"STRANGERS IN A STRANGE LAND": 
A LITERATURE REVIEW OF WOMEN IN SCIENCE

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I. INTRODUCTION

A. DIFFERENCES IN CAREER ATTAINMENT IN SCIENTIFIC PROFESSIONS:
WHAT THE RESEARCH SHOWS

The number of women pursuing careers in science worldwide has increased dramatically in the past 20 years. Despite these gains, research consistently documents disproportionately low numbers of women in senior scientific and leadership positions (Amato, 1992; Barinaga, 1992; Bielby, 1991; Brush, et al., 1995; Culotta, 1993; Gender Working Group, 1995; Homberger, 1997; Kahn, 1993; Luukkonen-Gronow and Stolte-Heiskanen, 1983; Northrup, 1988; Osborn, 1994; Primack & O’Leary, 1993; Selvin, 1992; Sharma, 1994; Sonnert, 1995, 1995b; Stewart, et al., 1994; Stolte Heiskanen, 1991; Subrahmanyan, 1997; Vitug, 1994; Zuckerman, 1991). For example, in her report on Russian women scientists Homberger (1997) found that “of 600 full members of the Russian Academy of Science, only 10 are women” (19). In India in 1993, “of the 628 and 698 scientists chosen as fellows by the Indian National Science Academy and the Indian Academy of Science, respectively, only 12 and 15 were women. In the selection committees of the two academies, women are represented only in the field of medical sciences” (Sharma, 1994: 1495). The British governmental report The Rising Tide (1994) indicates that women are sorely underrepresented in public appointments on key councils and boards responsible for developing policy in science, engineering, and technology-related fields: women made up only 12.8% of the 917 public appointments on which they reported. In Germany, though women earn 28% of science Ph Ds, they hold less than 3% of full professorships (Kahn, 1993). In a report on the status of women in science in Europe, Mary Osborn (1994) indicates:

Few women are on the top national and EU [European Union] committees that set policy and control funds . . . . In 1992, IRDAC [Industrial Research and Development Advisory Committee] had no women and 24 men, and CODEST [Committee for European Development of Science and Technology] had one woman from Ireland and 26 men. On CREST [Scientific and Technical Research Committee] all 24 members were men, but two deputy members were women, one from Spain and one from Portugal. Many EU advisory committees are all male, and almost all top jobs within the European commission to do with science and technology are filled by men (1389).

In their report on women scientists and managers in agricultural research in the Philippines, Brush, et al. found:

(W)omen occupy lower positions than men: more women occupy junior-level positions than men, and men are twice as likely as women to hold senior-level positions. While more than three-quarters of the women with BSc degrees are in junior positions, fewer than 60% of the men with BSc degrees are in junior positions. (33)
In their study of career paths of men and women scientists who had received prestigious postdoctoral fellowships in the United States, Gerhard Sonnert with the assistance of Gerald Holton (1995) found that "(w)hile the gender gap has narrowed . . . . full gender equality in science careers and women's full 'ownership,' alongside men, of science still seemed elusive" (Sonnert, 1995: 164). Indeed, among this elite group of scientists who entered science at the same level, women fared worse than their male colleagues in career attainment as measured by academic rank. The exception was in the biological sciences where women have achieved a "critical mass." "Among the younger cohort of scientists in [the physical sciences, mathematics and engineering], for instance, the women's average academic status was almost one full rank below the men's . . . . Controlling for the level of productivity in scientific publication, women were still at a disadvantage in rank . . . ." (Sonnert & Holton, 1996: 33).

B. WOMEN IN SCIENCE: WHERE THEY HAVE BEEN AND WHERE THEY ARE GOING

Because women are relatively new to many scientific disciplines and constitute a significant minority, they have been referred to as "strangers" and as the "outer circle" in scientific organizations (Sonnert, 1995; Zuckerman, et al., 1991). Women scientists' marginalized status in scientific organizations affects their ability to advance their careers. In fact, for many years, women's options in science were limited to assisting their husbands, fathers, or brothers. Discrimination against their entry into science was overt. And yet, despite many obstacles, there have always been women who have succeeded in science in their own right.

Everyone knows about the famous scientist Madame Marie Curie (1867-1934). In 1903 she won, along with her husband Pierre Curie, the Nobel Prize for physics for the discovery of natural radioactivity. The conditions in which she and her husband worked were grim, but that she had her husband working along side her certainly helped Marie Curie's standing in the scientific community. After her husband died in 1906, she took up his position at the Sorbonne and was the first woman to be appointed professor there (Raynal, 1995). She went on to receive the Nobel Prize for Chemistry (1911) for determining the atomic weight of radium. Ironically, however, the same year she won the Nobel Prize in Chemistry she was denied entry into the Academy of Science due to "hatred of foreigners and sexism" (Raynal, 1995). Clearly a genius in science, Curie's advancement in the field was affected by her gender.

Barbara McClintock (1902-1992), 1983 Nobel Prize winner in Medicine and physiology for her discovery of transposable genetic elements, was also an outstanding scientist. Nonetheless, though she made her discovery in 1948, she was not awarded the Nobel Prize until 1983. Explaining McClintock's pursuit of a scientific career in the United States in the 1920s and 30s, Evelyn Fox Keller (1983) writes:

For McClintock, the road ahead was uncharted . . . women in the sciences tended to be scientific workers and teachers rather than scientists, pursuing science more as an avocation than a vocation. Careers as research scientists were not available to them. Positions in the universities that were open to women were for the most part limited to assistantships and, occasionally, instructorships. They
might teach in the women's colleges or they might marry scientists and work in their husbands' labs. For most of these young women, their love for science was sufficient reward; they adapted to their situation. Barbara McClintock, by contrast, could not, or would not, adapt to the limitations imposed on her sex here any more than anywhere else . . . she knew who she was and where she belonged. She was passionate about her research, and she was good at it (52).

McClintock, in many ways, rejected female conventions, both in science and society. As she explained, "'When a person gets to know you well, they forget that you're a woman . . . The matter of gender drops away'"(Keller, 1983: 76). And yet she also acknowledged that gender was important in how she was perceived in science. "Now, she [McClintock] says, 'outside, it's [gender] always there, always intruding.' No efforts of her own would erase the fact that she was a woman in a profession institutionally established for men" (Keller, 1983: 76). This had the very real consequence of making a career difficult to pursue since no one wanted to hire a woman.

And McClintock is not the only famous woman scientist to acknowledge the difficulties of being female in the male world of science. Christiane Nüsslein-Volhard, a developmental biologist, was the winner of the 1995 Nobel Prize in Medicine, together with Eric Wieschaus and Edward Lewis, for discovering genes that shape development in the fruit fly. She explained that, when she began her work with fruit flies, she learned quickly but received little attention from her superiors. She assumed it was because of her inexperience and/or incompetence. "It took me a long time to realize that the issue was gender . . . . They expected less of a woman. The attitude was, 'I'll give her a chance, but I'm sure she won't perform!'' (Ackerman, 1997: 44).

C. THEORIES ON INFORMAL OBSTACLES TO WOMEN'S ADVANCEMENT IN SCIENCE

Recent research indicates that, increasingly, there are fewer overt obstacles to women's success in science (Amato, 1992; Barinaga, 1992; Bielby, 1991; Fox, 1991; Raharjo, 1995; Primack and O'Leary, 1993; Selvin, 1992; Sharma, 1994; Tabak, 1995). For example, in the United States, the passage of legislation and guidelines to eradicate discrimination in the 1970s has meant that the scientific community is, by outward appearances, as open to women as it is to men (Sonnett, 1995). But if many of these "overt obstacles" have been removed, what explains the low numbers of women in senior scientific positions? A review of the literature on women scientists' productivity and career attainment shows that women in scientific organizations often experience a "complex mosaic" of informal and subtle obstacles to career advancement. Robert Merton argues that, for women, "in the domain of science . . . . initially small differences amplify in later stages of the individual career and aggregate into strongly skewed distributions of resources, role performance and rewards" (Sonnett, 1995: x-xi).

In "A Theory of Limited Differences: Explaining the Productivity Puzzle in Science," Jonathan R. Cole & Burton Singer (1991) studied a population of what they call "primary producers" of science and the factors that influence their rate and amount of production. They found that disparities between men and women emerged gradually out of a process which they call a "kick-
reaction" effect. That is, in scientific careers, there are a series of "kicks" (negative, positive, neutral) that are followed by a "reaction" (negative, positive, neutral). Over the short term, "kick-reactions" can seem insignificant but the following is an example of long-term effects. Women experience a "negative kick" in that they are slightly more likely than men to be rejected for grants. This, in turn, influences their productivity potential which, in turn, affects tenure decisions. If tenure is denied, further negative kicks and reactions can follow.

Cole and Singer explain that there is a psychological component to reactions associated with particular kicks; the way men and women are socialized, for instance, can matter in how one reacts to a particular kick. As well, there are structural or institutional constraints associated with particular kicks. Some individuals are in better or worse positions to react to a kick. For example, past success in obtaining grant money generates resilience to future rejections (negative kicks). That is, once someone receives a major award, they do not depend significantly on earlier kick-reaction history.

Cole and Singer's theory examines the sources of disparity between groups. For example, it is more likely that women will experience some kinds of negative kicks than men (such as grant application rejections). Therefore, women are more likely to get discouraged about these negative kicks (because they are more likely, on the whole, to experience them) than men. Even when they compared eminent male and female scientists, they still found significant disparity in publications because the accumulation of negative kick-reactions for female scientists has such a dramatic effect. "At a micro level of analyzing individual histories, it examines dynamic interactions in which small, limited differences in reactions lead to large changes in individual career histories over extended periods of time" (Cole and Singer, 1991: 307).

Evidence of small numbers of women in senior scientific and leadership positions counters the prevailing notion that scientific disciplines operate according to the principles of meritocracy (See Section D., "Measures of Productivity and Performance"). Even the supposedly objective standards of evaluation and criteria for advancement within scientific organizations are found to operate against equal opportunities for women scientists in terms of the distribution of resources, role performance, and rewards (Bielby, 1991; Fox, 1991; Sonnert, 1995; Wennerås and Wold, 1997). Perhaps the most shocking and discouraging study to date on the bias against women in scientific peer review was published in Nature (May 1997). Christine Wennerås and Agnes Wold found that the Swedish Medical Research Council (MRC), one of the main funding agencies for biomedical research in Sweden, demonstrated peer review bias when selecting postdoctoral fellowship recipients. Wennerås and Wold show that women with the same publication records as men were awarded significantly lower scores for scientific competence than men. The researchers went to court to gain access to the evaluation sheets which the MRC was reluctant to make public. The court ruling, carried out under the Swedish Freedom of the Press Act, made these evaluation sheets available for scientific review for the first time. The authors emphasize the need for further analysis of peer-review systems which would mean abandoning the policy of secrecy guaranteeing anonymity to reviewers. The United Nations recently named Sweden the leading country in the world concerning equal opportunities for men and women. Surely if peer review bias exists in the country which provides the most equal opportunity for men and women, it is important to investigate evaluation systems in other countries and in other areas of scientific research.
The remainder of this working paper draws on current literature to highlight common areas of bias or of disadvantage for women in scientific organizations. This includes an examination of the gendered nature of the discipline of science itself and the effects that it has had on both the roles men and women assume in science and the language of the discipline. Understanding the informal obstacles that women in science face can assist both staff and managers to better understand areas in which their organizations may perpetuate subtle gender bias. This, in turn, can help them to develop policies and work practices that will foster the fullest productivity and job satisfaction for both men and women. It can also help women scientists understand that the constraints they experience are not simply individual problems, but are likely related to systemic issues within the culture of research organizations and the community of science. Most importantly, this paper is written in the spirit of ensuring the goal that scientific research organizations allow all members to work at their full potential and to create the best innovations possible in science.
Analyzing organizations through a gender lens enables us to identify the informal obstacles that hinder women scientists’ career advancement and thus limit the overall goals of scientific processes and inquiries. Below are eight frequently cited obstacles that women scientists commonly confront throughout their scientific careers.

A. OUTSIDER STATUS

Subtle gender discrimination is operative in fields and organizations where women represent a significant minority—as is the case in agricultural and forestry sciences (Kanter, 1977). In these situations, women tend to be viewed both as “outsiders” as well as tokens, or symbols of their group. Consequently, they are subject to both increased visibility and scrutiny as well as to stereotyping and its associated negative biases. This outsider status sets in motion subtle disadvantages (“negative kicks”) which over time can impede women’s career attainment. As part of a minority culture, women scientists “are closely scrutinized and judged, they have to work harder to receive the same rewards and recognition as men, and they tend to be isolated from informal collegial networks and mentoring” (Brush, et al., 1995: 63). In a study of women overcoming obstacles in science in Brazil, Tabak (1995) noted: “the Academe is often very rigid in the evaluation of scientific production (publications, etc.), higher demands are placed on women and they are expected to be much better qualified in order to get a promotion” (225). Men and women in Sonnert and Holton’s (1995) study had very different experiences with perceived gender discrimination during their careers. Whereas 73% of the women felt that they had experienced such discrimination, only 13% of the men mentioned experiencing discrimination. Interestingly, most women had experienced discrimination more in terms of subtle marginalization or exclusion, rather than more blatant forms such as being denied jobs or promotions. For instance, they reported that several women in this study, because of their minority status, experienced high pressure to take on extra administrative duties because they were considered the token representative for women.

The consequences of outsider status are born out by Sonnert’s study which shows that in fields—such as the biological sciences—where the gender mix is more balanced, women do not confront these same obstacles to career attainment as men. In the Philippines study, where there is parity in the numbers of women and men in science, it was found that: “Women feel comfortable with their position in the workplace and believe that they are rewarded equally for comparable performance” (Brush, et al., 1995: 65). While this is encouraging, it is important to note that this finding is related to women’s perceptions rather than behaviors. It is not clear that these perceptions are wholly accurate. For example, the same study found that while women scientists in the Philippines publish at the same rate as men, they still have lower rates of promotion than men (Brush, et al., 1995).

B. PROFESSIONAL NETWORKS

One of the most critical areas where gender affects career attainment is in the realm of social and professional networks. Mary Frank Fox (1991) reports that the key to obtaining resources for scientific research is the ability “to build and manipulate a professional network in and out of the
The concept of the "old boys" network is still powerful, particularly in fields where women are recent entrants. The costs of exclusion from these networks can be high. Marcia Barinaga's (1992) interviews with women neuroscientists indicated that in large democratic groups or societies women actually have fairly high representation. And yet, women are often not in powerful positions within their field. "A look at the foundation boards, or the university committees that allocate funds and space... will confirm that 'the glass ceiling' for women is still very much intact" (1367). In her article on women scientists in the private sector in the United States, Elizabeth Culotta (1993) cites the following studies:

One survey of Ph D scientists and engineers in R&D at 18 major companies, by Nancy DiTomaso of Rutgers University, found that women were less likely than men to discuss their work with someone in the company outside their own lab. And the Catalyst study [a survey of women engineers done by the nonprofit research and advisory organization, Catalyst, that supports women in business] found that women engineers tend to try to prove themselves by dint of hard work alone—instead of networking and building visibility. The same conclusion is echoed by Karel Czanderna, a Ph D materials scientist at Eastman Kodak Co. in Rochester, New York, who surveyed women's attitudes while building a new network of female researchers at Kodak: "I've read on hundreds of survey cards that women have a feeling of being isolated, especially in the technical community" (399).

Participation in informal networks influences access to cutting-edge scientific information, resources, opportunities to publish and collaborate, and forums for decision-making on important matters such as hiring, research directions, and resource allocations. Important information is exchanged and decisions are often made during casual meetings among colleagues, yet gender roles often exclude women from these interactions, particularly in fields and organizations which are still predominantly male milieus (Amato, 1992; Fox, 1991; Primack & O'Leary, 1993; Sonnert, 1995; Tabak, 1995).

In Sonnert's study (1995), 55% of the women and 40% of the men said that they interacted differently with colleagues of the opposite sex. Of these, 20% of the male respondents referred to sexual tension in interactions with women colleagues. When asked about incidents in their professional lives that made them feel uncomfortable or surprised, 40% of the women mentioned episodes of sex discrimination, sexism, or sexual harassment. In noting the difficulty of possible misinterpretation of collegial relationships, one female scientist reported "it was just impossible for a woman scientist at a conference to invite a male colleague to her room for an informal discussion about research over drinks, whereas this is very common among male scientists" (Sonnert, 1995: 138). In their study of women ecologists Primack and O'Leary (1993) found that "many women in private conversations mention that their ability to interact and go on field trips with their male advisor was often restricted by the advisor's wife" (164).

Shirley Jackson, a physicist and professor at Rutgers University in the United States, was, in 1964, one of 45 women and a handful of blacks admitted to the Massachusetts Institute of
Technology (MIT). While she became a successful scientist, she described the cost of being shunned by others at MIT because of her gender and race:

The courage of the outsider has been a great asset to Jackson. Yet while an independent style enabled her to survive alone in the MIT cafeteria, it had drawbacks in the collaborative world of research. "I was still pretty much of a loner. I tended to do my own thing, and that's not always the best way to do things in science. That's why when women are isolated -- or blacks or any minority -- it can be very destructive" (Gibbons, 1993: 393)

The impact of gender roles on the ability to develop collegial networks is not limited to the United States. In a study of men and women scientists in agricultural research organizations in the Philippines, it was found that gender role norms in the larger society impeded women's ability to cultivate informal professional contacts with men outside of the work place. This was seen by both men and women as a primary obstacle to women's ability to move into top management and leadership positions despite parity at other levels (Brush, et al., 1995). In her paper on women scientists in Brazil, Tabak (1995) explained that women are often not trusted to perform certain jobs or represent the institution and are excluded from professional circles because of their gender. In addition, she noted that sexual harassment is a widespread problem for women scientists. Subrahmanyan (1997) reports from her research in India that the most serious obstacle for women scientists is "their inability to lobby for research grants when their proposals are being evaluated by funding agencies" (23). Many of the participants in her study indicated that informal conversation between scientists and funding agency officials is critical to grant awards. Even though these women emphasize that merit should be the sole criteria according to which grants are awarded, they complain that the impossibility of informal networking with agency officials greatly decreases the likelihood of grant funding. As Fox (1991) argues, "[E]xclusion [from professional networks] limits the possibility not simply to participate in a social circle, but rather to do research, to publish, to be cited -- to show the very marks of productivity in science" (195).

C. COLLABORATIVE RESEARCH

Collaborative research is integral to success in scientific disciplines. Scientists who research and write collaboratively have a higher rate of publication than single authors and are more likely to be cited by others. Women's productivity suffers to the extent that access to professional networks is more difficult for women which, in turn, limits collaborative opportunities (Fox, 1991).

Even when women have the opportunity to collaborate, research suggests that they are often subordinated rather than treated as colleagues in the project (Fox, 1991; Sonnert, 1995; Chakravarthy, et al., 1988). In Sonnert's (1995) study, the same proportion of women as men (68%) were members of research teams, although the women's teams were on average smaller. Men and women also had, proportionately, a similar number of collaborative publications. Yet, significant gender differences surfaced when the nature and quality of collaborative relationships was examined. Sonnert's quantitative findings indicate that a highly collaborative research style during the graduate and postdoctoral phase for men correlated with positive career outcomes,
whereas for women it was associated with lower academic rank and fewer publications. Sonnert attributes this difference to the tendency for women to be placed in, or to be perceived as playing a subordinate role, particularly in collaborative relationships with their advisors. Sonnert argues that this "collaboration trap" may explain why women, in fields where they represent a minority, enter into fewer collaborative relationships than men at later stages of their careers.

Fox also reports that even when women and men collaborate at the same rate, men have significantly higher numbers of different collaborators, reflecting their broader professional networks. Several empirical studies have shown that collegial interactions are increasingly associated with research productivity and career advancement (Fox, 1991). To the extent that women's ability to develop productive and egalitarian collaborative relationships is limited, their careers will likely suffer.

D. MEASURES OF PRODUCTIVITY AND PERFORMANCE

Women often have the most difficult time advancing in a system in which the guidelines for work evaluation are vague and undefined. Because the system of advancement in science has been designed to evaluate primarily male scientists, "unwritten rules" are often neither known by nor explained to women scientists. Mary Frank Fox (1991) notes that: "Studies indicate that the more loosely defined and subjective the criteria, the more likely it is that white males will be perceived as the superior candidates and that gender bias will operate" (191). In his study of women scientists in academia, Cole (1979) found that "functionally irrelevant characteristics such as sex will be more quickly activated when there are no or few functionally relevant criteria on which to judge individual performance" (75). Several studies show that three key areas of evaluation of scientists' work—peer reviews, publications, and advancement to senior positions in the private sector—do not operate according to the principles of meritocracy.

1. Peer Reviews

As previously mentioned, Christine Wennerås and Agnes Wold (1997) found that the Swedish Medical Research Council (MRC) demonstrated peer review bias when selecting postdoctoral fellowship recipients. Using a scale of 0 to 4, the MRC judges applicants on scientific competence, relevance of their research proposal, and the quality of proposed methodology. Scores are multiplied together to give one final score. Women, by and large, scored lower in each category, thus giving them substantially lower total scores. Therefore, women's competence was generally considered deficient.

Wennerås and Wold (1997) measured each applicant's scientific productivity in six ways: (1) they determined the applicant's total number of original scientific publications; (2) they determined the number of publications on which the applicant was first author; (3) they added together the impact factors (listed in the independent Institute of Scientific Information's Journal Citation Reports which describes the number of times an average paper published in a particular journal is cited during one year) of each of the journals in which the applicant was published to get a "total impact measure"; (4) they generated a "first-author impact measure" by adding together the impact factors of the journals in which the applicant's first-author papers appeared (note that they gave one impact point for a paper published in a journal with an impact factor of
1); (5) they identified total citations from 1994 using the science citation database (yielding the measure “total citations”); and finally, (6) they repeated this procedure for first-author papers (giving the measure “first-author citations”) (Wennerås and Wold, 1997: 341-2). They report that “the peer reviewers gave female applicants lower scores than male applicants who displayed the same level of scientific productivity. In fact, the most productive group of female applicants, containing those with 100 total impact points or more, was the only group of women judged to be as competent as men, although only as competent as the least productive group of male applicants (the one whose members had fewer than 20 total impact points)” (Wennerås and Wold, 1997: 342).

Using multiple-regression analysis on scientific productivity, gender, and affiliation with a committee member, the authors found that “a female applicant had to be 2.5 times more productive than the average male applicant to receive the same competence scores...” (Wennerås and Wold, 1997: 342). The only other significant factor in whether a fellowship was awarded was whether or not an individual knew someone on the review committee. An individual who did not know someone on the review committee would need to be 2.5 times more productive than someone who did know someone on the review committee. Therefore, a female applicant who did not know a committee member would have to be five times more productive than a male applicant who did know a committee member. These odds make it nearly impossible for many qualified women scientists to succeed. Thus, it is not surprising that of the 114 applicants for 20 postdoctoral fellowships offered in 1995, 62 were men and 52 were women, and yet 16 men and only four women were awarded postdoctoral fellowships.

Mary Frank Fox (1991) reported on a study of psychologists in which professional summaries of 10 Ph Ds were sent to 147 psychology chairpersons across the United States. The summaries mixed together publication records, teaching performance, departmental committee service, and comments on sociability and conscientiousness. “For each questionnaire sent, female names were randomly assigned to four summaries; the rest were assigned male names. Asked to make hypothetical hiring decisions and assign academic rank on the basis of the summaries, most chairs recommended the rank of associate professor for the summaries containing male names and the rank of assistant professor for the same descriptions identified with a female name” (Fox, 1991: 192). Marcia Barinaga (1992) cites neurobiologist Mary Beth Hatten of Columbia University on women scientists pursuing tenure: “A female applicant who seems ‘too feminine’ risks not being taken seriously... On the other hand, she says, successful confident women are often considered unpleasantly aggressive, while ‘a man with those very same qualities is viewed as a go-getter’” (1366).

2. Publications

As William Bielby (1991) states, “there is widespread agreement among scientists that the extent and quality of research publication is an important measure of an individual’s contribution to the production of knowledge” (174). However, typically it is the quantity of publications that is used as a proxy measure of productivity for promotion decisions. The quality of publications is more difficult to judge and so is often not assessed with the same specificity in promotion decisions.
Several U.S. studies have shown that, overall, women scientists publish less than men (Bielby, 1991; Cole & Singer, 1991; Cole & Zuckerman, 1991; Primack & O’Leary, 1993; Sonnert, 1995; Zuckerman, 1991). Sonnert found that men in academe produce on average 0.5 more scientific publications than women per year (Sonnert, 1995). However, if the quality of publications was assessed in terms of the number of citations, a small study conducted by Sonnert suggests women as a group would fare better. In a small sub-sample of 25 former National Science Foundation Fellows in Biology, Sonnert found that women’s articles received, on average, 24.4 citations, whereas men’s received, on average, 14.4 citations (Sonnert, 1995a). Sonnert notes that in a similar study of a large sample of biochemists, Long (1992) found a gender difference in citations per article in the same direction. These findings, in conjunction with qualitative data from interviews, suggest that women tend to publish fewer but more comprehensive articles than men. Such results support current efforts to shift the scientific reward system toward a more qualitative evaluation of publication productivity.

3. Advancement to Senior Positions—Private Sector

What about the world of R&D? Science magazine’s 1993 special issue on women reports that in the private sector results on success and advancement for women are mixed (Culotta, 1993). Though numbers of women in the private sector in the United States are increasing, they are still relatively low compared to numbers of men. Women who enter traditionally male disciplines and long-established companies tend to experience the most discrimination. Not surprisingly, when women work in companies from their inception, they fare much better. In these companies, women write the rules along with men. But as Culotta says:

It’s not just that women are helping write the rules; it’s also that their co-workers are younger, and therefore more accustomed to having female colleagues. “We’re in a transition time. Age does make a difference—I can see a real difference, and a cutoff point at right around my age, 40,” says Karen Talmadge, Ph.D molecular biologist and director of market research at Scios Nova. That pattern cuts across the industrial lines... SAS [a software Institute in Cary, North Carolina] is 17 years old, and the average age of its workers is 33. Half the professional staff and 42% of managers are women (Culotta, 1993: 400).

And yet, at this same company, only 15% of vice presidents and directors are women, which indicates that there is still a long way to go. Felice Schwartz, founder of Catalyst (nonprofit research and advisory organization that supports women in business) designed a five-point scale to rate companies on how they address gender issues in the workplace: a ranking of one means the company follows anti-discrimination laws, two means the company tries to be fair but has not made much effort toward fundamental change in culture, three means that the company has managers who are “trying hard to shake up the culture,” and four and five would be reserved for organizations who have successfully developed a “truly level playing field” for men and women (Culotta, 1993: 400). This ranking system demonstrates that to achieve profound organizational change related to gender is a complex and multi-layered process.
E. SALARY DISCRIMINATION

Both Bielby (1991) and Zuckerman (1991) reported on the United States National Science Foundation's findings that women scientists in 1984, on average, had median salaries that were 71% as large as those of men. In part, this salary differentiation could be explained by gender differences in scientific rank. Northrup (1988) noted the difference between male and female salaries is less drastic when corrected for age, experience, and degree level. How much has changed since 1984? Based on statistics from the National Science Foundation Report (1996) from the United States, women scientists in 1993 made, on average, 79% of what men made. As the report explains:

In 1993, among employed science and engineering doctorate-holders who worked full time, the average salary for women was $50,200 compared with $63,600 for men. . . . [H]owever, many differences between men and women in the doctoral labor force help explain this salary gap, e.g., women are, on the average, younger than men and have more frequently majored in fields such as the social sciences that have relatively low pay (NSF, 1996: ch. 5).

The report indicated that 90% of the salary gap could be explained by the following factors: years since doctorate (women, are on the average, younger than men; 24.3%), field of degree (women are disproportionately concentrated in life and social sciences which pay less than computer/math sciences or engineering; 11.2%), other work-related employee characteristics (mostly that men have more work experience; 18.7%), employer characteristics (mostly that more men work in the private sector; 9.9%), type of work (14.9%), "life choices" (10.6%):

Variables in the "life choices" set include family-related variables—marital status; whether spouse was working full time, part time, or not at all; and whether spouse had a position requiring at least bachelor's-level expertise in the natural sciences, computer science, or engineering. Also included in this category are reasons related to why individuals took the following actions: worked outside of the field of doctorate, changed occupation or employer between 1988 and 1993, took courses following completion of the most recent degree, and took work-related workshops or other training (NSF, 1996: ch. 5).

There was a 10.4% (1400 USD) unexplained gap in salary. A number of possible explanations for this gap were proposed, including: that it was not possible to control for all possible variables (e.g., measures of productivity, prestige of school or department from which degree was received, more direct measures of the importance of salary as a factor in job selection); the measure of variables are imperfect; the results are potentially influenced by other errors such as sampling error and nonresponse bias; and finally, that:
Some or all of the “unexplained” gender salary gap may be attributable to “unequal pay for equal work.” Indeed, the size of the unexplained gap may even be underestimated. For example, it is possible that chance has led to the inclusion of a disproportionately high percentage of high salaried women in the sample. Further, one can argue that some of the “explanatory” variables included in the analysis should have been excluded. For example, if one believes that the primary reason that women are less likely than men to go into certain fields is a perception that these fields are inhospitable to women, one might argue that field of degree should not be used as an “explanatory” variable when examining the salary gap between men and women (NSF, 1996: ch. 5).

Indeed, there is some evidence that shows that pay differentials exist even when men and women are doing essentially the same job. Primack and O’Leary (1993) found in their study on women ecologists that they are paid less than men ecologists for similar work. In his work on engineering and science, Northrup (1988) found that, “As experience level increases . . . . women’s salaries become smaller in comparison to men’s salaries” (51). In other words, as women advance in rank, they are less rewarded than men for their accomplishments. In Zuckerman’s interview with Andrea Dupree (1991a), a prominent astrophysicist in the United States, Dupree described the response that she was met with when she discovered that she was being paid considerably less than her colleagues even though she was just as (if not more) qualified for the job. Dupree explains, “I was told with a laugh, well, we knew you had a husband who could support you, so we didn’t see anything wrong with keeping your salary down at this low level” (101).

F. SOCIAL ROLES

1. Marriage/Parenting

It is often assumed that marriage and parenthood limit women scientists’ productivity. While studies show that marriage and family have mixed consequences for the careers of women scientists, the assumption that women’s productivity is necessarily limited by marriage and children adversely affects the career advancement of all woman scientists (Cole & Zuckerman, 1991; Zuckerman, 1991).

In their study based on 120 interviews with scientists, Cole & Zuckerman (1991) found that neither marriage nor children significantly affected women scientists’ productivity (research and publications) or career attainment. They found that many of the women scientists they interviewed were married to scientists. Thus, they managed to mix work and pleasure easily with their spouses. They also noted that women scientists tended to time marriage and children to fit their career aspirations (i.e. - they waited to have children until after they received tenure). Some women even indicated that their productivity increased after having a child because they felt motivated by the pressure.
In their study based on interviews and discussions with staff from four public-sector agricultural institutions in the Philippines, Brush, et al. (1995), also found that family status did not affect research or publication output. Similarly, Sonnert (1995) found that marital and parental status were unrelated to career outcomes for both men and women scientists. Sonnert reported that of the interviewees who were married at some point in their lives (93% of men, 87% of women), almost half of them indicated that marriage had a positive effect on their careers.

And yet it seems clear that marriage and parenthood affect women and men differently. Primack and O’Leary (1993) found that women ecologists move more frequently than men for their spouse’s career, are more burdened with domestic work in their relationships than men, and are more responsible for childcare than men. Sonnert (1995) found that while marriage to another scientist may increase a woman’s productivity (because her spouse is more likely to be understanding and supportive of her work), it may also limit her career possibilities because it is often difficult to find two jobs in the same location. “Because women scientists are much more likely than men to live in two-scientist marriages, the problem is more prevalent among women scientists” (Sonnert, 1995: 158). Furthermore, in the case of dual-career marriages, priority is often given to the husband’s career. In his article on the state of women engineers and scientists (E/S) in R&D laboratories in the United States, Northrup (1988) found that in two-scientist marriages: “Most female E/S still tend to put their husbands’ careers before their own even though there clearly are now many more exceptions to this rule than heretofore” (46). This means that women will often turn down a job or a promotion if it will in any way hurt her husband’s career. Barinaga (1992) found that women neuroscientists are more likely to compromise their career goals if it would put a strain on their relationship. Brush, et al. (1995) concluded the following about women scientists in agricultural centers in the Philippines:

A much higher percentage of women than men have professional spouses. Women in dual-career families cited delays in training, relocations to follow husbands, and lack of mobility to pursue opportunities as career constraints. Deferral by wives in career decisions reflects the Filipino social norm in which men are the primary “breadwinners” (xiv).

Sonnert concludes that it is difficult to talk about marriage and parenthood as having a “fixed effect” on women scientists’ careers. Rather, he suggests that both marriage and parenthood should be viewed as presenting a “set of problems and opportunities” (Sonnert, 1995: 161). Depending on family decisions about the division of responsibilities within the private sphere, the effects of marriage and parenting on women’s careers can differ radically.

There are signs of creative problem solving in the age of dual-career families. For example, in the journal *Bioscience* Susan Stafford described her experience negotiating a year as director for the Division of Biological Instrumentation and Resources in the Biological Sciences Directorate at the National Science Foundation (NSF) in the United States. Stafford had to commute between the west coast, where she lived and taught at Oregon State University, and the east coast (Washington D.C.), where the NSF is located. What seemed like an impossible situation became manageable when the two organizations (NSF and Oregon State University) were willing to
negotiate a schedule with Stafford which took into consideration her family obligations (Stafford, 1996).

2. Association of Women with the Private Sphere of Life

And yet there are still ways in which women's association with private sphere activities limits their advancement in science. Several research articles note the persistent burden of constraining societal notions of proper roles for women once they have gained entry into the scientific community (Aldhous, 1994; Barinaga, 1992; Brush, et al., 1995; Fox, 1991; Gender Working Group, 1995; Homberger, 1997; Kabagaju, 1995; Kahn, 1994; Nzewi, 1995; Rabarjo, 1995; Selvin, 1992; Subrahmanyan, 1997; Tabak, 1995; Vitug, 1994). Subrahmanyan (1997) argues that in India what she refers to as "patrifocality," or a social system which gives precedence to men over women, "poses serious obstacles to women's progress in science . . . . Since women are not associated with the 'public' sphere, they can not become part of the scientific community except through great perseverance and effort, or by taking the risk of antagonizing those who feel that women should not be 'visible' except in socially mandated ways" (22). According to Subrahmanyan, women scientists in India, limited by gender stereotypes which assert that women are not as free as men, are not easily able to change their geographical location.

In Turkey, Patricia Kahn (1994) explains, it is difficult for women to advance in science because of their association with the private sphere: "The main obstacle isn't discrimination by the scientific institutions but forces that pervade society—especially the strong tradition that defines home and family as a woman's domain, placing a double burden on working women that grows heavier as hours and responsibilities attendant to more senior positions increase" (1487). Biologist Mary Osbom of the Max Planck Institute for Biophysical Chemistry in Göttingen explains that Germany's attitude toward women and careers "can be summed up in the three words of an old German slogan: Kinder, Küche, Kirche (children, kitchen, church). The idea that a woman has a right to a life outside of the home and family is still a radical proposition in Europe's economic powerhouse, and German society turns a disapproving eye on women who try to make such a life for themselves" (Aldhous, 1994: 1475).

3. Social Unrest and Issues of Personal Security for Women

Political unrest can result in the displacement of women pursuing science careers as well as women who have "made it." A study done in Bangladesh (Shafee, 1995), for example, found that the consequences of political unrest have been particularly severe for women scientists because of frequent interruptions in university life. It was estimated that it takes seven to eight years to complete studies up to MSc level. Consequently, many more women now leave to begin their families before their studies are completed. Working women scientists are often unable to work beyond office hours because of the lack of security. As well, the government has cut the budget for higher education and scientific research. This means that job openings are "almost nonexistent."

In Russia, a country in which women make up a majority of the workforce, high unemployment rates in the new free-market economy disproportionately affect women. Homberger (1997) notes that "despite the greater potential of women for retraining and career changes (given women's
better educational background), it is mostly men who escape the bleak employment situation in
science and education by entering the booming business sector or emigrating to the West” (19).
Under a Socialist regime, legislation such as maternity leave and childcare enabled women to
enter the work force in significant numbers. Ironically, this progressive legislation is currently
used against women in Russia by free-market entrepreneurs who argue that women workers are
less productive and more costly than men.

G. PROFESSIONAL AND SCIENTIFIC STYLE

Men and women in all cultures are socialized differently. Some researchers argue that these
differences in socialization result in gender differences in professional and scientific styles.
These differences, whether real or perceived, can affect women’s ability to succeed if they are at
study revealed that substantially more women (51%) than men (26%) thought that their gender
influenced their own professional styles and interaction with other scientists. The interviews
revealed that both men and women perceive men as having a more entrepreneurial and careerist
style. “They [male scientists] are, in this view, more aggressive, combative, and self-promoting
in their pursuit of career success . . .” (Sonnert, 1995: 144). This professional style is seen as
benefiting men in terms of gaining higher visibility and developing professional networks.

When confronted with such an array of subtle (occasionally not so subtle) forms of
discrimination, it is not surprising to learn from women scientists that self-confidence can be
difficult to sustain in such an environment (Barinaga, 1992; Nzewi, 1995; Primack & O’Leary,
1993; Sharma, 1994; Sonnert, 1995). Even though studies have shown that persistent informal
barriers within science organizations operate against women’s opportunities for career
advancement, women often feel that career problems are the result of their personal limitations
or the consequences of their personal circumstances (marriage, children, etc.). In Sonnert’s study
(1995), men and women, even among this elite group, differed in the degree to which they
assessed their own scientific abilities. Substantially more men (70%) than women (51%)
considered their scientific ability to be above average and thought that others shared this view. In
a study of women in Nigeria, Nzewi (1995) found that:

72% of the women indicated that they feel inadequate and lack
self-confidence when they have to tackle some especially difficult
task. Sixty-eighty percent of the women indicated that their
experiences on the job have sometimes made them consider giving
up their jobs and taking on the “traditional women’s jobs.” Fifty-
eight percent indicated that they had given up the struggle to excel
since they can never win” (237).

Vineeta Bal, a scientist at the National Institute of Immunology in New Delhi notes she “finds
that while her male colleagues have no qualms about pushing for promotions and salary
increases, she hesitates, wondering whether she deserves such things—even though she knows
her work is superior to that of many of her male contemporaries” (Sharma, 1994: 1495).
With respect to scientific style, perceptions of gender differences were not strong in Sonnert's (1995) study. Yet, a substantial minority of women also thought that their gender influenced their choice of research topics (40%), their ways of thinking in science (36%), and the methods they used (35%). In contrast, only about 15% of the men saw gender as an influencing variable in these areas. Women reported having to be extra cautious in their methods in order to stave off criticism. Many women reported using a “niche approach” in selecting research problems. Women had a higher tendency to carve out their own areas of expertise rather than competing in a dense field of researchers to solve a high visibility problem. Some of these differences in style may reflect different patterns of men’s and women’s socialization. For example, Sonnert suggests that in the United States, women may not be as comfortable with competition as men. But many differences may also reflect the choices that women, who are still relative newcomers to the community of science, have made in order to be able to cope with the accumulation of small and subtle disadvantages in the pursuit of meaningful careers.

H. THE GENDERED NATURE OF SCIENCE

1. The Culture of Science—How it Affects Women’s Status in Science

Even though the number of women entering scientific professions has increased, studies have shown that in most scientific disciplines, women are still a minority. For example, Joe Alper (1993) reports on the United States:

(W)omen make up 45% of the U.S. workforce, but they account for only 16% of employed scientists and engineers. Though women earn more than half the bachelor’s and master’s degrees and more than a third of doctorates awarded at U.S. colleges and universities, in science and engineering disciplines they receive only 30% of bachelor’s degrees and less than a quarter of advanced degrees. And those dismal statistics would look even worse if the figures for one traditionally “feminine” field—psychology—were removed (409).

In United States culture, many women with scientific aptitude are not encouraged to enter scientific professions. The problem begins early in life when boys are encouraged while girls are discouraged to pursue science. Because science is supposedly not “people-oriented,” which girls/women tend to care about more than boys/men, women have been reticent to pursue their interest in science as a career (Alper, 1993).

But what about women scientists in newly industrialized countries? In the mid-1980s sociologist Beatriz Ruivo of the National Board for Science and Technological Research in Portugal began to ask why newly industrialized countries seemed to have a higher percentage of women scientists than highly industrialized countries. “In countries now undergoing economic development, including Mexico, Argentina, and the countries of eastern Europe, women made up from 20% to 50% of the scientific researchers, compared to fewer than 10% in the United States and northern European nations such as Germany” (Barinaga, 1994: 1468). At first Ruivo assumed that this was because in places that had well-established scientific communities, these
communities were established in an era when women were not as integral to the labor market, unlike the more newly industrialized countries which began developing science and technology during the twentieth century. Ruivo is less hopeful than she was in 1987. "Back then, she says, she assumed women in newly industrialized countries would continue to advance. . . . Although there are plenty of women in science, she says, she has observed that the glass ceiling is firmly in place in Portugal: Women are concentrated in the lower levels of the scientific establishment and are not rising to the top ranks" (Barinaga, 1994: 1468-9). Barinaga notes that this, in part, can be explained by the culture of science in newly industrialized countries.

In countries that are still undergoing economic development, basic science isn’t as closely integrated into the production of goods and services as it is in the advanced economies of Europe, Japan, and the United States. In developing countries, she [Ruivo] says, “to work in scientific research has a different meaning than in advanced countries. It is more of a cultural activity.” Not only does it have low status, in some countries it is quite low-paying, making it a pursuit undesirable to men and therefore left open to women (Barinaga, 1994: 1469).

In Turkey, for example, academia is a low-paid occupation, making men more likely to pursue careers in engineering and medicine rather than in teaching. Because girls are not brought up to worry about being the breadwinner and because Turkey’s educational system is relatively unbiased against women in science, the statistics of women in science are quite high: 32% of faculty and 38% of students in science in Turkish universities are women (Kahn, 1994). A similar situation was described for India, according to the Shobhana Arasimhan, who explained that, “A ‘real’ career meant designing factories or bridges, not studying DNA. Girls, not subject to the same pressures [as boys], were free to pursue academic science or math” (Barinaga, 1994: 1469). In the former Soviet Union, where a high percentage of physicians were women, the same idea applies in that being a physician was not considered a prestigious position. The highly valued scientific positions were held by men (Kahn, 1994). In a sense, then, it seems to hold that the more prestigious a scientific discipline is in a culture, the more likely women will be excluded from that discipline (see also Brush, et al., 1995).

2. A Closer Look at the Culture of Western Science

In Secrets of Life, Secrets of Death: Essays on Language, Gender and Science (1991), Evelyn Fox Keller, a microbiologist and a Professor of History and Philosophy of Science at the Massachusetts Institute of Technology, discusses the need to do more than simply demand parity in numbers of men and women in scientific practice. Keller explains the importance of exploring the ways in which masculine norms, taken as universal norms, have been absorbed into the practice of science itself. For example, she questions the assumed normative relationship between men and science while women are relegated to the position of “other.” In doing so, Keller (1991) defines gender and the role that it plays in constructing the culture of science as:

the basis of a sexual division of cognitive and emotional labor that brackets women, their work, and the values associated with that
work from culturally normative delineations of categories intended as "human"—objectivity, morality, citizenship, power, often even, "human nature" itself . . . From this perspective, gender and gender norms come to be seen as silent organizers of the mental and discursive maps of the social and natural worlds we simultaneously inhabit and construct—even of those worlds that women never enter (16).

This definition articulates a more complex notion of gender than simply biological sex or even of social roles for men and women. Keller explains this as a "double shift" in perception: "This double shift in perception—first, from sex to gender, and second, from the force of gender in shaping the development of men and women to its force in delineating the cultural maps of the social and natural worlds these adults inhabit—constitutes the hallmark of contemporary feminist theory" (17).

It is often assumed that the language of science is transparent and neutral, and therefore does not require examination. However, since Keller believes an important barrier to women's success in science is related to the belief in the intrinsic masculinity of scientific thought, she began to question the practice and the discourse of science. For example, "Where does such a belief come from? What is it doing in science, reputedly the most objective, neutral, and abstract endeavor we know? What consequences does that belief have for the actual doing of science?" (24). Keller explains, "In order to see how cultural norms and values can, indeed have, helped define the success and shape the growth of science, it is necessary to understand how language embodies and enforces such norms and values" (26). Keller explains this as follows:

Different metaphors of mind, nature, and the relation between them, reflect different psychological stances of observer to observed; these, in turn, give rise to different cognitive perspectives . . . Such variability is of course always subject to the forces of selection exerted by collective norms, yet there are many moments in scientific history in which alternative visions can survive for long enough to permit identification both of their distinctiveness, and of the selective pressures against which they must struggle. The clearest and most dramatic instance in my own research remains that provided by the life and work of the cytogeneticist Barbara McClintock . . . "Nature," to McClintock, is best known for its largesse and prodigality; accordingly her conception of the work of science is more consonant with that of exhibiting nature's "capacities" and multiple forms of order, than with pursing the "laws of nature." Her alternative view invites the perception of nature as an active partner in a more reciprocal relation to an observer, equally active, but neither omniscient nor omnipotent; the story of her life's work (especially, her identification of genetic transposition) exhibits how that deviant perception bore fruit in equally dissident observations . . . the ultimate value of any accomplishment in science—that which we
all too casually call its “truth”—depends not on any special vision enabling some scientists to see directly into nature, but on the acceptance and pursuit of their work by the community around them, that is, on the prior existence or development of sufficient commonalities of language and adequate convergences between language and practice (32).

Keller is not alone in her view of science as culturally constructed. In an article in Science magazine’s 1993 issue on women and science, Marcia Barinaga (1993) cites other feminist scholars on the culture of science:

"(S)cience is totally inside culture," says Sandra Harding of the University of Delaware. “All kinds of social meanings are used to constitute the very ways in which science goes about its projects.” And that means that “there is no such thing as value-free science,” adds Anita Solow, a mathematician who teaches a course on gender and science at Grinnell College in Iowa. “If you look at science in the past, not just bad science . . . . but even the good stuff that works beautifully, it is a creation of the culture and context” in which it was created (392).

In order to understand the language and practice of science as culture-bound, it is necessary to understand the history of the discipline.

In The Mind Has No Sex? Women in the Origins of Modern Science, Londa Schiebinger (1992) explores “the long-standing quarrel between science and what Western culture has defined as ‘femininity’” (2). The Scientific Revolution in seventeenth- and eighteenth-century Europe was a time of transition in which old theories and ideas were being challenged and debated. Yet, Schiebinger argues, in this fork in the road where scientific men could either invite women into the world of science or continue to exclude them, the latter was chosen. Schiebinger illustrates how traditions within science today that seem natural actually grew out of a process of conflict and negotiation amongst male and female practitioners. For example, the growth of universities and academies as central centers of learning throughout the eighteenth century meant that women (who were barred from these institutions) would be increasingly excluded from scientific endeavors. Thus the institutionalization of science worked against rather than for women’s inclusion its fields of inquiry.

Schiebinger concludes that the scientific revolution did not involve a revolution in ideas concerning gender. Consequently, if women wanted to pursue science they had the option of attempting to gain access to universities or they could be “invisible assistants” to their husbands, brothers, or fathers at home. “University degrees awarded to women in the eighteenth century were unique to Italy and Germany; none were awarded in England or France” (246). Schiebinger sums up the bind for women:

Those who might have criticized the new scientific views were barred from the outset, and the findings of science (crafted in their
absence) were used to justify their continued exclusion. The image of women developed in this context had the character of a self-fulfilling prophecy: women did not excel in science—but, then they seldom had an opportunity to work in science (266).

Keller (1991a) explores problems with liberal arguments—rooted in Western Enlightenment culture—used to demand parity in numbers of men and women in science in the latter half of the twentieth century. She argues that neither the assertion nor denial of difference (both strategies of liberal thinkers) will procure equity for women in science as long as the conception of science is monolithic. “To the extent that we acknowledge a multiplicity of goals and standards in science, it becomes possible (at least in principle) to argue for the inclusion of difference—in experience, perceptions, and values—as intrinsically valuable to the production of science; hence, it becomes possible to envision equality without sameness” (234).

For example, asserting difference between men and women scientists by separating the work that they do has resulted in a ghettoization of women scientists in low-paying less prestigious scientific work. Alternatively, attempts to prove the irrelevance of sex difference in science has ultimately been futile and has even been used against women. In the 1950s in the United States, the push for women to stay home and care for their families meant that the number of women in science was drastically reduced. The women who did participate in science and the generation who followed their stay-at-home mothers worked hard to erase their gender from their professional identity. In the 1960s-70s the women’s movement demanded that women in science be increasingly counted and recognized. Keller explains that in the 1960s-70s, “Almost as a consequence of the reemergence of their [women scientists] group identity as women, their commitment to intellectual sameness—to the repudiation of difference—returned with renewed force” (231).

It is as if the acknowledgment of difference (in this, case, recognizing one’s gender as part of one’s identity) leads to exclusion. If difference is equivalent to inequality, then sameness is equivalent to equality. In this way, there is no room for other, and science is therefore monolithic. Because of this, for women, Keller argues, “Successful assimilation [into scientific communities] has thus tended to require not equal ability, but extra ability—the extra ability to compensate for the hidden costs incurred by the denial or suppression of a past history as ‘other’” (234). Keller warns against the danger of mapping difference onto sex, or assuming that difference is equivalent to duality. It is important to be able to think more complexly than, for instance, “because women are different than men, they would necessarily do a different kind of science than men.” As she sees it, the goal would be to shift from “women and science” to “men, women, and science,” realizing that none of these categories is itself monolithic. In this way, we would also challenge the notion that “gender” equals “woman.”
The field of science has significantly changed over the last 100 years. Women are no longer relegated to the status of invisible assistants to fathers, brothers, and husbands. They are, however, still remarkably absent from senior scientific positions. While great strides have been made concerning overt discrimination against women in science, clearly there are still informal barriers to success for women scientists. Taken together, these barriers have major effects on women scientists' careers. Mary Frank Fox (1991) notes:

> productivity in science is irrevocably tied to the environment of work: the signals, resources, and reward schemes of the institutional setting, and the networks of communication and exchange in the larger community of science (204).

The work environment is fraught with gendered barriers which unduly burden women scientists in their scientific endeavors and, thus, in their career advancement.

This literature review points to the importance of working to change the environment, or the culture, of doing scientific work in order to make it more hospitable to women. It is not enough to simply work on increasing the numbers of women in science. In their study of 30 academic science departments in the United States in five disciplines (biology, chemistry, physics, computer science, and electrical engineering), Etzkowitz, et al. (1994) described the problem of simply assuming that greater numbers of women in science will change the culture itself:

> Encouraging more women to enter the pipeline is fruitless if so few emerge as professional scientists. At each transition point the number of women decreases at a significantly higher rate for women than for men. For women the pipeline is an exceedingly leaky vessel. In the face of exclusionary practices, both explicit and implicit, built into the research university system, many women Ph Ds seeing the handwriting on the wall and seeking to balance work and personal life, sought employment in industry and teaching colleges. As our observations emphasize, the pipeline, a supply-side approach, needs to be supplemented by a focus on changing the institutional structures where science takes place (53-54).

One of the goals of the scientific community is to provide an environment for all of its members which allows them to work creatively and productively. Understanding the informal obstacles women face in scientific endeavors can help us to create this environment, which in turn, will allow all scientists to produce the best possible scientific innovations.
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