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# Fixing the Leaky Pipeline: Women Scientists in Academia[1,2]

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**ABSTRACT:** Although the number of women receiving doctorates and in academic positions has increased over the past 20 yr, females still are under-represented on university faculties. The extent of and reasons for this inequity are discussed. There are four critical periods that influence the retention of women in science: early childhood, adolescence, college, and the graduate school/job entry period. For each of the later three periods, the paper addresses the relationship between self-esteem and job performance, the quality and impacts of classroom interactions, and the role of the advisor/mentor. In addition, some of the difficulties in combining career and family responsibilities are considered. Effective networking and mentoring play an important role at the faculty level. If our goal is to have a scientific community open equally to all members of the general population, it is necessary to keep adolescent girls involved in math and science and to maintain their self-esteem. New faculty need to be more completely included in departmental and professional activities through both formal programs and good neighborliness on the behalf of existing faculty.

Key Words: Women, Science, Mentor, Self-Esteem

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## Introduction

Controversy still surrounds the gender equity of hiring and promotion on university campuses. The leaky educational pipeline, beginning in childhood, is held partly responsible for the unequal numbers of men and women in faculty positions in the sciences at universities across the United States. Are women under-represented? Does the educational pipeline have serious leaks? Why? What repairs are needed? These are the questions that will be addressed in this paper.

To develop effective policies to include and encourage under-represented faculty and students, we need to know which forms of support work and which do not. Byrne (1993) used the Snark analogy from the poem “The Hunting of the Snark” by Lewis Carroll (“‘Just the place for a Snark! I have said it thrice: What I tell you three times is true’”) to describe situations in which constant repetition gives credibility to otherwise unsupported assertions. An example of the Snark Syndrome is the importance attributed to role models. Many programs to encourage female and minority scientists assume that role models are effective, although few data support or contradict this assumption. Distant role models may convey a weak message to students that it is possible for a woman to be a scientist but do little to make a student believe that she might consider becoming a microbiologist (Byrne, 1993). Active encouragement by advisors, family, and teachers is necessary to make that transition. Despite convincing evidence that role models alone are ineffective (Byrne, 1993), most programs for women in science strongly emphasize role models because their significance has been reiterated so many times.

## The Extent and Nature of the Problem

### *Equal Representation?*

A comparison of the numbers of female undergraduates, total faculty, and tenured professors in science and engineering at American universities shows the leakiness of the academic pipeline. Women receive approximately 40% of the undergraduate degrees in science and engineering, but they comprise only 22% of the university faculty and 8% of the full professors in these fields (White, 1992). These statistics on

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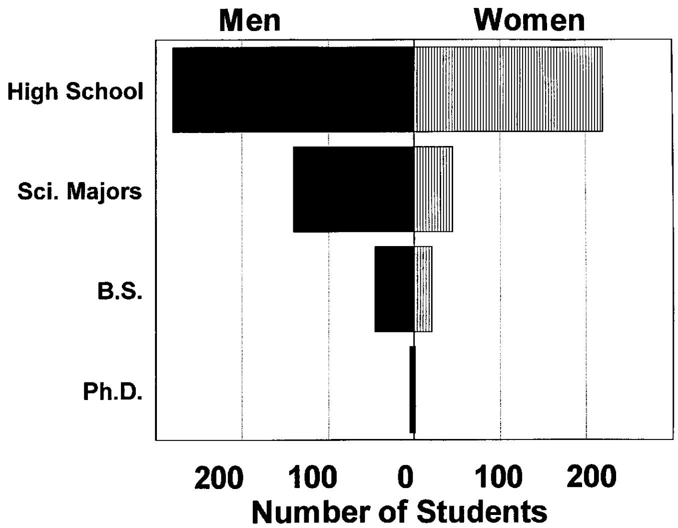


Figure 1. Data from Widnall (1988) and the Office of Technology Assessment (1985) that show the decrease in the number of students eligible to continue in science from high school through a doctoral program in the sciences and engineering. By high school, half of the original 4,000 students (2,000 of each sex) have taken insufficient mathematics to meet the requirements for technical careers.

faculty and student representation may not provide a fair comparison because they fail to show the progress of the last 20 yr. The number of doctorates awarded to women in all fields has increased from 1,759 in 1965 to 11,790 in 1988 (NRC, 1989), an impressive increase from 11% to 36% on a gender basis. Unfortunately, progress has been very slow in some fields, and representation of women in faculty positions has not kept pace with the awarding of degrees (Vetter, 1992). In 1988, 27% of all faculty in all fields were women, up from 25% in 1978 (Hensel, 1991). At this rate of increase, equity will not be achieved until the year 2109. Doctoral level jobs, however, are at the end of the pipeline. Many losses occur because of events that happened much earlier in the educational process.

The pipeline has several leaks, beginning in elementary school and continuing until retirement. A report by the Office of Technology Assessment (1985) cited by Widnall (1988) studied a cohort of 2,000 male and 2,000 female ninth grade students (Figure 1). By ninth grade, only half of each group had studied enough mathematics to remain eligible for scientific careers. By the end of high school, the number of adequately prepared students had decreased to 280 males and 220 females. When these students selected college majors, 140 men and 44 women chose majors in science and engineering, of which 46 men and 20 women actually received B.S. degrees. Women entered graduate school in numbers that reflected the number of science graduates in their field. However, graduate school took its toll, and, of the 2,000 students in each original group, 5 men and 1 woman received a Ph.D in the sciences or engineering. Widnall's presentation did not include data on scientific professionals such as physicians or veterinarians.

Recent figures from neuroscience, a field with employment patterns similar to many of the other life sciences, provide a more detailed breakdown of where leaks occur for women with doctorates. Although 45% of the entering graduate students are women, 38% of those receiving their Ph.D.s, a third of the neuroscience postdocs and only 18% of the neuroscientists with tenure-track positions are female (Barinaga, 1992). Women, finding tenure-track positions elusive, often remain in academia in non-tenure-track positions. Among scientists in general, women are more than twice as likely as men to hold these less-desirable positions, a trend that has not changed in the last 10 yr (Vetter, 1992; White, 1992). Promotion from tenuous-track to tenure-track positions that usually pay better and have more prestige is difficult. The less applied sciences like math and physics have significantly fewer women at all levels. Agriculture is intermediate, with 28% of the doctoral degrees granted to women (Alper, 1993).

The small number of female department chairs, deans, and college presidents suggests the existence of an academic glass ceiling that has few cracks (Vetter, 1992). The number of female department chairs in medical schools has not changed in the last 20 years, and only one medical school had a female dean in 1992 (Committee on Women in Science and Engineering, 1994).

Having briefly assessed the leakiness of the academic pipeline, I would like to move to the central purpose of this paper, an exploration of the causes of the leaks at different junctures. Why do women drop out and what can we do to retain them in numbers equal to their male counterparts?

There are several critical periods when the risk of leakage is particularly high: 1) early childhood, 2) adolescence, 3) sophomore year of college, and 4) the later part of graduate school and the job entry period. I have decided reluctantly not to discuss early childhood, a period that is critical for the development of self-esteem and for the acquisition of basic skills that affect later education. Gender development and self-esteem during early childhood are well described in books by Golombok and Fivush (1994) and by King et al. (1994) Because the self-esteem of women drops significantly during adolescence, we must examine this period. After self-esteem has dropped, it is not long before performance in technical subjects also falls (Am. Assoc. Univ. Women, 1992). Academic decisions made in elementary and junior high school often exclude women from technical careers because they have inadequate preparation for science and engineering programs. Failure to take sufficient mathematics in high school can disqualify students from three-quarters of all college majors (Matyas, 1985).

## *Adolescence*

*Unequal Performance.* Since 1973, the National Assessment of Educational Progress project has studied achievement in math and science of 9-, 13- and 17-yr-olds (White, 1992). In 1990, the performance in mathematics of 9- yr-old girls equaled that of their male peers, but they scored 3 points lower on a 300- point scale in science than boys, a significant difference. The gap in science performance narrowed between 1973 and 1990. Unfortunately, by age 9, girls already had less experience making scientific observations and using scientific equipment than boys (Matyas, 1985). This lack of experience was ascribed to a lack of opportunity rather than to a lack of interest in science.

At the age of 13, the math achievement scores remained equal, but the girls scored 7 points lower than the boys on the scientific assessment test. This gap has widened since 1973 (White, 1992). On the scientific proficiency test, 53% of the girls and 60% of the boys were able to apply basic scientific information. At the end of high school, women received scores that were 3 points lower in mathematics than the males, and fewer females could complete moderately complex procedures and reasoning. In science, the gap widened to a 10-point difference between the sexes among 17-yr-olds. The science performance of both male and female 17-yr-olds declined between 1973 and 1990. The widespread use of computers may increase the gaps in math and science performance. Not only are boys three times more likely to have a computer at home than girls, but they use it differently, for programming rather than for word processing (Sadker and Sadker, 1994). Studies from the mid-1980s on computer access showed that 75% of the participants at high school computer camps were male (Alper and Holmberg, 1984).

These figures indicate that the performance of preadolescents in math and science does not differ by gender but, by the end of high school, gaps in math and science performance exist. What happens during adolescence that decreases the performance of girls in technical subjects?

*Self-Confidence.* During the last 5 yr of high school, the self-esteem of girls drops more precipitously than that of boys (Am. Assoc. Univ. Women, 1992) and is never regained. Girls emerge from adolescence with reduced expectations and less confidence than boys. In elementary school, 60% of the girls agreed with the statement “I am happy the way I am” compared with 67% of the boys. Only 46% of the boys and 29% of the girls in high school were content with themselves. These results are affected strongly by the ethnicity/race of the respondents. The self-images of Latina girls suffered more during high school than did those of other ethnic groups, whereas African-American females usually retained more of their confidence during adolescence except in their feelings about school. Many studies indicate that loss of self-confidence precedes diminished performance in math and sciences.

Single-sex education has been proposed to prevent loss of self-esteem. Supporters of this theory point to the higher retention rates of women in the sciences at women’s colleges (Sebrechts, 1992). However, several of these studies involved comparisons of elite women’s colleges and selective coeducational institutions so selectivity, socio-economic class, and gender may have been confounded (Oates and Williamson, 1978). Data on the effectiveness of coeducational colleges with adequate support for female students are limited because many of the programs to encourage female participation in the sciences were implemented recently.

*Classroom Teaching.* The patterns of interactions in the classroom among students and between teachers and students contribute to the lower aspirations and performance of the female students (Sadker and Sadker, 1994). Boys often receive more attention from teachers and are given more time to express themselves than girls. Not only do teachers give more attention to boys, but teacher feedback also differs by the gender of the student. Boys are more likely to receive precise comments on their contributions than girls. These more detailed responses may be praise (10%), criticism (5%), or remediation (33%) but, in all cases, the students get more information about their efforts than the teachers’ most common type of response, acceptance. The non-committal “uh-huh” acceptance responses made up 52% of the teachers’ comments to their students. The only area in which gender differences were not evident was in the number of acceptance responses that students received (Sadker and Sadker, 1994).

One reason why boys command more teacher attention is that they demand it. According to Sadker and Sadker (1994), boys are eight times more likely to call out in class than girls. Teachers respond to assertive classroom participation differently depending on the sex of the student. They are more likely to accept the answers of outspoken boys while admonishing girls to wait their turn. The message is clear: assertiveness in the classroom is more valued among boys than among girls. The upshot of these differences in classroom interactions is that the learning environment within the same classroom can be quite different for male and female students. Compelling anecdotal evidence documenting these inequities in high school classrooms is provided by Orenstein (1994). In a classroom where attention was equally distributed among students, the males felt shortchanged.

*Remedies.* If we are to avoid the dissipation of self-confidence and feelings of competence among adolescent girls, changing classroom interactions is a necessary first step. Sadker and Sadker (1994) described a short teacher training program that has been effective in modifying classroom dynamics. Ohio has developed a similar program that is available statewide. We must create environments in and out of school that value academic performance so that negative stereotypes of science students do not persist (Brush, 1991). Extramural programs such as Expanding Your Horizons, designed to show girls in junior high school that they can be scientists, doctors, or mathematicians, may help. Extension 4-H programs provide a useful vehicle in the agricultural sciences. Female science clubs give girls a chance to use scientific equipment and conduct their own experiments, rather than assuming the role of data recorder as they often do in coeducational situations (Travis, 1993). Professionals in science in industry or academia can make valuable contributions to these programs.

## College

*Self-Confidence and Advising.* Many of the solutions that are effective at the elementary and high school levels also are appropriate at college. Lack of confidence and fear of failure often lead students away from the sciences. The process women use when reevaluating their goals, an activity undertaken by many college sophomores, often differs from the approach used by their male counterparts. Although Brown and Gilligan (1992) interviewed adolescents primarily, they provide insightful descriptions of the questions and conflicts that confront both adolescent and mature women. Sophomore women may seem unfocused because they are unsure of their ability and, consequently, reluctant to take bold steps to change direction. What seems to be a simple question of changing a course or a major is often a much more complicated issue. These students are not simply altering short-term goals, but rather are trying to discover who they want to be and how to integrate this vision with what is expected of them. Hence, this period of “regrouping” may last longer than the advisor expects. Advisors need to acknowledge the breadth of these questions and provide encouragement for this exploration, rather than lamenting the student’s indecision and lack of focus.

From personal experience, I know that encouragement and support from an advisor can be important in enabling a student to make a risky but worthwhile choice. It was not coincidence that each of the three speakers at the 1994 Animal Science Symposium “Trails to Success” mentioned her mentor(s) by name. These men and women had important impacts on our lives. None of these mentors was part of a specific mentoring program because all of the speakers were at universities before such programs existed. Such programs may be helpful, but they are not essential to finding needed advice. In my case, words of support from my undergraduate advisor, spoken several years earlier, made my decision to change careers and go to graduate school much easier. Often, only a few words of encouragement make a tremendous difference to the student who feels incapable of meeting current challenges. This is true for all students but is especially valid for those whose self-esteem is low.

*Classroom Teaching.* In a college classroom, fewer than half of the students participate during a class by asking or answering a question compared with 80% in high school. Those that do participate are twice as likely to be male (Sadker and Sadker, 1994). Faculty also make more eye contact with male students and are less likely to interrupt them (Hall and Sandler, 1982). Faculty often leave insufficient time for students to respond to questions, giving the “eager beavers” encouragement and allowing many to remain silent. Having a graduate student tally the number and length of student contributions can give the instructor useful information on classroom dynamics and can provide useful training on teaching evaluation for the student. Hall and Sandler (1982) suggested many other teaching techniques to improve the classroom climate for the benefit of all students.

## Graduate School and Beyond

*Self-Confidence and Impostors.* Although the women entering graduate programs at Stanford and the Massachusetts Institute of Technology had the same initial grade point averages and career goals as their male counterparts, they received less financial support and were less likely to complete their doctoral degrees (Widnall, 1988). Low self-esteem, which is further diminished during graduate school, continues to be a concern (Hall and Sandler, 1982). The literature on women in academia includes frequent references to the “impostor phenomenon” (Clance and O’Toole, 1988). “I’m the Michigan mistake” and “I just got my job as a fluke” are comments made by very able female Ph.D.s that exemplify this problem. Despite their selection for very competitive positions, the victims of the impostor phenomenon ascribe their success to luck, hard work, being in the right place at the right time, knowing the right people, and interpersonal skills instead of to ability or competence. Fear of discovery of their underlying incompetence means that the so-called impostors experience significant anxiety, over-prepare even simple assignments, and often procrastinate to avoid failure. The result often is that the “impostor” does not enjoy her usually numerous successes and limits her productivity. The extent to which this problem exists was made clear to me when a senior faculty member who had two concurrent grants from the National Institutes of Health (N.I.H.) and was widely viewed as a leader in her field almost bowed out of a presentation at a Gordon Conference because she felt unqualified.

*Career and Family Conflicts.* In graduate school, few female faculty role models are available when some of the very real problems of combining career, marriage, and child-rearing become apparent. Zuckerman (1991) argues that marriage and having children do not adversely affect research productivity themselves: married women with children publish as many papers as their single peers. In fact, women publish more papers than average during the year in which they give birth. Zuckerman argues that it is the perception that women are incapable of simultaneously meeting family and work demands that often hinders their hiring and promotion, not actual decreases in productivity due to family commitments. The Zuckerman data show that women at the faculty level are committed to their careers and to maintaining research productivity when family demands are high. These women are survivors with high investments in the academic system. It is likely that those who have not been able to resolve the conflicts between academic science and leading a fulfilling life outside of the laboratory have dropped out already (Etzkowitz et al., 1994). Crosby (1991) in a very complete discussion of the pros and cons of balancing career and family argues that, although the juggling act is difficult, there are often both practical and psychological benefits for the entire family.

Caplan (1993) contended that family demands do affect women's productivity. Balancing work and family demands is difficult when children are young, even with shared parenting and salaries that permit buying day care services. Unfortunately, biological and tenure clocks tick simultaneously, so women often face tenure decisions when their children are young. Adequate maternity leaves and quality day care benefit children, parents, and employers alike. Supportive administration and "stop the clock" tenure policies for pregnant faculty reduce the stress faced by faculty-parents. A choice between children and a career should not be necessary.

*Outsiders.* One of the most important roles of graduate school advisors is to teach students the many unwritten rules of academia. There are numerous expectations for doctorates and for tenure, but few are explicit, a problem for graduate students and new faculty. This problem becomes more serious if the person is unfamiliar with the dominant culture of the department (Caplan, 1993). A mentoring program can protect young faculty from failure to get tenure because they didn't understand the rules. What is successful research? Is one "block-buster" paper better than a stream of lesser publications? Currently, interdisciplinary projects are in vogue but they often yield little recognition. How involved should untenured faculty be in these efforts? Young faculty need guidance from department chairs and other faculty as they tackle these issues. The "if you don't know the answer to that question, you shouldn't be here" response is unhelpful and irresponsible.

*Inclusion and Recognition.* Young faculty members need to weave themselves into the teaching and research life of their department. Stray threads are likely to get cut off, but this weaving process often is a problem for women and minorities. Successful, ongoing interactions with both departmental faculty and professional colleagues provide new ideas, funding, job opportunities, and recognition, all of which are essential for tenure. Too often, young female/minority faculty eat lunch alone in their offices while some of their peers eat together. This exclusion usually is unintentional and arises from the incorrect assumption that everyone feels welcome to participate in the brown bag lunch. An informal explicit invitation may be all that is needed to encourage the outsider to join the group. In other cases, efforts may be needed to ensure that the conversation includes topics of interest to the newcomer. An examination of the coffee drinking, lunch eating, and after-work beer drinking habits of a faculty can indicate whether new faculty are being woven seamlessly into the social tapestry of the department.

Being "one of a kind" or even "two of a kind" in a department can be a lonely and demanding experience. Female undergraduate and graduate students often have unrealistically high expectations of the change that will occur due to the initial hiring of female faculty (Etzkovitz et al., 1994). The first female faculty member in a department must face these unachievable demands with limited support, a justified fear of antagonizing senior faculty members, and without same-sex consultants for assistance. Intentional inclusion and good mentoring programs can ease the transition from outsider to insider. This responsibility for inclusion lies largely with the tenured faculty.

The time required for promotion for women is usually longer than for men of comparable achievement. Even women like Rosalyn Yalow, Barbara McClintock, Gerty Cori, and Maria Mayer, all Nobel laureates, received promotions to professorships far later than men of comparable achievement (Epstein, 1991). This lag in promotion is equally evident among "rank and file" female scientists. In some cases, this lag is due to inequitable access to resources, and, in others, it is due to discrimination. Failure to network and receive appropriate recognition is another explanation for slower promotion. At the 1994 joint ASAS-ADSA meetings, 92 (86%) of the invited papers and symposium papers were given by men, 5 (5%) were presented by women (excluding "Trails for Success"), and 10 (9%) could not be classified. If we assume that the gender breakdown of the unclassified papers was representative of those that were categorized, only 5% of the speakers asked to give papers that confer added recognition were female. Given the large number of female graduate students who have received doctorates in Animal Science in the last 15 yr, those of us who train graduate students should bear some responsibility for this poor female representation. This under-representation contributes to the impression that there are no women in science and deprives younger women of needed role models.

Women also are discouraged from entering science and engineering because they continue to experience higher unemployment, difficult working conditions, lower wages, and fewer promotions than their male peers (Brush, 1991). Unless some of these conditions are changed, Brush (1991) argues that not entering the sciences may be a rational decision for able women.

## Implications

The issues that hinder the repair of the leaky pipeline are not going to be resolved quickly. The slow turnover of university faculty precludes quick remediation of the under-representation of women. However, there are a number of steps that can be taken by faculty to address some of the problems: 1) Become involved in science programs for elementary and high school students. 2) Encourage participation by all students in classes. 3) Spend enough time with advisees to become familiar with their problems. 4) Teach graduate students the unwritten rules of academia. 5) Do not overlook underrepresented faculty when invitations to give invited papers and write book chapters are issued. 6) Inform new faculty of what is expected for tenure. 7) Be a good neighbor and ensure that new students and faculty feel welcome in the department. Each of these steps alone is rather small, but together they could change life for many within universities. Virginia Woolf (1929) argued in her Girton College lecture at Cambridge that all that was needed for women to make significant literary contributions was £500 annually and a room of oner's own. A lab of one's own and £500 do not suffice today. We need an open, integrated work environment as well.

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