**Barriers to Women in Academic Science and Engineering**

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## Introduction

Questions of gender and science have come into the foreground in sociological theory, feminist research and human resource policy. This chapter focuses on the experiences of women in Ph.D. programs and as faculty members. Rather than examining threshold effects that might keep women out of graduate programs, or glass ceiling effects that might keep women with high quality training from progressing to the peak of academic careers we investigated the conditions under which women are at a disadvantage during their doctoral training and early stages of their academic careers. Academic practices, presumed to be meritocratic and gender-free, often work against women's professional success. Their deleterious effects on most women are sometimes hidden behind a neutral or even positive facade erected on the highly publicized achievements of a few exceptional women, some of whom deny the existence of obstacles in their path (Science, 1992). In our discussion we do not mean to imply that men do not have some of these same experiences as well as different ones. However, the lack of social and professional connections available to most women in academic science and engineering departments, in concert with overt and covert gender bias as well as differences in socialization, creates special and unique problems for women.

## Data and Methods

The initial research site is classified as a Carnegie I research university (Boyer, 1987). Four science and engineering departments were selected for examination, including two basic sciences (physics and chemistry) an engineering discipline (electrical engineering) and a hybrid discipline, computer science (at this university located located jointly in the Engineering School and the Faculty of Arts and Sciences), to determine the receptivity of their cultures to women graduate students and faculty members. Three hundred and fifty current students and seventy six dropouts were identified in the four departments, along with one hundred and ninety eight students who received their doctorates within the past five years. In these departments there are one hundred and seventeen faculty members, including five women, two each in computer science and physics and one in chemistry. At the time faculty data were collected only one of the women was tenured. During the course of the study another

was granted tenure, she was apparently the first to be accorde d permanent status in the engineering school. (The physics department previously had two tenured women, one now emeritus and the other deceased.)

We collected data from departmental academic records on advisors and advisees and interviewed female and male faculty members, female graduate students and academic administrators. The quantitative data consists of a listing of current graduate students, along with Ph.D. recipients over the last five years, paired with their main faculty advisors (from one of the departments, electrical engineering, data on Ph.D. recipients only spans the past two years). Supplementing this, data were also gathered for students who dropped out of their programs prior to earning their doctorate. In the computer science and physics departments, dropout information was obtained for the previous five years, while in chemistry it spans three years, and in electrical engineering only one. (Since physics students are not assigned a faculty advisor until after they have completed two years, advisor data were missing for those who dropped out of the program before this point. In electrical engineering, dropout data were provided only for the prior year and did not include students who left after failing a qualifying exam administered after t heir first few months in the program.)

The qualitative data consists of forty six interviews with faculty, graduate student, and adminstrator informants. Twenty five interviews were conducted with female Ph.D. students who were currently attending or rece ntly graduated within the physics, chemistry, electrical engineering, and computer science departments. Interviews were conducted with all five female faculty members. Two recent former women faculty members who are currently faculty members at other unive rsities were also interviewed. Interviews were conducted with eight male faculty members who had been identified by chairs or graduate students as having either particularly good or poor relations with female graduate students. Chairs were also interviewed to ascertain whether there were any special departmental policies concerning the recruitment of women (there were none). Interviews were also conducted with administrators in the engineering and graduate schools. Women's experience as faculty members and graduate students was studied in the same four disciplines at a public research university. In addition, a department of molecular biology with a critical mass of women faculty was studied at a third university for a total of nine departments. This chapter primarily reports on the qualitative findings from the initial site.

**Barriers to Entry**

Barriers against professional women have been framed in two different ways, emphasizing two stages at which obstacles might occur: a threshold "beyond which gender no longer matters," and a "glass ceiling of gender specific obstacles to advancement into top positions" In the first, women encounter difficulties advancing in a field but the obstacles fall away once a certain status is attained; in the second There is a particular career level women may attain at which point a blockage occurs to further advancement, e.g. women are blocked from attaining full professorship in science departments at leading universities. (Sonnert, 1990) The "threshold effect" presumes that women only face barrier in the early stages of their career, while the "glass ceiling" presumes barriers only at the higher levels of careers.

We find, instead that women face barriers to entry and achievement at all stages of the academic ladder. We have identified a series of mechanisms that mitigate against the progress of women in academic careers in science and engineering. First, such extra -

academic factors as the differential socialization of men and women and marriage and family. Second, the normal working of everyday features of academic science such as advising patterns have the unintended consequence of excluding women.
Thirdly, there are sources of subtle and not-so subtle bias derived from the taken-for-granted male model of doing science that also discourage women from full participation. Needless to say, these characteristics are often intertwined and a phenomenon discussed in one category of analysis will also overlap into another. In the following sections we discuss examples of each of these three types of barriers to entry into scientific careers and offer suggestions as to how they can be eliminated or at least lowered.

**Socialization Barriers**

Barriers to women deriving from the structure of the academic system are reinforced by "cumulative disadvantage" factors that excluded other women from science but also carry over and affect the academic careers of women. These include the differential socialization of men and women, impaired self-confidence, and expectations regarding the impact of children on women's academic careers. The roots of this problem lie in the different gender experiences of boys and girls. As young girls and women, females are socialized to seek help and be help givers rather than to be self-reliant or to function autonomously or competitively, as are boys. Girls are encouraged to be good students in-so-far as they expect to be given a task, complete it well, and then receive a reward from an authority figure. In graduate school, behavior is expected to be independent, strategic and void of interpersonal support. These expectations are antithetical to traditional female socialization. In addition, the needs of women, based on socialization which encourages supportive interaction with teachers, is frowned upon by many male and some female faculty as indicative of inability. As a female graduate student put it: "The men have the attitude of 'Why should people need their hands held?'" Lack of a supportive environment exacerbates problems of an often already low level of self-confidence.
Many women come into graduate programs in science with a low degree of self-confidence. Women in physics, chemistry, and computer science reported that their graduate school experience further eroded their level of self-confidence. A female graduate student described the following symptoms: "Women couch their words with all these qualifiers [because they are so insecure]...'I'm not sure, but maybe...'" One female graduate student said: "I have the symptoms of the insecure woman. A comment from a professor can cripple me. I would be self-deprecating. My science is different because of my socialization, not my gender." Another woman reported that: "Women tend to measure themselves: 'Am I allowed to do this? This I know and this I don't know. This I should be ashamed I don't know."
If things are working out well, then initial lack of self-confidence is not too important: but if problems arise, then negative feelings come forth. For example, one woman had this to say: "It is much worse if a woman fails an exam because her self confidence is so low. I got an A- on an exam and was upset. The man sitting next to me got a C and he said, 'So what?'" Another woman described the invidious comparisons that she began to make if things were not going well:

> If I'm not feeling good about myself, I start comparing myself to these brilliant people [highly qualified foreign students]. It doesn't effect American males as much."

Finally, if the barriers remain high low self confidence translates into an increased rate of attrition. Such attrition can be viewed as a result of an accumulative thrwarting of the development of a viable professional identity. Even those who do not give up often reduce their professional aspirations.

Not surprisingly, low self-confidence in conjunction with lack of a viable professional identity produces reduced aspirations. A male faculty member said of his female students:

> Their job aspirations are so low, their self-confidence is so low, they tend not to apply for what they see as a very tough place.

It is no surprise that pregnancy and child-bearing still have negative consequences for women in the world of work in the United States (Gerson, 1985). However, the impacts appear to be especially strong in academic science, given its structural features that mandate virtually exclusive attention to research achievement during the years that coincide with fertility. Realization of what lies ahead sometimes deflects women from pursuing the Ph.D. A woman engineer speaking to a colloquium at a private research university organized to encourage women students to pursue engineering careers advised them to seek jobs in industry after the B.A. She said that once they were established in their group industry would accommodate part time work or work at home during childbearing and early child-rearing years. She said that she had chosen not to pursue a Ph.D. because she wanted to have her children before she was thirty.

Marriage and children negatively impact women's careers in academic science at three key times: having a child during graduate school, marriage at the point of seeking a job, and pregnancy prior to tenure. In addition, we found some disparagement of marriage during the graduate student career. Women, but not men, are sometimes thought to be less than serious about their science if they do not stay single while in graduate school. As a female graduate student recalled:

> When I first interviewed to come here, I was single. On my first day of walking into this department I had an engagement ring on my finger. [My adviser's] attitude was "families and graduate programs don't go together very well." First he was worried I was going to blow my first year planning my wedding. I got a lot of flack about that and so did other women...teasing. "So and so's not going to get much work done this semester because she'll be planning her wedding." [sarcastically] The guys' don't plan weddings.

Earlier in the century, marriage was grounds for a woman's expected retirement from a faculty position. The mutual exclusion of academic and family life has a long history. Until well into the nineteenth century Oxbridge male academics were also expected to choose between academic career and marriage. Neveretheless, there have been few if any residual carryovers from the male academic celibate role. Even when a choice between academic career and family is no longer an offical requirement, the presumption that each role requires a woman's total attention survives. It next surfaces when children are contemplated or arrive.

Women graduate students expect that they will be penalized for having children. One informant visualized her advisor's and the department's reaction: "If I had walked into _____'s office and said I was pregnant, they would have been happy for me as a

woman, but in their list of priorities as to who to get out of the program and who to support I would have plummeted to the bottom of the list." These concerns arise because the existing academic structure is ill equipped to deal with pregnancy. Pregnancy is discouraged and graduate women who have children are encouraged to take leaves of absence that tend to become permanent withdrawals. In one department an informant reported that: "The only one left is _____[of the students who has a child]. Two women Ph.D.s who got pregnant were strongly encouraged to take leaves of absence. One did and one did not come back." In another department a female graduate student reported that:

> One person took a leave of absence to get married and asked her adviser if she had a child would she be able to work parttime and he told her, 'Absolutely not. No way.' What if I should want to do something like that? Is it the end of my career in _____? Was it just the adviser? What am I going to do with my life? People say they're not going to have children until they're 40 and have tenure. I can't think like that. Thinking about [these] details is what scares me. That's when I think I should drop out.

Graduate student women were caught in a bind, wanting to have children and, while doing so, wanting to show that they could keep up with the pace of graduate work. A female faculty member reported that:

> I had one student who was having her child in the middle of the semester and was to take and pass her qualifiers at the end of the semester. She wanted to do it. I said, 'don't do it'...because of the emotional state you are in and the physical state after having a baby. We discussed this at length at one of our meetings...she ended up not doing it.

One department had taken childbearing into account to a limited extent:

> During evaluations, If a Ph.D. [student] has a child she will be given some leeway for that semester... I think that's pretty funny...it's such a small amount of time. I think the women should get more leeway, you're physically out of it. It should be longer...at least a year. What's the big deal. [In one case, a student]... had the baby in November and had until the end of the semester. It was partly her fault as well; she did not want to say she could do less. The faculty gave her a choice of doing a part time thing or keeping up to pace. She chose to be put to the same standard as everyone else.

A peer had a somewhat different view of the faculty's action and described an unusual instance of solidarity among women graduate students:

> She decided not to take a leave [when she had the child] and made the decision at the end of the semester when we are all evaluated. She got a particularly harsh letter, [the faculty] essentially threatened to cut her support. They gave her requirements that would not be achievable for anybody...even without a baby. Two people had left the department

> earlier in the semester. One was a new mother, the other was a man who was very involved with his family. We got the feeling this was being done to discourage her and tell her to go away. She was encouraged by her husband and a number of us to renegotiate this because it was clearly off base and came out of the blue.

The expectation that women students will succumb to the pressures of child beari ng and child rearing makes some male and female faculty wary of taking on women students in the first place especially since funding is tight and every place must be made to count. Another female faculty member stated that,

> If a student had a baby with her, I wouldn't have her. Students who have babies here get no work done. It's not that I wouldn't take a woman with a child in the first place, but the first sign of trouble, I would just tell them to go away. If my students fail it looks bad for me.

Women who survive the strain of lack of support for childbearing and childrearing in academia and complete their degrees at the highest levels of achievement may nevertheless find that their career will not survive the next hurdle of the academic career path. Two shifts in work site: from Ph.D. program to post-doctoral position in a different university and from post-doc to yet another work-site. The highest climbers on the academic ladder of success are able to accept the most promising and prestigious post-doctoral and faculty positions without regard to any other consideration. The rule of intellectual exogamy has disastrous career consequences for women who are unable or unwilling to make individualistic locational decisions. As one observer put it: "The academic market is a national one. Those who do not accommodate their choice of geographical location and willingness to move to their careers may lose out"(Rosenfeld, 1984: 99).

The next impediment is at the point of the job search. When a married woman is a bout to attain the Ph.D., the 'two body' problem comes into play, typically deflecting women's careers from their highest potential.

Marriage and children are generally viewed by male faculty members as impediments to a scientific career for women. Even those most supportive of women note that

> I've had some disappointments with very good women who settled for jobs that are less than an equivalent man would do. You have some extremely good people you think are going to go out and make a mark and then somehow or other they marry somebody and spend their time in a bad career. For a man to decide not to take his career seriously is like admitting he takes drugs. For a woman to say she puts her family ahead of her career is considred a virtue; the pressures are all in that direction. The women are told, 'Isn't this wonderful. You are giving up your career to sacrifice for your husband.' The pressures come from society, relatives, to some extent the men involved, the parents of the husband.

On the other hand, a few women take a different tack. They are willing to break off personal relationships that interfere with accepting the best possible job. A male professor portrayed the situation of a woman, involved with a man, whom he said,

> ...could have gone either way. I asked her, 'To what extent is his career going to interact with what you do?' She said, 'Not at all. I want to find the best job I can and if it works out for him O.K. and if it doesn't well then that's the end of the relationship.' So she had decided that career is what really mattered. She's at [prestigious Eastern university] and he's still out in California so that's the end of him. She took what I would say is a typically man's approach to things, that the career is the primary decision but they don't all do that.

Universities are seldom eager to hire both husband and wife in the same department. The departmental work site tends to become a place where graduate students find marriage partners, disciplinary endogamy is not reflected in hiring practices. At the time of the study, a search for chair was underway at one department in our sample. The leading candidate's wife was also seeking a position at a junior level. Even though she was regarded as eminently qualified for a line that was available in her area and the administration was willing to aprove both hirings, faculty members objections to bringing in both husband and wife overrode all other considerations. Whenever one set of specific objections were taken into account such as removing the chair from oversight of review decisions concerning his wife by sending them directly to the dean, new objections would be raised. The departmental culture was resistant to accommodating a dual career-family. Department members believed that a married couple would bring a heightened level of personal relationships into the department and that this would be inevitably disruptive, beyond the usual friendship patterns and cliques of academic life.

Given the presumption of geographical mobility as a prerequisite for academic mobility women's careers typically suffer disadvantages. Of course, there are (rather than logical reasons) only cultural reasons why the norm differentially impacts males and females. The requirements of intellectual exogamy illustrate how the genderization of society affects science and how presumed neutral requirements have a male bias built in. As more men are married to women whose careers are important to them male geographical mobility will also be affected. As both men and women face geographical constraints on their job choices it can be predicted that the link between career success and ability to change work site will be weakened. Departments that made exceptions and hired their own female graduates provided a signficant and at times essential career boost for women who otherwise might have been shunted aside from research careers in academia due to locational constraint.

A faculty member's tenure review has caused an added measure of anxiety. She said: "When it comes to the real facts that's when you feel discrimination. The pregnancy worries me. It's the wrong moment, always, the wrong moment. It puts you on a slower track. Maybe they do see it like that. Maybe I've ruined my chances. They want you to sacrifice something. If the baby hadn't shown up, I would have pushed for an early decision. Now I will wait." Even under the best of circumstances the academic structure is resistant to accommodating family needs. A female faculty member in one department was able to arrange a modest reduced percentage of official time commitment involving a reduced teaching load. She reported that in her department: "The faculty have been very supportive of me having children. After my review I've had people say, 'How can you do that and have children too?'" This professor adopted the strategy of reducing her work load and lengthening the time period before the tenure decision. She said that:

> The university policy allows you to work part-time to have children...that part-time work stops the tenure clock for the percentage of time you are not working. Because of tenure, I didn't want to cut my [research] back by 50%, so I made an arrangement to work 70% and cut the teaching load. Everybody assumed, including the chair that this time off would not count for tenure. A year before I was supposed to come up for tenure the chairman brought it up to the provost because [it was found that] the clock was still running. If it had stopped, I should have had an extra year before I was up for tenure so I would have more time to publish and get my research done. I decided not to fight it because I was concerned how going through a fight would affect the tenure decision. I was quite worried when the case went before the engineering school who are all older men who were all looking at me not having worked full time.

In this instance, the outcome was favorable but the anxiety level, normally high about tenure prospects, had been raised even further by the difficulties that the academic structure had in recognizing the presence of children in her life. A few years later she was involved in an effort in the Senate of her university to make reduction in work load for women with children an official option. Some of the participants in the debate on the issue suggested that it should be among a list of limited choices in fringe benefits or that it should be equally available to men and that therefore it was too costly to be made available at all, suggests that the academic system is still resistant to accommodating women's needs.

**Academic Advising**

In graduate school, students are expected to develop a close working relationship with their faculty advisor, a relationship that lasts several years and is crucial to the progress of the student through the program and out into the professional world. Previous researchers have identified negative interactional patterns in male advisors relationships with their female graduate students that "...lessens their opportunity for advancement (Fox, 1988: 226). We also found a series of gender-related blockages to successful advisement. At best, there was an attempt at equal treatment based upon the faulty assumption that women had been socialized and educated the same as men. At worst, women graduate students were sterotyped as less capable and uncompetitive and were viewed as non-scientists. Such advisors simply could not take women seriously as graduate students.

Male faculty can exacerbate or mitigate the effects of traditional female socialization, depending upon their awareness, sensitivity and political stance on sex roles. There are two types of men in science with respect to women: (1) those who follow the male model; with negative consequences for women; and (2) those who are aware of the deleterious effect of the male model on women and who attempt to avert its worst consequences for their female advisees.

Female experiences with male advisors range from denigrative to supportive. On the negative side are interactions that leave women with doubt about their self-worth. Even though this advisor probably thought that he was allaying concerns, the effect was the reverse. "He said to me, 'you don't have anything to worry about, they want women; so you'll pass [the qualifying exams].' You have the feeling, 'Am I here because I'm a woman or because I am qualified? It's like they take away all your

achievements." Women also discussed specific negative incidents of gender related presumptions of lack of scientific ability. For example, [A female student] was talking to a professor about her problems and he said she was an 'emotional female'. "I couldn't believe he was thinking that. Maybe he was thinking I shouldn't be in physics. I always thought he was a nice guy. That's when I feel it: I'm out there on my own."

Attempts to find an analogy to the traditional female role for women in the laboratory are in accord with the thesis that academia is a "male milieu" in which women's presence is viewed as disruptive and threatening. These "degradation ceremonies" may be followed up by subtle and not so subtle attempts to eliminate the unwanted presence. For example, one woman commented: " When I was trying to get something to work, [my advisor] would come up to me and say, 'Did you see it yet? Everyday he would say, 'did you see it?' I should have stopped it, but sometimes it takes a long time to see what's going on. It was very humiliating." It is not only male advisors treatment of female students that affects their situation but also how male advisors instruct their male students to act toward women. A female graduate student said that: "I hear rumors about myself...being involved with somebody. [I heard that] a faculty member was advising his students that it might be interesting to have an affair with me."

These frequent negative instances are complemented by occassions where men have served as successful advisors to women. A sensitive male adviser helped a student make future decisions based on the reality of being a woman within the field:

> His attitude toward women is very understanding, very supportive, without being condescending. He doesn't say "I understand what's going on," which is offensive because it's hard for a man to understand what's going on. He doesn't bring these issues up, I bring them up. He is very politically aware. He'll say, "Don't talk to ____." Sometimes [his advice] was because of sexism and sometimes because this person was an arrogant son of a bitch and sometimes because this is a good person, but is just not comfortable with women.

Women report that the best advisers are encouraging, give you concrete directions and show them the ropes. Women's relative lack of knowledge of how to negotiate the academic system was called attention to by a woman faculty member who explained that many women lacked a strategy to deal with the admissions process:

> What you're supposed to do is get a hold of the brochure and if you want to get in at least say that's what you want. The women don't seem to have grasped that...the men go down the list and say, I want to work with this professor for this reason, that professor for that reason...the females give me no indication that they have even looked at the brochure.

Without an adviser who is willing to encourage and be directive, women are often unable to puzzle out the strategies necessary to get through graduate school. Most women are not socialized to understand the political strategies necessary to advance within the academic system. These and other culture conflicts result in the discouragement of many women graduate students and young faculty members from pursuing careers at the highest academic levels.

**Career Choice**

What is the response of women to the strictures of academic life? A majority of women graduate students in all departments studied reported that they intended to pursue an industrial rather than an academic career since it was more compatible with family life. As an informant, comparing the two scenes, concluded:

> Women will go in to industry. It's 9 to 5. It's more flexible. They have daycare and childcare. There are federal rules they have to abide by in terms of maternity leave whereas in academics you're on your own, and where there are rules to protect you, you are not protected by your peers who are saying, 'She hasn't been here in six months, she's not current with the literature.' The support systems exist [in industry] and it's the only way you can [have a family].

Of those who aspired to academia, most were interested in jobs in small teaching colleges rather than research universities because, as one woman summed it up: "Science isn't everything." In recent years two women had resigned their positions to take appointments at teaching colleges where they felt that they could be respected as individuals and not have to confront a discriminatory environment.

As part of the cumulative thwarting of a female professional identity, devaluation of women's scientific contributions has been found to be widespread (Benjamin, 1991). It takes many forms, including crediting the male partner in scientific collaborations and ignoring the work of women (Scott, 1990). At our primary research site, despite a formal and even at times a strongly stated commitment to non-discrminatory treatment of women, discrimination was manifested informally. For example, a female graduate student reported differential treatment of men's and women's contributions. She said: "In group meetings I get the sense that if a woman says something, "okay fine" and that's the end of that.]

Sometimes, women are devalued by not being included in events. A female graduate student reported that invisibility was imposed when "you have a visitor to the lab, the professor introduces the male students, but does not you." Another reported self-imposed invisibility in reaction to expectations that her contributions would not be valued:

> [In lab meetings] you feel very self conscious saying what you think and I think it's because you are a woman. They would just as soon you would sit back and be quiet and when they ask you if it turned red or green, [you say] 'it turned red,' rather than saying 'it turned red and this is what we're going to do next.'

Women found it difficult to be taken seriously as professionals outside the department as well. One said that: "If I go to conferences, if I ask a question, the answer gets addressed to a man in the room. It's worse in physics than in other fields." A female graduate student reported her response to being ignored: "It's always a thing where being invisible, you don't exist...It was in a sense, I didnt exist." Other times, women are made to feel different by being given excessive visibility. A female graduate student reported that a professor was: "... addressing the class, 'Gentlemen'...and then made a big pause and looked at me and added, 'and lady.' I was different. Other people noticed it..." Still other times women are patronized. A female graduate student

told how: "I was sitting at this table and he kept referring to us as 'my girls.' In that context I didn't like it. He was thinking of us differently. He didn't say, 'my boys. '" At the public university, many graduate women felt that they were treated as"one of the boys" but this was an unsatisfactory resolution, as well, since differences between men and women with respect to child bearing were not taken into account.

**"Instrumentals" and "Balancers"**

Essentially women are expected to follow a "male model" of academic success involving a total time commitment to scientific work and aggressive competitive relations with peers. There are two contrasting "ideal typical" responses t o this situation by women graduate students and faculty members. We have identified two types of responses by women scientists to gender issues: (1) women who follow the male model and expect other women to do so, too; and (2) those who attempt to delineate an alternative model, allowing for a balance between work and private spheres.

Relatively few women are willing to adapt to the male model of academic science, which involves an aggressive, competitive stance and an unconditional devotion to work, at least until tenure. We call these female scientists "instrumentals." Instead, most attempt to define a women's academic model, balancing work and non -work roles, with an emphasis by faculty members on cooperation at the work -site among members of their research group (Kemelgor, 1989). These women are the "balancers." Women faculty in a department seldom constitute a homogeneous group. Instrumentals may even act more negatively and be less sensitive to female students than male faculty members who are aware of women's issues. The presence of several women in a department faculty may not, in itself, be sufficient to overcome barriers to female students and will not even provide many of them with relevant role models if they are primarily instrumentals. Neverthel ess, the "critical mass" thesis of several women on the faculty of a science deparment remains to be seriously tested, especially in departments in the physical sciences and engineering that likely have no senior women and may even have no women on their f aculty. Even when "instrumentals" and "balancers" are at odds with each other, these contrasting models at least provide women students with a range of possibilities to choose among to integrate into their own stance.

Instrumentals are able to act indepen dently and strategically. A female faculty member described her strategy for getting through graduate school: "When I went to grad school I specifically chose the chair as my adviser because I wanted to graduate...He had a reputation for graduating all his students. I knew I was doing well when I picked that guy. [His research area] didn't matter so much. The research I wanted to do, I could do after I graduated. ) Instrumentals typically viewed the system as favorable to women and regard the status of wome n as a non-issue. A female graduate student who believed in doing "the politically right thing" said: "When you get to graduate school [physics is] incredibly biased in favor of women. They work much harder to keep the female students and there is good rea son. Most of them don't come in with adequate preparation. There are women who talk themselves out of taking the qualifying exams." This individual was outwardly hostile toward women, favoring the men whom she emulated: "I worked all through my undergradua te career all by myself. I don't see the need to work with others. The women don't have enough intelligence to work things out for themselves."

However, she also noted the debilitating effects of traditional socialization on women: "The guys have more of an idea about mechanical things and are selfconfident. Women end up getting help, and then they end up in graduate schools they wouldn't normally get into and they're stuck because it is built into them to get help, assistance.

Instrumentals were willing to put in night and weekend work hours, making the lab the center of their social as well as work life. One such woman faculty member said: "It never occurs to the males that they could come in at 9 and leave at 5, five days a week and get a Ph.D. They're here at 3 a.m., weekends. You never see a woman here off hours. You see all the males. the males are socialized that they have to do their work and it always pissed me off because I always worked as hard as the men and so did the women who went to school when I did."

Instrumentals were typically unmarried or divorced and without responsibilites for child rearing. An informant noted that: "A common pattern is that women who are successful are single or divorced and really dedicate most of their energy to their career." They are often ambivalent toward women students who are not as directed as they are. A female faculty member said: "Males come to me immediately with a problem. Women muddle off. I try cajoling them, pleading with them, yelling at them. I would rather have men...I guess I don't really mean that."

In contrast to the instrumentals, who emulate the male model, balancers find the highly competitive nature of academic science to be problematic since it conflicts with their own preference for cooperation as described by this student: "Given the competitiveness that goes on around here, it is a lot harder to be open, honest, and supportive because you don't know if you are going to get turned on." Balancers are aware of their difficulties in functioning strategically. Anxiety and confusion over the desire to balance multiple roles overwhelmes students sometimes

The current constrained funding climate exacerbates women's unstable position, causing faculty who are fearful of productivity losses, to be less willing to tolerate deviation from the traditional male model of doing science. Despite these obstacles, a new scientific work role is emerging as women and men struggle to restructure traditional family and work roles (Gerson, 1985). To treat the lab strictly as a work site is a necessary strategy for women (and some men) who want both to be highly productive as scientists yet maintain an outside life. These faculty members had a commitment to raising children and interacting with their family that was equal in importance to their work commitment.

The balancers wished to pursue muliple roles, typically family and work, seeking a reasonable division between the two spheres. They organized their laboratories on a collegial, noncompetitive basis and tried to keep close to normal business hours, resuming intellectual work at home after their children were asleep. Balancers also adopted a non-hovering management style that allowed their students considerable leeway and initiative in order to keep their scientific life from becoming an all-consuming activity. Despite this effort to develop an organizational style that delimited work from personal life, some female students felt that their mentors were not spending enough time with their children and questioned whether they would be willing to make such a choice in order to pursue a high-powered academic career.

Perhaps ironically, multiple roles have recently become accepted for high-status males in science who wish to combine participation in entrepreneurial ventures with the professorial role (Etzkowitz, 1989). However, combining the professorial role with serious attention to family obligations is seldom an acceptable stance for a high level career in academic science or other professions (Fox and Biber, 1984). Informal activities outside of the department are also often linked to traditional sex role

activities and venues. In one department in a related study, a regular pick-up basketball game was a site for exchange of informal comments on research activities along with visits to a male-oriented local bar. Inevitably a female faculty member felt excluded from "the club" (Kemelgor, 1989).

Some women were able to work out an accomodation with the demands of a career at a research university by strictly budgeting their work time and making every minute of it count. For these women the university was solely a work site, not combining with it a social environment. For many males the time put in in the lab is not all work related, but being in the lab extremely long hours is part of the accepted persona of the successful academic scientist. A single male professor in a related study (Etzkowitz, 1988) reported that:

> A lab, in a sense, is a little bit like a country club. You have your friends here... I don't stay here because it's competitive. I stay here because who wants to go home? It's what I see most of the people here doing, too. They get the newspapers, they talk to their friends, this is the place. It's a club.

Despite recognition of the non-work related nature of some of this presence on the job, in the culture of academic science, time spent in the lab is still viewed as an independent indicator of strength of commitment to science.

The balancing stance is not solely a female response to academia. Some male faculty adopted this position to a limited extent but typically admitted that their participation in domestic life and child rearing was less than their spouse's. Moreover, not all women who wished to balance the demands of an academic research career and family were able to achieve this goal. Graduate students who were encouraged to take leaves after a pregnancy often did not return. Ph.D's interested in academic research careers often decided to accept industry positions either to give their husband first preference in a job search or to have a work role that was explicitly limited to a 9-to-5 commitment. Some junior faculty members abandoned research careers to accept positions in teaching colleges. Thus, at present, the strategy of balancing career and family is contrary to the culture of high-status research universities and is difficult to arrange and sustain. Neverthless, this is the option that most women in our sample wished to pursue. Few had the support of their institutions or persons available whose example they could follow.

Role modelling has been identified as an effective socialization process in work life. Modelling oneself on an older person has been found to be a good way of creating a pathway into a career, making for likely early success. A younger person can take on the characteristics of an older person in a professional role while serving in a junior capacity. The closer the modeler is to the person modeled, the easier is it for the transformation process to occur. Conversely, the more differences that exist, whether in the behavior directly being modeled or in associated personal characteristics, the more difficult it is for the socialization process to work. Previous research has indentified the characteristics of successful women role models who integrated, "... professional and personal concerns" (Mokros et.al, 1981: 11). Beyond strictly professional issues women mentees are concerned with the interpersonal quality of the relationship and seek a sympathetic mentor (Dowdall, 1979).

In the sciences, male senior researchers have traditionally served as role models for their junior colleagues. As women entered scientific careers they were expected to follow a male model, accept a distinctly subordinate status (the scientific equivalent of

the traditional female role, the research associate), or leave the profession. More recently, some women have attempted to carve out a new status and a new professional identity for themselves in the world of academic science (Kemelgor, 1989). This involves a different relationship to work and students in which work life is pared down to professional elements and limited in time so that a private life may be constructed and compartmentalized apart from the professional role. This is not dissimilar from a 9-5 job with little carryover from work to home and vice-versa in terms of socializing, professional relationship and affect. Indeed it represents a formalization of the work role and an attempt to remove sexualizing and other personal elements that may interfere with work.

Women graduate students prefer to have a range of models of female behaviors in science available to emulate. At present, the numbers of female faculty are so small that there are often few or even no choices of role models. A junior female faculty member described her role model in graduate school: "Another woman did quite well. [There were] many things I didn't like about her, but it showed it was possible. There were a number of women in my field who were well known as I was going through, most of them were single and remained single."

Most women graduate students made a sharp distinction between women faculty whom they viewed as relevant or irrelevant as role models. Women faculty who were perceived to be instrumentals, emulating an aggressive male scientist role and attempting to become 'one of the boys,' were often not viewed as viable models. As a female graduate student said: " There are no real good role models to follow. The women a generation ahead of us had it so difficult that they are by and large a very aggressive group. [They had to be so aggressive] and that's who got ahead. You have trouble looking at them and saying, 'I want to be like that.' You don't."

On the other hand, a woman faculty member who was successfully balancing career and family was looked to as a model by several women in her department, even though she was somewhat less available due to time constraints. A female graduate student said that: "[She] is a role model precisely because she can balance the two. She definitely finds time for the things on both sides. It can be hard on her students. When you do find the time to finally meet with her, you do have her attention. Everyone feels the same way: Frustrated that it's tough to get her, but that they re ally have her when they do."

However, for most female students anxiety about the present and the future is exacerbated because there is no model to demonstrate how to deal with problems or issues. "Women are dropping out because there are no role models t o show you how 'you get there.'" This is related to the ability of men to identify culturally with male advisers and enhance their self-confidence, leaving women with no one to "pave the way." The need for women faculty to show how professional and family responsibilites could both be met was expressed by a student who said: "I think it would be interesting to see [the female professor] get pregnant, so we could see how someone else deals with the situation. I have no clue whatsoever. I don't know what it's like in academics. I'm scared about that." Thus, for the most part, students are left to feel they must be pioneers. In some instances this situation was resented. The few who felt they did have role models, identified them as being from high school, undergraduate school, or industry, --or they were their mothers.

Most importantly, the role model women wanted was the woman who could concretely explain the necessary strategies and steps to be taken to succeed in graduate school. This conclusion derives fro m the reality that: (1) rules are made by men, (2) young men are socialized to those rules and further socialized in graduate

school. They have learned the strategies, (3) most women have not been socialized to be autonomous, and therefore they have diffic ulty figuring out the rules; and (4) most male advisors do not teach women the strategies necessary to succeed.

Of course, this finding does not hold for those very few graduate women who excluded other interests in favor of their career. The absence of v iable female role models in most of the departments studied creates anxiety among women graduate students and is believed by them to contribute to the rate of attrition. Nevertheless, women graduate students report successful and unsuccessful experiences w ith both men and women advisors. Men can be sensitive advisors and women can be relevant role models but few men and women faculty currently meet the needs of most women graduate students. (22% of the female students in the four departments at private research university, as against only 4% of the male students, have female faculty advisors. While the proportion of female and male students entering subfields where female faculty advisors are available is fairly similar (32% and 24%, respectively), the proportion actually signing up with those female professors differs by a factor of four (68% to 17%).) Women graduate students seek out women faculty members as advisors in hopes of finding a sympathetic mentor, while male graduate students sign up with a woman only after she has achieved a distinguished position in the field.

**Policy Implications**

Some take the current low rate of womens particpation as an accurate reflection of the number of women with the ability to contribute to science. We find that the organization and culture of academic science deters many women of high scientific ability from making their contribution. In those instances where a department faced up to this situation and altered its behavior, womens participation improved dramatically. A broader recognition of the need to change and requisite actions are required to reconstruct male-gendered science and engineering departments. (Indeed, the experience of In-balance Program at Center for Particle Astrophysics, University of Califronia, Berkeley is that many of these changes are necessary for both women and men.) From our analysis of the experience of women graduate students and faculty in the sciences and engineering, we make the following recommendations to open up academic science to womens full participation:

- acceptance of a female model of doing science in a collegial workplace accompanied by time for a private sphere of life apart from science;
- synchronizing the biological and tenure clocks by allowing a longer time span before tenure;
- rescinding exogamy requirements for career advancement thereby reducing the negative effects of limits on geographical mobility;
- provision of a signficant number of relevant role models so that younger women can envision a future in science.

With regard to institutional culture, it is clear that administrative actions, engendered from above or below, even if they do not change attitudes, can affect behavior. A female graduate dean at another university reported on the efficacy at her institution of administrative leadership to remind people of gender and minority issues at every step of the academic process. "We had a graduate program director who took this issue up as a personal cause." She reported that it was most important to be stringent

on sexual harassment so that eveyone knew that it is morally and legally wrong, officially and unofficially.

The affirmative action officer at the primary research site, a female attorney, reported that she received virtually no complaints from women in the science a nd engineering departments, while there were many from the humanities and social sciences. She presumed that the universalistic spirit of science, rather than an environment that suppresses the expression of gender differences, was responsible for the pauc ity of complaints . In one instance a woman graduate student contemplated making a complaint against a male faculty member who was discussing porngraphic images on a computer screen with his male graduate student. The incident took place in her presence in an office that she shared with the graduate student. She drew back from making an official complaint, fearful of endangering her degree. However, the matter attained sufficient visibility within the department that the chair sent out a strongly worded message condemning the practice as unnacceptable and warning against its repetition.

One department studied had undergone significant change with respect to its treatment of women. Among its leaders were several middle-aged males who had simultaneously been in therapy in a community where the local culture had been strongly influenced by feminist values. In this context, one of them pointed out to the others that they were being unconsciously dismissive of the work of a female faculty member up for tenure. They accepted the validity of the charge, reviewed their behavior, and decided to change their attitudes and practices. (In another instance the change did not come voluntarily but only after a female faculty member threatened to resign when a sexist male faculty member was about to be named permanent chair. This action received nationwide publicity, forcing university officials to do something about the sexist environment of the department. They prescribed a year of gender sensitivity training for the acting chair who resigned the position. See *Chronicle of Higher Education* April 1, 1992 p. A 14.) They also revised the departmental structure to emphasize collegiality and gender-blind decision making. For example, graduate student admission decisions are made by a committee with equal representation of faculty and students. Two students are elected each year to review and interview applicants. A male and a female had served in the previous year and two females in the current year. Applicants stay with other stu dents when they come to campus to be interviewed. Once the incoming class has been picked, the incoming students are invited to a social event involving the entire department, with a picnic and other activities.

All women students and faculty interviewed reported that they joined it rather than a department at an other prestigious institution, because of their perception that it offered a collaborative, cooperative, and collegial milieu. They were attracted by the warm interpersonal interactions they had e xperienced when they interviewed and by a sense of personal concern for the candidate conveyed by faculty and students. They were also impressed by the sense of well-being members of the department displayed. Most had been disturbed by the demoralization o f students at other departments where they had interviewed, having heard stories of exploitative advisors and anonymity in large research groups.

Since almost all of these students had previously worked in laboratories as undergraduates or as technicians in academia or industry, they had a clear idea of the laboratory evironment that they wished to find as well as what thay wanted to avoid. Several had suffered isolation in sexist, autocratically run, competitive laboratories in which their status as female technicians promoted loneliness and professional

stagnation. They had relocated to laboratories in which laboratory heads and post-doctoral fellows had enhanced their self-confidence by direct teaching, generosity in allowing time for communication, and responding to questions without derison. In each of these instances, the informant came away feeling capable and competent to undertake graduate work having experienced empathy and understanding from a mentor figure, whether female or male.

While the science being done in the department or by a faculty member often initiated a candidates interest in the school; the emotional gratification of the interview process together with a preference for a collegial research environment, influenced the candidates final decision. Thus, selecting this particular department was a means of recapturing a significant professional and personal growth experience that had promoted self-confidence and emergence of a scientific self-identity. In this department a female academic model based on interpersonal relationships, affiliation and nurturance had become acccepted as legitimate and had even become the departmental norm. This was in strong contrast to another research site, where the expression by women of a need for these characteristics in the laboratory environment was derided as a desire for dependence and emotionality by the adherents of the patriarchal system that was in place.

The key to mentoring women is not whether the mentors are women or men, but whether they are able to relate to women. Women professors who follow the male model, in fact, often heighten performance anxiety among their female students by expecting more of themselves and their women students than do males. Patriarchal institutional roles, whether enacted by men or women, result in female behaviors and preferences being misinterpreted, for example, preference for a collegial rather than a competitive working environment, as inferior rather than different. Moreover, most women students reject an academic lifestyle that excludes non-scientific relationships and activities, including childrearing.

That the seven year race for tenure with the biological clock for child bearing are incompatible has obvious negative consequences for women's participation in high-powered academic science. A male faculty member told us that if women would wait until after age 35 to have children, there would be no problem. They would be able to pursue tenure singlemindedly without intereference from other obligations. He recognized that most women were unwilling to delay having children that long and thus saw no answer to this dilemma. A graduate, now a professor at another university, reflected upon the relationship between the biological and tenure clocks. In discussing her plans for children she said: "I take every day as it comes. It would be outrageously difficult. I would feel much more confidence if I had tenure but I would be 38 and I don't choose to have a child that late."

One female professor has spoken up in faculty meetings on behalf of extending the time before tenure review for women with children. She sees this recommendation as a double edged sword, however, pressuring for reducing the demands made on women with children might jeopardize their status by supporting the notion that women with children cannot be productive. Of course, the extension could be made gender-neutral, with the same provisions offered to men with extensive responsibilities for childrearing. Nevertheless, in practice, this would likely be seen as a measure to accommodate women. Departmental and university-wide efforts to make workplace child care facilities more widely available would help. An infant care center in a neigboring school, discovered by one female graduate student, made a significant difference in the ability of several women with children, in one of the departments studied, to carry on their graduate work virtually without interruption.

If the objective is to significantly increase the number of women pursuing high-powered scientific careers institutional accommodations will have to be made for women who wish to combine family with career. To achieve equality it is not just a matter of opening up opportunities but of changing the structure of the academic system. Women who wish to pursue traditional female roles along with a scientific career must be accommodated by allowing a longer time span before the tenure decision. This accomodation had been promised to one faculty member in our sample but subsequently was not allowed.

This is not a call for a "mommy track" with different and lower expectations of achievement and rewards but a serious effort to accommodate the significant number of women who are not willing to forego family and children prior to tenure. It is unrealistic to expect significant numbers of women to follow the male model. If the goal is to substantially increase the participation of women in high-level academic science, a female model will have to be legitimated. Acceptance of an alternative career model is crucial both to placing more women in faculty slots in the immediate short term and to providing relevant role models for a broader range of female graduate students.

Accommodation for time conflicts will have to be made for women faculty members with children. Accomodation is currently made for faculty members, typically men, who found corporate firms or research centers; however these time conflicts usually occur after tenure has been attained, whereas women's time conflicts involving family responsibilities tend to occur earlier in their career trajectory, prior to tenure placing them at risk. While time conflicts at later career stages may affect colleagues views of a department member, they seldom if ever have deleterious career consequences. Simply put women are more vulnerable than men prior to tenure.

The limited geographical mobility of many women restricts their choice of both graduate school and job. A highly successful female scientist interviewed in another study explained the impact of location on her career, given existing norms of hiring. A research associate, her advance in rank was limited, as was her exposure to students and the experience of raising her own funds. She felt that these consequences of having to accept a position of lesser status had delayed her professional maturation.

> I was married---I'm still married---and I didn't have the flexibility of moving around. That's one of the best ways to achieve a permanent position and to increase one's standing; to have the lever or the threat of saying, well, I, I'm going to leave. And to mean it. You can't do it as an empty threat. You have to be ready to leave, and people are. I was never in that position, so I could never use that threat, (Dupree, 1991: 117)

A typical scenario that has been identified is marrying a man in the same field who completes his graduate work before his wife. He finds the best job he can without geographical constraints. When the woman finishes, she finds what job she can in a circumscribed region (Max, 1982). Women who are already married often select their graduate school based on what is available in a region and choose a job with similar considerations in mind. Second rank research universities attract many higher quality candidates than they might otherwise, due to women's geographical restrictions.

The limited geographical mobility that many women face can be addressed in at least two ways:

1. hiring both husband and wife, even in the same department, taking account of the fact that graduate students in the sdame discipline and department often marry.
2. relaxing formal and/or informal prohibitions against hiring one's own graduates.

The highest-achieving woman scientist in our sample was hired by her graduate department after a stint at a local college. This practi ce is especially significant for women who are geographically immobile in a region with few or even only one research university.

The succession of impediments to the entry of women into scientific careers that narrrows the stream to an extremely small fl ow at the stage of graduate training has been conceptualized as cumulative disadvange. However, even given these disadvantages a significant number of women receive degrees in science at the BA and even the Ph.D. levels. Nevertheless, fewer pursue careers in science and there are few senior women professors (Moen, 1988). The disadvantages that accumulate to narrow the flow into the science career pipeline are supplemented by additional disadvantages, at the margin, that discourage even the most highly motiv ated women who have taken steps to pursue scientific and engineering careers at the doctoral level. It is expected that removal of some or all of these barriers at the doctoral, junior and senior faculty levels could have an effect, in the short term, in i ncreasing women's participation in science and engineering. Taking such steps could also provide role models to assist in long-term efforts to lower barriers at the early stages of the life course, thereby increasing the flow into the science career pipeli ne. Thus, the importance of focusing policy intervention at the later stages is two fold:

1. Encouraging the creation of a critical mass of women faculty in academic science and engineering departments that, in and of itself, has an effect in changing academic cultures and, by implication, lowering barriers for future generations,
2. Revising the image of high level careers in science and engineering for women from anomalous to "normal" provides the incentive of examples of achievement to encourage younger women to break through the barriers prevalent at early stages of the career.

These graduate students and professors, after successfully negotiating the numerous barriers to entry that exclude so many other women, often pursue less demanding careers than their male peers. These women are not lost to science. Rather they are women who, with a few exceptions, are excluded from positions in the top academic departments in their field. Many pursue research careers in industry; others have taken appointments in teaching colleges. Whether these scientists are excluded from high - level academic careers through discrimination by academic departments unwilling to accept women as equals or other reasons the result is the same. There is a pool of women scientists working in industry and lower down the academic ladder whom their advisors, usually men, agree are the equal of their male peers who are pursuing research careers at the highest academic levels. If professorial jobs were made available, qualified women scientists co uld be recruited to create a critical mass of at least three women in each leading academic department. This would provide the range of female role models necessary to bring forth an enlarged next generation of women scientists.

Culture is generally believed to be highly resistant to change but our findings suggest a few key points of intervention. Specific steps could be taken to mitigate the negative effects of the male scientific ethos on the recruitment of women to science and engineering. The rigidity of the existing academic structure and male faculty misperceptions of women scientists constitute formidable barriers to the entry and retention of women at the highest levels of academic science. However, the fact that qualified women who would be interested in academic research careers are now in industry or teaching colleges suggests that, should these final barriers be lowered or removed, women scientists who already exist might pursue careers at the highest levels of academic science.

What can be done to implement these proposals? A first step is to become more self-conscious about the social organization of human scientific endeavors By accepting various parochial ways of conceptualizing, investigating and organizing the conduct of science, significant sectors of the population have been excluded from full participation, and alternative cognitive perspectives and organizational styles have been repressed. As we become aware of such factors as masculine models of gender as the basis for many modes of doing science, a policy space is opened up where change can take place. Social movements and support groups organized by excluded groups, changes in departmental practices and university policies taken at the initiative of faculty and administrators and governmental affirmative action policies and funding programs are all part of the emerging picture of science open to all talent in fact as well as by precept.

The second step is transcending masculine and feminine scientific roles and practices (Abir-Am, 1991). The sociology of gender and science itself has moved beyond comparing men and women scientists according to implicitly masculine criteria. The traditional study of number of publications, with article counts accepted as a primary indicator of productivity and achievement, is ambiguous. Women publish less frequently than men but their publications are more frequently cited (Long, 1990). This finding may indicate different gender styles of scientific work. Perhaps women work more intensively on a subject before making their work public. There is much to be said for and against each of these styles of scientific work. Scientific practices that incorporate both traditional male and female perspectives into a broader non-sexist framework would free both experimentation and verification of knowledge from the exclusionary oppositions in which that which defines *feminine* as automatically antithetical to "good science"(Keller, 1980). Under these conditions impersonal evaluation would be realized as a component of the social structure of science.

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