will not be easy. But we can do it. We have the talent, we have the creativity, we have the diversity, we have a multitude of approaches that are very much needed, particularly in this time when resources are so constricted that the traditional ways of doing science will not work. If we continue to do things in the same way that we have, it's going to be very bad.

On the other hand, we must also realize that resources are not going to grow suddenly. They simply will not. Resources will continue to be constricted. And so we have to be very creative in ways in which we will be able to say to students, yes, you must learn science. This is a wonderful thing for you to learn about. At the same time, make them realize that even with all of the talk of, "there are no jobs for scientists," "we are producing too many scientists," we have a scientifically illiterate society. This is not acceptable. We may, in fact, be educating too many bench scientists, but that is a remarkably limited view of the role of science in this society. We could use a few more scientists in this Congress and the Senate.

A talented student came to my office the other day. She came in, closed the door, looked at me very seriously, and said, "Was it worth it?" And I said, "Was

what worth it?" She said, "You know, this. What you're doing." And I said, "I can't imagine doing anything else. You know, what am I going to do, stay home, and do whatever? That's a perfectly wonderful thing to do, and I admire people who make that choice. But the choice needs to be made consciously. It's not a matter of, 'you will be able to do everything you want to, all of the time.' It's a matter of setting your own priorities and deciding what costs you will pay to reach them."

I think what I'm going to do is stop a little early with the thought that we should rejoice in this challenge before us. We have made progress. We will continue to make progress. There will be times when it will be very discouraging, probably tomorrow after we hear more of the budget talks. But we must remember that there is a group of people who care about the scientific enterprise. It is critically important to the health of this nation.

There is not a child in the world, I don't think, who doesn't begin as a scientist. I sometimes think that is our purpose in life. We were meant to be scientists, and somehow we have managed to turn that off in most children. That is not necessary. We need to change that. Reach as high as you can. Reach out and embrace, as Lena Horne would say, life. Hard life. Unfair life. Because...that's the way it is.

Luther S. Williams

Closing Remarks

December 15, 1995

This has been a remarkable gathering that began with an ambitious agenda and ends with a tribute to the hard work of all of you. We affirmed, from our various professional communities and experiences, that we must permit ourselves — at all levels of education and career in science, mathematics, engineering, and technology — to develop and nurture talent, independent of background, independent of perspective, independent of any of the categorical labels we apply to individuals.

The ultimate objective will be realized when our society is able to draw talent freely to address the challenges that confront it. To make these gains, the fundamental climate of science and engineering has to be made more accommodating and more engaging. Throughout the program, everyone has worked in small groups; has made contributions by taking stock of the status of past efforts, the challenges; how far we have come; what needs to be done in terms of affording quality participation, formally, at all levels of this science learning continuum.

As was pointed out, knowing the baseline is important. So understanding the data, having it available, acting on it, putting it into the context of the larger demographics that informs the disciplines, is very important to define opportunities and shorten the course for the future.

At some level, there is the opportunity for more discussion — at least to consider the broad outlines of a plan for action. But I suggest, as several people have, that those considerations be very much informed by the Policy 101 lesson that we had this morning, provided by Dr. Shirley Malcom, with respect to do-able activities. Not to suggest that the large impediments do not exist. It simply seems to me, to be an opportunity to make a fundamental structural change.

Nonetheless, in all of the efforts, there would not be the opportunity instantaneously to revise the status quo. That is a self-evident observation, so it should not require additional periods of lament. Yet, we would rather suggest that, as



Luther S. Williams

Assistant Director for
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Foundation

everyone leaves and returns to their colleges and universities, they really focus locally on what can be done. Recalling, of course, that no agency, or sector of society, can change these conditions, at least acting alone.

The impediments and the barriers are simply too great. So there is much to recommend collaboration as we attempt to make progress against these great challenging efforts.

We, as an agency, obviously can continue to make a contribution. Soliciting everyone's ideas to our planning is crucial. We can, in particular, continue to undertake activities; test models; and share attempts to reach all segments about science learning to the extent to which ingenuity, program planning, and our resources will permit.

We have, with everyone's participation — meaning that you are the performers doing exceptionally good work — exhibited in excess of 100 such projects or samples of a large investment at this conference. The point of this sample of work is that we used it as a base to engage in discussions about the future.

As to the conference outcomes, I know I speak for Director Lane, Deputy Director Petersen, and all of my fellow Assistant Directors, in ensuring that everyone on our staff will take the advice given here; but, more substantially, in written form that reflects what everyone shared with us as we deliberate on NSF's future role in this regard.

We are, as you have heard on several occasions, examining most of our programs and structures in the current fiscal environment, ensuring that they are characterized by higher outcomes in the context of engaging all participants.

So, again, on behalf of the NSF family, thank you for coming to this meeting — for everyone's engaging participation, raising expectations, and I hope everyone will return with a sense of having profited from this activity and we look forward to everyone's subsequent reports.

Happy Holidays.

Linda S. Wilson

Plenary Speaker

Achievements and Challenges

December 14, 1995

It is a rare, indeed unique privilege to gather here with all of you who are women scientists, individuals seriously interested in women and science, or both. Surely this conference itself is a significant milestone.

Last night's celebration of the achievement of women in science was engaging and inspiring, laced with poignant touches of realism. Clearly progress toward the goal of tapping women's talents in science, mathematics, and engineering has been made, but just as clearly there is a long way to go, and the obstacles to swift passage are several and complex. I believe this conference can be the impetus for an important breakthrough. Assembled here is a critical mass of talent and experience. The agenda is well-focused. This meeting presents an extraordinary opportunity to share knowledge and experience and to consolidate them into more coherent understanding, commitment, and action.

What is perhaps even more significant is the potential for postconference interaction to build on what we accomplish here in these 2 days. Now, with the flick of a switch and the typing of a brief address, we can easily remain electronically connected with each other. We now have the means to counteract the isolation that has long been a prominent feature of women's experience in science.

I want to focus my remarks on charting the challenge. I want to direct attention to the large view and the longer term. Let me address three questions:

- What is at stake?
- What should shape our goals and expectations?
- Where and how can we leverage our efforts?



Linda S. Wilson

President
Radcliffe College

First, what is at stake?

Human resources are the most valuable asset America has and the most complex asset to steward. The individual freedom cherished in our democracy increases the value of this asset and at the same time makes its stewardship complex.

For a nation whose welfare is intimately linked with sustained leadership in science, math, and engineering, the stewardship of this asset is critically important.

For society in general to function effectively, talent, skill, and understanding in science, math, and engineering will be needed more in the future than in the past and will be needed over a wider spectrum of occupations and jobs for society. Our whole citizenry must gain scientific and technological literacy. In a democracy, failure to do so presents grave danger.

Furthermore, the scientific enterprise cannot thrive in the future unless it is open to all segments of the population. The native intellectual capacity for significant and sustained contributions in science, math, and engineering is present in all groups in the population — male and female, white, Native American, African American, Asian American, Hispanic American, and across all socioeconomic groups. Diversifying the pool of scientists, mathematicians, and engineers is necessary to ensure excellence in these fields. Drawing only or primarily on a narrow segment of the population will inevitably diminish the capacity for excellence.

The national strategic goals over the long term will not be met unless we succeed in recognizing and understanding the diversity in our human resources and unless we succeed in bringing the diverse members of our population into full partnership in science, mathematics, and engineering.

Wise investment in human potential is imperative. It is not just an option. As a nation we have been squandering talent partly through ignorance of its existence, but partly through reluctance to share power and responsibility. affirmative action is a necessary step and a fair step if implemented wisely.

Let me turn to the second question.

What should shape our goals and expectations?

A dominant factor is the degree and pace of change. George Schultz, Professor of International Economics at Stanford wrote, “The world is shifting gears. Enormous changes are underway. We must discard outdated habits of thinking and make room for new possibilities.”

After years of addressing the question for the scientific enterprise, should we expect business as usual or is this the beginning of a new era? We can now see that the answer is the latter. We can expect and will certainly need changes in institutions and organizations. There is a growing understanding that given the changes that have already occurred in the composition of the workforce and in the lives of most Americans, the structure of education and work and the design of our educational institutions and workplaces have significant dysfunctional features.

Most of our organizational structures, practices, and expectations were designed in a bygone era for a much more homogeneous population of workers. It was also in an atmosphere of expansion, when single-wage-earner families were a viable option for the middle class. It was an era before urban sprawl added hours of commuting to the workday, when extended families were geographically close, and when neighborhoods and communities were more close-knit. The very fabric of our society has changed, affecting every worker, man and woman, minority or majority.

We need a new economic equation that accommodates the interconnections between the economy, work, family, and community. We will be reframing workplace questions, asking, “How can work be organized to support family and community health, and at the same time allow us to compete effectively in the global economy and sustain a healthy environment for our planet.”

Women, who bring half the talent and represent half the public, will need to help shape these changes. They need to help the nation interpret and accommodate these changes.

Another dominant factor in shaping our goals and expectations is the resource environment. Intergenerational equity is a very important resource issue, heretofore inadequately addressed. Reconciling our aspirations and our resources brings new challenges that will make us change our ways. Opportunity lies in these challenges. This is a time for development of new paradigms, for reexamining assumptions, for reviewing values, and for redistributing roles and responsibilities.

This is therefore a time when newcomers — women and minorities — should play an important role in setting priorities and shaping institutional renewal. Managing our diversity is both a new challenge and a great opportunity.

As we examine progress and near-term challenges for women in science, I urge that we be sure to broaden our view of the roles needed in the scientific enterprise to include all the components: discovery of knowledge, synthesis of knowledge, interpretation, application, science education and public understanding of science. We now seem to have supply and demand imbalances for scientific personnel, but that is partly so because we have had too narrow a view of the roles to be played by those trained in science. We need a more robust design.

What else should shape our goals and expectations? The dramatic opportunities (and dilemmas) presented by advances in information technology must figure in our planning. The extraordinary potential of easily accessible information is empowering. It will eventually change in fundamental ways both our education and our lives. It is a genie that has been let out of the bottle — with enormous potential. But like many other advances, technological progress has far outpaced social, ethical, and political progress. In this case there is also a major financial resource question. The technologies extend what we can do, but thus far have not contributed the economies we had hoped for. And the cost of new technologies and the personnel to make them useful is large and recurring.

Let me turn to the third question.

Where and how can we leverage our efforts?

I offer several ideas.

- Identification of assumptions, clarification of expectations and of the time horizon for which they will operate are all very important for developing coherent and effective action.
- Rejection of stereotypes is especially important in turbulent times.
- Develop mutual respect across boundaries of difference in several areas: socioeconomic boundaries, cultural and gender boundaries, as well as disciplinary boundaries.
- Build bridges to allow workers to accommodate change. For example, we have a fine higher education system, but it functions primarily in the preparatory stage, at the beginning of a career. We have made some progress in executive education, or continuing professional education, but we have neglected to build efficient, economical ways to bridge between fields or between stages in careers. This is particularly problematical for women in science, but it affects everyone.

Women's advancement in science (and in any other field requiring long and intensive training and that makes heavy time claims in its pursuit) will be stunted unless we can provide more creative solutions to their combined roles in the family and workplace.

Redistribution of roles between men and women, as well as affordable and adequate dependent care are important elements. But a robust framework will have to include affordable learning over the life cycle to stay current and to regain currency.

My view of the future then is optimistic because I see the opportunities to restructure and reshape our expectations. I am utterly convinced that a key to

advancing our society lies in advancing women. But I am also convinced that the path must involve concerted, sustained attention to the development of partnerships and deeper communication between men and women across disciplines and institutions among the sectors of our society. We need to bridge the gaps among scholars and educators, policymakers, the media, the business community, grassroots organizations, and the public at large.

We need to become a nation of learners and a learning nation. This goal shapes my dreams and aspirations — as a woman in science, as an institutional leader, and as a citizen.

Let me close with a reference to something a colleague from the University of Michigan taught me. I refer to Carol Hollenshead — known to many who are active in developing women's opportunities in science. Carol and I worked together; I was Vice President for Research, she was my "right hand." I had high aspirations and drive. We had strong talent to help us pursue these goals.

What Carol introduced was the recognition of the importance of taking time for feelings of accomplishment — we called them FOAs. Large goals are motivating, but they are achieved in steps. As you work today, tomorrow, and in the future, keep your eyes on the horizon as well as on the immediate tasks, and take time often for FOAs.

Congratulations to all of you. I applaud the progress you have made. I feel buoyed up and confident about our future even as I recognize the challenges.

Lilian Wu

Plenary Speaker

Achievements and Challenges

December 14, 1995



Lilian Wu

Research Staff Member,
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My talk today will be on the careers of eight women in industry. The goal of my talk will be to show you the enormous diversity of possible career paths in industry that women with science backgrounds can have. Also, I would like to show you the wide variety of problems that each of these eight women have worked on throughout their careers.

My plan this afternoon is to start with women who work in large companies. Three of them will be from IBM, which is where I work. And then I will end up with women who have started their own companies. I will also start with careers that have the most overlap with an academic career. The first I will talk about is my own.

I received my Ph.D. in applied mathematics, and then joined IBM. At IBM, I started work on population biology and to make this work, I worked with scientists and ecologists at Yale and the Marine Biological Laboratory primarily. Our group received a large NSF grant to work on population ecology and nutrient cycling in East Africa in the Serengeti Plains. My role was to develop population models for large mammals, the most complex being elephants.

I spent several summers at the Marine Biological Lab working with colleagues. Pretty soon I realized that most of my colleagues were outside IBM. I started feeling quite isolated inside IBM, quite alone. So, I looked for some interesting problems within IBM to work on.

One of the greatest advantages of working for a large company is that large companies do a lot of different things. There are people who work on inventing new products, the manufacturing of these new products, individuals that work on how to keep employees well trained, people in human resources who work on making the workplace a better place for women and minorities. And, of

course, there are also people in finance and marketing. My background being applied mathematics, with an interest in economics, I decided to look in the area of business economics.

Now, another big advantage of working in a large company is that there are well-established mechanisms for individuals who want to change direction. These changes can often be done with very little risk. So that is another thing to keep in mind.

I started to work on problems that had more direct interest to IBM. One of the areas I worked was on the behavior of our customers. It was felt at that time, perhaps since I could model elephants, I could model our customers.

There turned out to be just masses and masses of data. To gain an understanding of these data, I quickly found that I needed to be able to look at one part of the data, come up with a hypothesis, then check it out on another part of the data. I needed to be able to repeat this again and again, many times easily. At that time, the mathematical techniques for studying masses of data were purely computational, and not really suited for fishing for relationships in the data. Being a very visual person, I took a detour with several computer scientists and developed an interactive graphical data analysis system. This system was the first of its kind and is still used in IBM today.

Since then, I have been working on business forecasting and planning problems, primarily for personal computers. This is a fascinating problem and actually very difficult. Working on solutions to these problems has brought me in contact with many different kinds of individuals in IBM, including executives and people who deal with manufacturing cost, marketing, and pricing.

This is typical of the kind of solutions you have to develop in industry. There are many dimensions to consider, and it isn't just solving a technical problem.

I also work with scientists from universities. I write papers, the usual work of academics. And I have taught at business schools. More recently, I have done consulting for other companies, which is great fun.

In the last 2 years, I have also become involved in science policy in Washington. I am a member of the President's Committee of Advisors on Science and Technology and a member of the National Research Council's Committee on Women in Science and Education. This work has been enriching and has given me a chance to give back to my country and profession, both of which have been very good to me.

The next person I'd like to talk about is a physicist at IBM. Pat (Patricia Mooney) started her career at a 4-year college. She then visited at SUNY Albany and the University of Paris, where she learned a new area in solid state physics and started work on the defects in semiconductor devices.

This new interest naturally brought her to IBM research, where she essentially has been working in the same field of physics and has studied different materials, with the same physics that she started in Paris.

At IBM, the study of defects in semiconductor materials is very fundamental to our business because computers are made up of integrated circuits, which are made up of chips and semiconductor devices. Physicists and engineers are constantly looking for new materials to make faster devices.

In growing these new materials, defects are very common. Defects cause changes in the optical and electrical properties of materials. So identifying defects, eliminating them, and studying what effect they have on the devices is fundamental to IBM.

This kind of work is very common in our company. Pat and I both work in ways that are very similar to how research is done at a university. The main difference is that the material she chooses to study and the applied math problem I choose to work on are of direct interest to IBM. But the methods are the same.

Also, our work is very interdisciplinary. We don't just work with scientists in our own fields, but also work with engineers, scientists in other fields, and business executives. We both are very active in our professional societies as well.

The next two women have careers that have a lot in common with what is generally considered successful careers in business. The first is Caroline Kovac. She started at IBM research as a bench scientist. She applied chemistry to material science, and worked on new materials and processes for electronic devices. Her work environment was very similar to Pat's.

The way Carol sees this environment for her, besides being interdisciplinary, is that it stretched her in new areas because she was working around the edges of chemistry. IBM's problems were always pushing her.

Later, Carol wanted to get a broader view of the other work that was going on at IBM research. One of the mechanisms large companies have available for doing this is to join the staff of an executive. In these positions, people not only learn what is going on, but also expand their network. In Carol's case, she met an important mentor who got her into management.

Her next move was to manage a group in manufacturing research. This group not only worked on interesting material problems but also on several new areas for Carol, which included the logistics of where to place warehouses and distribute materials, and how to put the solutions together in a software system so these jobs can be done more effectively.

The big difference Carol sees between being a bench scientist and being a manager is that she is now a generalist rather than a technical specialist. She still thinks about what are the "right" problems to think about, but right now that

has a broader meaning than when she was a scientist. It not only has to be technically feasible, it has to be financially possible, and customers have to want to buy it.

She says it is great fun to apply her good technical judgment over a wider range of problems. She is now an IBM executive responsible for producing software for manufacturing, distribution, and inventory planning.

The other company executive I want to talk about is Judith Goldberg. She started work as a statistician in one of the very first HMOs in New York City called HIP (Health Insurance Plan of Greater New York). She was a statistician on a program to study the effectiveness of mammograms on breast cancer. In this early project, mammograms were proved to be effective in prolonging life for women who had breast cancer.

She was involved in other epidemiological studies at HIP. But then she wanted to do some teaching. She left and became an assistant, and then later an associate professor of biostatistics at Mount Sinai School of Medicine.

Besides teaching research, she also did a lot of consulting as a statistician and collaborated with others in the School of Medicine in getting grants. After 8 years, she decided she really wanted to get her hands dirty and actually do some drug development. So she left Mount Sinai, joined the medical research division of Lederle and headed a statistics design and analysis group. This group worked on all phases of drug development, from the pre-clinical design stage to analyzing the data from the clinical trials.

Later she had another important responsibility, which was to lead and provide technical and scientific leadership for the company's information system, which is the heart and soul of how Lederle actually manages its new products. Drug companies have databases to establish to the FDA and other international regulatory agencies that their new products meet regulatory requirements.

Lederle was later bought out by another company. And in fact, all the statisticians were laid off. This is probably one of the most difficult things about working for a company. Companies downsize, they refocus, they are bought out. And people lose jobs.

In this case, it was a happy story. The statisticians all found new jobs. In Judy's case, she said this was a very difficult time. She did a lot of soul-searching to decide what her next step should be. In fact, she has made a fantastic move to Bristol Myers-Squibb, where she is now the vice president of biostatistics and data management. Her experience has been that, during these difficult times, you really do regroup, refocus, and think very hard about how you really want to spend the next 5 to 10 years of your life. As you can see, Judy is very active in the professional societies as well.

The next individual I would like to talk about is Marcia Grabow. Marcia is a physicist by training. She has left the field and tried many different things in Bell Labs. She started out as a material physicist and did computer simulations of conditions for growing very flat crystals.

This problem required heavy-duty computer power, and the computers at Bell just weren't fast enough. So she took some time off and, with several computer scientists, built a computer.

At that time, their computer was faster than the Cray. After this work she wanted to take a sabbatical from science, as a bench scientist, and learn something really new. What she chose to do was to work in the licensing group and bring together scientists with patents inside AT&T with businesses outside the company.

In this job, she had to learn a great deal of finance, planning, just strategic thinking. That has gotten her so excited, she has now decided that she wants to work in a very different direction, she left Bell Labs and is planning to set up her own company.

The next person is probably not a type of scientist you would think of finding in a company. Toni Tomacci is a sociologist by training and has a degree in education. She has found a really interesting laboratory for her research and her interests, and that is the Apple Computer Company.

She is in the multicultural programs department. She has brought together her understanding of how people work and how people learn from her background in education to develop a workplace in Apple that is friendlier and more effective.

I can give you other examples in IBM where scientists with unexpected backgrounds work. We have psychologists who study how people think about programming. We have vision scientists who study how people look at the screen and how they think or how their eyes and mind interact.

The next person I would like to talk about is also not traditional. Carol Balfe started out teaching high school in inner cities, went back to graduate school and got her Ph.D. in chemistry, and then used her chemistry training at Sandia and Raychem. Her interests at age 25 and at age 40 went through changes. She has become interested again in education, and especially education for the disadvantaged. To do this work she has left Raychem and formed her own company.

She wants to leverage her experience as a scientist, educator, and member of the business community to use company contributions and volunteer efforts for math and science education reform. So this is another avenue. Women change over their lifetime, and in industry you can often mix and match, and step from one place to another.

The last person I want to talk about is an entrepreneur. Evelyn Berezin did her graduate work in nuclear physics and did work in coincidence counting of

mesons. In the early 1950s in the infant stage of computing, she felt there was a similarity between her graduate work and coincidence counting in computing. So she joined one of the very first computer companies, called Electronic Computer Corporation, as a logic designer. She worked on many computer systems, some of them I'll mention — one of the first on-line banking systems, a query system for the American Stock Exchange, a passenger reservation system, and a paramutual betting system. These systems, she assured me, worked, and people used them.

But she got a little itchy and wanted to start her own company. And she started a company. I don't know if any of you remember, in the very early days of word processing, the way we did it was by putting text on a magnetic card. She started a company that made magnetic card word processing systems, and built it up so that it was the second largest in the world, second only to IBM.

Her company both designed and manufactured machines worldwide. She finally sold the company to Burroughs and joined Burroughs for awhile but decided that wasn't for her. She thought it was just too much fun to work with high-tech, start-up companies, so she worked as a venture capitalist. This fun essentially funded over 20 start-up companies during the time that she was there.

Today, she is still having a great deal of fun. What she does is consulting, not just on technical issues, but also on financial issues, manufacturing issues, and personnel issues for high-tech companies. These range from electronics, biotech, and medical to communications. She is also a director of many small start-up companies.

She feels that her technical background has been really important to her in three different ways. The first and most important is when you are not doing the technical stuff yourself, often you are judging what other people are telling you. With a technical background, you can easily judge who is trying to con you. People without technical backgrounds have a much harder time separating good work from bad work.

The second is in business you have to make trade-offs constantly. When there is a technical aspect to a problem, there is often also a manufacturing aspect to the problem, or a cost aspect. Making those trade-offs without a technical background can be almost impossible.

The third is when you're projecting into the future an event with a technical component, a feeling of how long different things will take often is just absolutely critical. Again, without a technical sense, you can make nonsensical estimates. Those are the three ways that her technical background has been vital to her success.

"I would like to close with a few words," she said, "one of the best things about working in industry has been working together with a group of people, trying to achieve a goal. Also, there has been the thrill of beating out the other person,

and seeing that your ideas actually work.” She thinks of her career as a series of stepping stones, each leading to the next and each more interesting.

So, in conclusion, I hope I have shown you that there is a wide range of things you can do in industry with a science and technical background. In fact, I often hear from women that the hardest thing is figuring out what you really want to do because the choices are so many.

Thank you.

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414 Russell Senate Office Building
Washington, DC 20510

CONFERENCE EVALUATION FORM AND RESULTS

Please help us in planning future women and science activities by filling out this brief questionnaire.

[Results in percents have been rounded to whole numbers.]

1. Organizational affiliation

- 70% Faculty or administrator, higher education
- 16% Industry, non-profit or foundation representative
- 14% Other, specify:
- 0% Not ascertained

2. Please tell us which breakout sessions you attended.

Thursday Morning, Disciplines

Biological Sciences	20%
Computer & Info. Sci.	13%
Engineering	18%
Geosciences/Polar	10%
Math & Physical Sci.	24%
Social & Behavioral	12%
Not ascertained	4%
	101%

[2 people attended 2 sessions]

Thursday Afternoon, Cross-Cutting Themes

Research-Ed Infrastructure	18%
Impact of Technology	17%
Family Issues	10%
Shattering Preconceptions	17%
Bridging Transitions	11%
Changing Curriculum	26%
Not ascertained	4%
	103%

[6 people attended 2 or more sessions]

3. Indicate your satisfaction with the following conference sessions by circling the most appropriate response.

[Responses in percents in parentheses ().]

<u>Very S</u> atisfied	<u>S</u> atisfied	<u>N</u> eutral	<u>D</u> issatisfied	<u>V</u> ery <u>D</u> issatisfied	<u>U</u> nable to <u>R</u> ate	NA = not ascertained			
Opening Night Celebration			VS (44)	S (28)	N (8)	D (2)	VD (1)	UR (13)	NA (4)
Plenary Session, Thurs. Morning			VS (49)	S (34)	N (5)	D (1)	VD (<1)	UR (6)	NA (4)
Breakout Session - Disciplines			VS (27)	S (42)	N (13)	D (8)	VD (2)	UR (3)	NA (4)
Plenary Session, Thurs. Lunch			VS (18)	S (33)	N (20)	D (15)	VD (4)	UR (5)	NA (5)
Breakout Session - Crosscutting Themes			VS (27)	S (34)	N (15)	D (13)	VD (5)	UR (1)	NA (5)
Sharon Glassman Performance			VS (16)	S (10)	N (5)	D (<1)	VD (<1)	UR (58)	NA (10)
Plenary Session, Friday Morning			VS (55)	S (24)	N (4)	D (1)	VD (0)	UR (5)	NA (11)
Breakout Group Reports			VS (29)	S (37)	N (13)	D (5)	VD (1)	UR (3)	NA (14)
Panel Discussion with NSF ADs			VS (24)	S (24)	N (2)	D (<1)	VD (0)	UR (14)	NA (36)

4. How satisfied were you with the following conference arrangements?

Conference Dates	VS (31)	S (36)	N (13)	D (12)	VD (6)	UR (0)	NA (2)
Pre-conference Information	VS (23)	S (43)	N (16)	D (12)	VD (2)	UR (1)	NA (2)
Lodging	VS (43)	S (34)	N (5)	D (1)	VD (0)	UR (15)	NA (2)
Meals	VS (23)	S (33)	N (18)	D (12)	VD (9)	UR (2)	NA (2)
Meeting Rooms	VS (32)	S (47)	N (8)	D (10)	VD (1)	UR (0)	NA (9)
Scheduling of Sessions	VS (32)	S (45)	N (11)	D (7)	VD (1)	UR (0)	NA (4)

5. Please rate the usefulness of the following conference activities.

<u>Very Useful</u>	<u>Useful</u>	<u>Neutral</u>	<u>Not Useful</u>	<u>Unable to Rate</u>	NA = not ascertained			
Video segments			VU (45)	U (38)	N (8)	NU (3)	UR (2)	NA (4)
Showcases			VU (41)	U (37)	N (13)	NU (1)	UR (2)	NA (6)
Exhibits			VU (41)	U (39)	N (13)	NU (2)	UR (2)	NA (4)
Responses to questions posed to invitees			VU (28)	U (35)	N (13)	NU (3)	UR (10)	NA (11)

6. Did the conference stimulate any new ideas for you?

89% Yes 7% No 4% NA

7. What would you like to see result directly from this conference?

Please select only one or indicate your preference.

29% Conference proceedings 33% Resource guide
 48% Brief action plan 20% Video of conference highlights
 11% Other

Includes people who gave more than 1 response.

8. What is your overall rating of this conference?

53% Excellent 35% Good 8% Fair 1% Poor 3% NA

9. Should NSF plan to hold future women and science conferences?

76% Definitely 19% Probably 2% Probably Not 1% Definitely Not 2% NA

10. Race/ethnicity and sex (optional)

1% American Indian/Alaskan Native 4% Hispanic 2% Male
 5% Asian/Pacific Islander 79% White 75% Female
 5% African American/Black (non-Hispanic) 6% not ascertained 23% not ascertained

11. Do you have any other comments or suggestions about this or future conferences?

The following are a few samples comments or suggestions:

This conference provided a wonderful caring and accepting environment in which we felt free and comfortable contributing to discussions and not as though people were continually critiquing. This is a first for me. Being accepted for being a woman and not having to prove myself.

Basically I am walking away with the realization: It's not only me. So okay, ignore the unpleasant and continue to do what I am doing!

This meeting has revived my optimism that there will be a better environment for women in science. I really needed this. I have just gotten tenure and the process of preparation and defense of my documents was very negative. I have been considering alternative careers that were non-science. My experiences at this meeting have provided me with the hope that I can survive and make a change for the next generation of women in science. Thank you!

The conference could greatly benefit from industry representation. Industry is dealing with some of the same issues as academia. The joint discussion between the two on topics of interest could be very beneficial. Having more industry represented in the exhibits and, more importantly, in the panel discussions, would make this conference a powerful forum to create change.

It was by attending this conference that I first realized I really was a leader and my work was not trivial. I also realized I need more training to develop my own leadership skills. I got some of this at this conference.

Include men in future conferences, especially men in administrative and lead positions, e.g., department chairs and associate deans of academic affairs. Issues have to be leveraged into policy.

Thank you for this opportunity. As a junior faculty member, this was my first exposure to the workings of NSF and policy arena. I believe I learned a lot and hope I can contribute in the future. It was great to hear library science mentioned Friday morning. Library and information sciences sometimes appear not to have a place or "home" in NSF and it was encouraging to see that it is thought of in greater terms than as a recipient of digital technology.

The different levels of knowledge about females and science between those who are female scientists and those who work on these issues as a career often felt like we were speaking different languages. The female scientists clearly have little idea what has been learned and done. This is very instructive!! I'm not sure if this means the next conference should address these two groups separately. It's something to consider.



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