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16 Athena Unbound: Policy for women in science

'For women there are undoubtedly great difficulties in the path, but so much the more to overcome,' exulted Maria Mitchell (1818–1889), the first female professor of astronomy in the U.S., at the then newly founded Vassar College. More than a century later, on the 175th anniversary of her birth, women's scientific aspirations are still restricted by 'tradition and authority' (Enna, 1993). Few female scientists are as happy as the nineteenth century astronomer Mitchell to have put up a brave front in the face of a host of gender-related problems. Despite significant improvement, especially in the numbers of women who wish to enter scientific careers, many of the organizational structures of science, and some scientists, continue to resist women's full participation. Additional steps are necessary, beyond encouraging women to take up science, to insure that science is open to them (Lovitts, 1996).

In this final chapter, we discuss the policy implications of our findings in terms of motivators and inhibitors that shape the experiences of women and conditions of inequality in academic science. First, the arguments behind each thesis are described and its accomplishments and shortfalls reviewed. Second, we argue for new policy recommendations related to department reform, the factor that is most relevant to the organizational issues explored in the preceding chapters and that we have identified as a means by which programs for change can be implemented.

Five strategies have been suggested during the past thirty years to promote improvement of the condition of women in academic science. These include: calls for equity, expectation of personnel shortage,

national economic competitiveness, generational transition and departmental reform. Equity, of course, is based on the moral grounds that women were excluded in the past and as a matter of right they should be included in the future. Shortage, or expectation of too few recruits to science and engineering, engenders initiatives to broaden the recruitment of scientists. This typically leads to consideration of drawing more women and minorities into the scientific enterprise. Economic competitiveness or the realization that science is increasingly closely connected to developing future high technologies is the mirror image of the 'shortage' theme.

Failure to make full use of the talent in the national population creates a potential economic deficit, especially in comparison to other countries that make fuller use of their available talent pool. Generational change is based upon the expectation that a new generation of male scientists, feeling some of the same pressures to take responsibility for home and family life, will support change to realign science with changes in family structure. Departmental reform is the injunction to 'solve one's own problems' before being forced to do so by external authorities. Leadership by the department's power structure is essential to this approach.

A MORAL AND LEGAL IMPERATIVE

Laws prohibiting discrimination are on the books of most industrialized nations, and although they apply to academia, they are seldom vigorously enforced (Carson and Chubin, 1992). From the 1970s, efforts to increase the number of women in U.S. academic science departments have largely resided in affirmative action programs, requiring full consideration of female and minority candidates. However, in the 1980s lack of vigorous enforcement reduced the spirit of the law into a bureaucratic requirement that became a routine part of the paperwork of the academic hiring process, often with little or no effect on recruitment and no impact upon retention.

Nor did this strategy, focused on getting entrants into the system,

address the hidden inequities of academic departments. Many academic scientists and engineers are aware that the Defense Department's strong interest in military contractors hiring women made a significant difference. Indeed, a dean of engineering proudly pointed this out as an instance of women's advancement in engineering. But when asked if the same measure could be applied to the academic environment with similar results, he admitted the 'logic' of the suggestion but expressed a lack of interest in the experiment.

Affirmative action creates a formal procedure that helps insure that a broader range of candidates are considered for a position but often without the expected result of a significant number of positions filled by women and minorities. Despite the presumption that minorities and women are insured positions through this process, a selection committee always has the option of certifying that its choice was best qualified. Since women and minorities often follow careers that are lightly off the beaten track, it is easy to find fault with their career choices. For example, a senior male respondent questioned the hiring of a female physicist by a prestigious research institute on the grounds that she had deviated from the normal academic career path by becoming an astronaut.

Most diversions from the track are much less spectacular but even accepting a less than optimal post-doctoral fellowship because it is close to home can be the basis for exclusion from a short list. Thus, the effects of affirmative action procedures in promoting the interests of minority and female candidates are debatable. A respondent said, 'I have never seen affirmative action in the sciences, never seen it achieve equal employment.' He questioned whether implementation of affirmative action policies at his university was much more than a bureaucratic façade in which invitations were issued for job interviews to minority and women candidates with little real intention of recruiting them.

Affirmative action is a double-edged sword that creates a double bind for women and minorities in the sciences and engineering. It modestly increases the numbers in the system but then is used to denigrate

blacks and women and keep them down. As one respondent put it, the implicit and sometimes explicit message is that 'if we weren't being good guys, you wouldn't be here.' Those few minorities and women who do get into the system are presumed to be of lesser worth than their peers. The most subtle and insidious aspect of the exclusionary process for faculty women at all levels is the virtually inevitable stigma. When women attempt to initiate mechanisms to achieve symmetry with their male colleagues, it is used against them. The most glaring example is attributing a faculty appointment as a 'quota' hire.

An unintended consequence of efforts to empower women is that they may provide ammunition for devaluing women as needing special support. Thus, providing a mechanism for affiliation, a program can instead encourage attrition. Support of programs by senior faculty members deters this: a program that is legitimated by an authority figure escapes the presumption of deviant behavior that is often the fate of women in graduate departments who suffer reprisals for engaging in even the most modest collective activities. An initiative that is protected by an individual or group with the power to advocate or at least accept change can also be the first step to creating a supportive ethos for students in a department. Such experiences have led to a re-valuation of affirmative action among many of those it was designed to assist.

Affirmative action has at times been transformed from a public intervention on behalf of women and minorities into a private instrument used against them by some of the very people whose discriminatory practices it was designed to thwart. This experience has, not surprisingly, driven some minorities and women to the conclusion that the existence of affirmative action procedures does them more harm than good. They themselves become opponents of such policies, and the unlikely allies of the very persons who have turned affirmative action into a discriminatory weapon against them.

It is important to note that affirmative action is currently in a retrenchment trend that may permanantly wither the system. A good example is the present ruling of the regents of the University of

California to abolish affirmative action in recruitment and hiring. The system's visibility and prestige will surely stimulate mimicking by other universities which now have cause to view the system as delegitimated or politicians who will seize the opportunity to eliminate affirmative action for their political gains rather than the gain of the wider system. Furthermore, affirmative action has a systematic problem: it does nothing to affect the 'feeder pool' of qualified applicants. Because it is designed to equalize opportunity for individuals with the right credentials, it suffers from an inability to insure that persons from minority groups will get credentials in the first place. This is a central problem because it gives rise to the argument that affirmative action promotes the hiring of unqualified minorities, which in turn, defines them as 'quota hires' and intensifies feelings of animosity by the majorities.

At best, affirmative action is a necessary but not sufficient condition for inclusion of minorities and women in the sciences. It has too often become a method of protecting an academic department from protests against its lack of diversity. It allows the appearance of a neutral double-entry bookkeeping system in recruitment efforts: an overt procedure with white males and women and minorities interviewed, covering a hidden decision-making process in which white males are typically offered positions. A department head at a major university reported that his wife, who was head of the County Equal Opportunity Employment Commission, did not like to investigate academia because its employment practices were arcane and difficult to fathom. Certainly, a reinvigorated affirmative action effort and enforcement of existing federal laws could make an important difference to the advancement of women in science (Chubin and Robinson, 1992).

THE EFFECTS OF SHORTAGE

Recruiting from underrepresented groups, such as women and minorities, is always suggested as a potential solution whenever a shortage of scientific and engineering personnel appears. The First and Second World Wars opened up opportunities for women that largely

closed down with the conclusion of hostilities. A human resources deficit became a national policy issue in the U.S. during the Cold War when availability of sufficient technical personnel was viewed as essential to national security (Pearson and Fechter, 1992). The issue arose most recently in the US during the 1980s.

In the mid-1980s, Erich Bloch, then director of the National Science Foundation, called upon social science knowledge to help resolve the dilemma of too few women in science. The then director of NSF's Sociology Program, Dr Phyllis Moen, was asked to analyze existing research on women and science for clues (Moen, 1986). In addition, NSF commissioned new studies (including some on which this book is based) to fill gaps in knowledge through its research funding programs. NSF also established a number of programs to improve scientific education for girls and to encourage female scientists by making fellowships and visiting professorships available.

In the short term, an open immigration policy was put in place as a temporarary solution to expected technical personnel shortages. This policy was retained during the aftermath of the Cold War in part through bureaucratic inertia but also at the insistence of 'high-tech' employers seeking open access to international labor markets. Combined with a surplus of scientists and engineers in some fields produced by the decline in military and military-related research and development spending during the post-Cold War era, the policy impetus to address the issue of unequal gender participation in science has largely dissipated. Projected shortages of scientists and engineers turned into an oversupply, exacerbated by some overly pessimistic estimates that, coupled with highly optimistic retirement expectations, led some university presidents to predict a Ph.D. shortfall that has yet to occur.

One shortcoming of policies for immigration and recruitment is that they are applied on a temporary basis: they are put into place only after a shortage problem has been identified. This lag disconnects the benefits of the policies (ample supply) from the periods in which they are needed most. Also, this policy ignores the dictum that 'supply

creates its own demand.' As such, in countries such as India, Israel, and China, the investment in scientific training programs has stimulated growth in scientific as well as technical and entrepreneurial fields that spring up when the demand within science wanes.

Deficits in women's participation in science attract heightened attention from policy makers during periods of expected personnel shortages, such as the mid-1980s (Moen, 1988). A cyclical pattern can be identified, with alternating themes of equity and 'national needs' utilized to justify efforts to improve the condition of women in science (Office of Public Service and Science, 1994). When the moral injunction of equity is enforced by self-interest, the way is open to change, especially for groups that are currently underrepresented (Campbell, Denes and Morrison, 2000).

ECONOMIC COMPETITIVENESS

The third thesis to advance the cause of women in science is one of economic competitiveness. Highly trained human resources are the key to future economic development. A society that neglects the native talent in any sector of its population does so to its detriment. In the emerging information economy, universities and other knowledge-producing and disseminating institutions are the ultimate source of wealth, just as mineral deposits and ports were in the past.

So much of the prospect for future economic advance now rests on knowledge that any nation that does not utilize all its talent runs the risk of falling behind other nations that do.

Until the present the U.S. has been the greatest repository of talent in biotechnology and software, providing the basis for leadership in those industries. As other countries gear up their universities to produce more Ph.D.s locally, the need to study abroad will become less pressing. Science, of course, will remain international, but in the future, U.S. Ph.D. graduates will be just as likely to be found in attractive post-doctoral positions in countries such as Sweden as will their Swedish counterparts in the U.S. Indeed, the current abundance of research funds in Sweden, which is upgrading its ability to translate

research into economic development, is proving a strong attractor to junior researchers elsewhere to relocate. Swedish professors are also importing intellectual guest workers, including underemployed American post-doctoral fellows, in order to carry out their expanded research programs.

Certainly, it is easier and perhaps cheaper for technology entrepreneurs to recruit from abroad, rather than address the long-term causes of this shortfall in technical human resources at home. Beyond the sometimes narrow perspective of individual firms and universities eager to attract the best current talent from whatever source it arises, there is a longer-term dynamic of scientific mobility to consider. Such flows of people and talent can reverse directions. This fact should give pause and lead even those companies that wish to encourage immigration to take a longer-term view. Even in the medium term, many scientists and engineers who stayed in the U.S. after completing their education to teach in U.S. universities or work in high-tech companies are returning home, often encouraged by special schemes to attract them back to head up new research units in Singapore or found companies in Taiwan.

As the international mobility of technical labor becomes reciprocal and more equal, any country that excludes a portion of its population from scientific or technical careers, whether de jure or de facto, will operate at a disadvantage. In Japan, for example, it is expected that the approaching demographic decline will produce an opening for women to enter scientific and technical careers, from which they have heretofore been largely excluded. This population problem, coupled with a national science and technology strategy that increasingly relies on an academic science base to enhance high-tech industrial development, creates an opportunity. Nevertheless, demography only creates a possibility. Without the necessary social and political impetus to translate this into schemes to recruit those formerly excluded, and modify scientific institutions to make them more attractive and welcoming, the status quo will persist.

Each country must focus on increasing the participation of its

population in science and engineering in order to maintain national competitiveness in high-tech industries. Hoffman and Novak (1998) recently argued that '[If] a significant segment of our society is denied equal access to the Internet, U.S. firms will lack the technological skills needed to remain competitive.' If such a conclusion is warranted for Internet use, then surely it should be applied to the users, with appropriate implications drawn for the training and employment of minorities and women as scientists and engineers.

GENERATIONAL CHANGE

The thesis of 'generational change' is based on the assumption that a younger generation of male scientists, facing some of the same family pressures as women, will help reform the academic structure in ways that benefit both women and men. Institutional reform that takes into account the needs of female scientists also benefits men by introducing some flexibility into career paths. The traditional structure was that an individual scientist devoted themselves to their career completely, without much attention to the details of life. A spouse normally would be at home and take care of the private sphere. This allowed an individual, virtually always male, to spend 70, 80 or 90 hours per week in the lab. They could establish their lab, build their career and have a firm basis for their later stability that fit with the model of the family and the model of work structure that was then universal in society.

What may be happening at present is that the traditional model is eroding in the U.S. The women's movement has encouraged more openness to dual career families, with men having to share some of the burden of housework. At least there is a cultural movement in this direction, even if it is not always in place in fact. The previous model virtually precluded women who wished to have a family from assuming professorships, given the demands of the position. It was very difficult to combine home responsibilities and an academic career. Recently, an awareness has grown that the traditional model not only discriminates against women but gives rise to complaints from younger male academics as well. They are feeling much more

pressure and, in part, it is because their own home situations are no longer organized according to the traditional model.

This introduces a stress into the system that did not previously exist. This stress is related to deeper changes in family structure and in the structure of work that has brought women into the work force in unprecedented numbers during the past three decades. Thus, there may be a shift from a single focus on strictly career issues, not just for women who are trying to move into the system, but also for younger male academics who find it intolerable to try to manage both the traditional academic jobs and their new home responsibilities. This may create pressures to modify the system in a way that universalizes it a little more than in the past. There is some evidence that this shift is beginning to happen in the U.S. To the extent that it does take place it is not only a gender issue but also a generational cultural issue.

Nevertheless, the thesis of generational change has its limits. It certainly exists on the level of wishes expressed by younger scientists, both female and male, for a less pressured way of life. However, the pressures for publications, for raising funds, are becoming even greater as competition increases, especially at the highest-status universities. This is not due to a decline in research funding, which has indeed recently been increasing, especially in the biomedical sciences. But there is increased competition for these funds, from additional universities in other parts of the country, trying to establish themselves as research centers. As scientific research is seen as increasingly closely related to future economic growth, competitive pressures increase, even though some of the most competitive people, especially among the younger generation, would like to see these pressures reduced. Despite their wishes, as the competition increases, they are forced to write more grant proposals and feel pressured to spend more time at work. These young scientists feel themselves under an even greater strain even though they would prefer a different system (Etzkowitz, in press).

The stresses revealed in the coevolution of the institutions of family and work may also recreate new and possibly greater pressures towards inequality if not managed properly. University scientists are currently

experiencing intensified budget constraints that put even more pressure on research productivity and premiums on time. Universities have also placed new demands on faculty time in regard to teaching quality, widened access to students for faculty time, new electronic teaching materials, web pages, Internet class discussion groups, and university-wide published teaching assessments. All of these trends intensify the risks of starting and successfully managing an academic career, which may be more likely to 'double bind' Athena, rather than unbind her.

Another factor related to the coevolution of family and work is that professions that have increased the number of women often suffer a decrease in status and mean pay because of an increase in the effective labor supply. If this happens without an attendant increase in the demand for services, it is likely to decrease the incentive to pursue a scientific career in the first place. However, there is a counterbalancing force that may improve the condition of women in science, the opening up of new opportunities and positions in firms based upon academic science.

University science is becoming more entrepreneurial as evidenced by the number of academic scientists who are starting their own businesses, taking equity stakes in part-time businesses, or partnering with their university to start businesses that share university resources (Powell *et al.*, 1996; Murmann, 1998). Consequently, in creating firms that span the boundary of the university into the private sector, it is likely that models and accepted practices in the private sector will begin to be imported into academia. This suggests that the better gender balance (demographically speaking) and the stronger expectations for equal treatment and pay for women in the private sector are likely to flow over into academia. Thus, while these coevolutionary pressures lack the intentionality and organized features of the movements are most likely to accelerate positive change, the growth in the private sector and the power of the commercial market to pick winners will offer women more opportunities to use their skills.

ORGANIZATIONAL REFORM

A thesis of this book has been that macro-economic and social indicators tell only part of the story of disadvantage for women. Through triangulation of theory on professions and inequality, original fieldwork, and statistical analysis we have found that much of the process by which disadvantage is created and reinforced occurs within organizations and at the level of the department. It is at this level that recruitment, socialization, learning through networks, and access and referral benefits are created and combined with human capital factors. In this sense, we follow similar sociological literatures to the conclusion that the seat of change is at the department and organizational level, rather than in the environment or in human capital, because it is the organization that connects human capabilities with environmental requirements (Baron and Bielby, 1980; Baron, 1984).

RESISTANCE TO CHANGE

What are the forces for change to achieve gender equity in science and the countervailing forces for stasis? The organization and culture of academic science deters many women of high scientific ability from making their contribution. In those instances where a department has faced up to this situation and altered its behavior, women's participation has 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 the Center for Particle Astrophysics, University of California, Berkeley suggests that many of these changes are necessary for both women and men. Male participants in the program's seminars and retreats expressed interest in reducing the all-consuming pressures of scientific work-life, although they could not see how this could take place within the strictures of the existing system.

MARGINAL DISADVANTAGES

The succession of impediments to the entry of women into scientific careers that narrrows the stream to an extremely small flow at the stage of graduate training has been conceptualized as cumulative disadvantage. However, even given these disadvantages 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 motivated women who have taken steps to pursue scientific and engineering careers at the doctoral level.

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 increasing 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 cycle, thereby increasing the flow into the science career pipeline. Thus, the importance of focusing policy intervention at the later stages is twofold:

1. Encouraging the creation of a critical mass of women faculty members 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' thus providing the incentive of examples of achievement to encourage younger women to break through the barriers prevalent at early stages of the career. As we have sugggested above, sympathetic male faculty members can play an important role in mentoring women, relieving some of the pressure on overburdened women.

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 for 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 could 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.

Women should be recruited into 'pivotal jobs' or 'linking positions' in order to formally increase their social capital. A pivotal job is one that places someone in a position with a lot of crosstalk between other faculty members, particularly crosstalk that is often not spoken about openly but is critical to promotion and understanding of how the system rewards performance. For example, in academic circles, a position on the personnel and review committee offers great insight into how the university operates and reviews performance. It also permits members to gain first-hand knowledge about how outside letters (letters from external referees) are written, from whom outside letters should be solicited, and how issues of research productivity, teaching, and service are balanced in tenure decisions.

If women were consistently placed on such committees it would (1) widen their network of personal contacts, (2) allow them to display their competencies, (3) increase their access to information on how promotion processes work (information that is normally only

circulated among male ingroups), (4) help them demystify the tenure process in their own minds, and (5) position them as knowledgeable colleagues among their peers who will in turn rely on their counsel. Some universities and professional schools have adopted this system with great success by creating 'untenured observer' positions on their tenure and review committees. These positions are open to junior (untenured faculty) for 1-year stints. The untenured observers have access to the entire decision-making process. They attend all the meetings, read all the outside letters, observe decision-making processes (and tenure battles), and learn how the decisions emerge.

At one university familiar to the authors, the expressed public mission of the observer is to reveal the scepticism felt by outsiders about the process, and report back to peers and senior colleagues on the way the system works. Another method of expanding women's access to social capital is through arranged mentoring. While it is commonly understood that mentors offer advice and access, it is less commonly recognized that assigned or organized mentoring programs can have effects that are comparable to informal mentoring. In a number of universities for example, new faculty members are assigned to teaching and research mentors. These individuals are usually just a year or two ahead of the new recruits. Their mission is to familiarize the new faculty members with the idiosyncrasies of the department and university. They pass down factual knowledge, advice, tips, and strategies that help bring the new faculty member up the learning curve more quickly.

Importantly, much of this information is in the form of tacit knowledge that is rarely available through other means but critical to success. It could make the difference between speaking to a decision-maker who interprets policy one way and speaking to one who interprets it very differently, even though both interpretations may be right in a formal sense. In this sense, it has the objective results of reducing errors and increasing efficiency which is good for academic staff, students, and universities. Mentors also help introduce new faculty members to others, invite them to social functions, and impart

advice without the baggage of creating status differences. In this sense, arranged mentoring helps reduce subjective barriers to entry.

Mentoring should be recognized as an important part of the service to the department and university, and should be recognized with remuneration, reduced committee work, or flexible teaching schedules. At one university we are familiar with, arranged mentoring has been developed to a sophisticated level on these dimensions. For example, mentors are rewarded in direct proportion to the success of those they mentor – creating an added incentive in mentors to produce productive collective results. Systems like this have shown their success in the private sectors, particularly in law and consulting fields which are driven by similar systems of teamwork, interdependence, and networking.

Luce professorships and the National Science Foundations Program of visiting professorships for women provide individual permanent and temporary positions but no program is yet available of the magnitude to create a critical mass by itself. However, an internal university commitment can provide the necessary scale of resources for achieving a critical mass at least in some departments, as in the molecular biology department that we studied. A more radical suggestion, given the success of women's colleges in encouraging women's participation in science at the undergraduate level, is the development of graduate departments at some of these same institutions (Lazarus and Nair, undated).

Such a bold step would provide a place for faculty members to set an example of women organizing research groups that function collegially, effectively and differently than the male model. Serious consideration of such a course of action might lead existing graduate programs to re-evaluate their treatment of women since the resources to initiate this reform of the academic system could well be drawn from the National Science Foundation, National Institutes of Health and other agencies that support existing graduate programs.

POLICY RECOMMENDATIONS FOR DEPARTMENTS

Although culture is generally believed to be highly resistant to change, our findings suggest a few key points of intervention. Specific steps could be taken to mitigate the effects of the male scientific ethos on the recruitment of women to science and engineering. The rigidity of the existing academic structure and misperceptions of women scientists among male academics 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.

Women scientists wish to legitimate an alternative model that will open up science to women's full participation. They raise equity issues in the face of strongly held beliefs on the part of many male scientists that the existing system produces enough female scientists. Because parochial ways of conceptualizing, investigating, and organizing the conduct of science have been accepted, significant sectors of the population have been excluded from full participation, and alternative 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.

CONCLUSION: SCIENCE POLICY FOR WOMEN IN SCIENCE

Questions of gender and science have come into the foreground in sociological theory, feminist research and human resource policy

(Abir-Am, 1989; 1991). The sociology of science is moving beyond comparing men and women scientists according to implicitly masculine criteria, which have themselves come into question. Hyper-competitiveness has been attacked as counterproductive to 'good science' (Marvis, 1993), leading to premature publication and possibly to 'fudging' and fraud. It has also given us the 'smallest publishable unit', the practice of subdividing findings into numerous articles. Harvard University has recognized the problem, limiting the number of articles that can be submitted for tenure review. The definition of research achievement in terms 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 suggests different gender styles of scientific work, with women taking a more measured approach to research. Women appear to work more intensively on a subject before making their work public.

Institutional reform that takes into account the needs of female scientists also benefits men by introducing some flexibility into career paths. How can the phenomenon that graduate departments are more active in organizing programs for undergraduates and high school students than for their own students be explained? One answer is that instead of changing a structure that the people in power are satisfied with, it is much easier to deal with other people's problems, elsewhere. Perhaps this is why there are very few programs at the graduate level even in departments that are active in organizing programs lower down the academic ladder.

Departmental change to advance the interests of women is unlikely to be widespread unless there is intervention from above, either from the leadership in the university or from the funding agencies that support the research system on which Ph.D. programs are based.

Innovative university-wide policies can change department policies; for example one might be a department review for diversity issues. Just as a U.S. university department has an external review every three years that is meant to assess the department's research, internal

dynamics, and links to the wider university, it should have a separate diversity review (as in private industry), or a diversity assessment should be made part of the conventional three-year academic review. The outside referees (usually from comparable departments elsewhere) should evaluate how well the department is doing on issues of recruiting, hiring, and retaining women. Just as the review evaluates a department's coverage of subspecialty areas in the field (e.g., gene splicing in biology departments), it can assess a department's track record and current gender balance.

This change could have the effect of bringing the systematic disadvantages of women to the attention of university administrators, who could then dedicate funds to improving these conditions. It also opens up channels of discussion among female and male faculty members about the subject, which can help inform women faculty about how to choose and locate progressive departments. Finally, because these reviews are sometimes used in ranking departments, they tie department status to affirmative hiring of women – reversing some of the present and reprehensible biases. Related to the idea of an academic review with a diversity component or simply a separate diversity review, diversity committees should be set up across university departments. These committees should have the objective of assessing issues of critical mass, recruitment, hiring, and retention, identifying and diffusing models of success, and providing counsel on issues of bias.

At present, most universities only have avenues of recourse for women who experience bias or harassment that affects pay (or promotions – easy to assert but difficult to prove). These programs are necessary, but lack attention to the processes and experiences of women that shape job satisfaction and feelings of empowerment that are needed to sustain a cutting-edge research program. These committees should be staffed by men and women who are interested and motivated to effect change. Finally, a network of these committees should be created across campus in order to increase knowledge transfer about best practices and to promote the sharing of resources

(e.g., to share the costs of instituting talks and seminars by elite women scientists). Members of the committee should be rewarded for their participation in annual salary and promotion reviews, with reduced teaching loads, or guaranteed teaching time slots (to help accommodate the balance between work and private life).

When departments become more inclusive, there will be less need for intervention. In the interim, programs have an important role to play in strengthening nascent female networks. Opening up existing networks to women is especially important because of the general lack of formal rules and the resistance to increased levels of formalization in academic departments. Systemic change in networks creates a level playing field for networking among both women and men. 'Normative' change, in which values informally shift over generations, with younger male and female mentors sharing non-sexist values, is a slower mechanism for the distribution of social capital to all, regardless of gender.

Critical mass was expected to be achieved through affirmative action, to clear up blockages in the pipeline on the premise that attracting a sufficient number of persons, from a previously excluded social category, will foster inclusion of others from that background. The paradox of critical mass, and the interest of many female scientists in creating an alternative mode of doing science, suggest that this is not the case. Encouraging more women to enter the pipeline is fruitless if so few emerge as professional scientists. In the face of exclusionary practices, both explicit and implicit, built into the research university system, many women Ph.D.s, see the writing on the wall and, seeking to balance work and personal life, seek employment in industry and teaching colleges. As our observations emphasize, the pipeline, a 'supply side' approach, needs to be supplemented by a focus on changing the institutional structures where science takes place.

In contrast to little more than ten years ago when we began our research, women scientists are increasingly more able to identify and reveal their sometimes painful and frequently confusing experience as graduate students, post-docs and junior faculty. Some middle-aged

women retrospectively understand their personal sacrifices, adaptive strategies and defenses as responses to tenuous and hostile situations. Moreover, some male scientists now not only acknowledge the presence of bias, but openly attempt to provide women students and colleagues with strategies and support for success. Ironically, the endeavors of some male scientists to reduce marginalization shows that real inequities actually do exist. As mentors they provide the primary relationship required by every young scientist to learn the craft, the unwritten rules, and means of entry into social networks crucial for continued growth. Thus our findings show that in roles of power and authority, both male and female scientists are able to re-create departments into genuinely democratic institutional contexts. However, they are few and far between.

In response to relying on 'critical mass' as the panacea for change, we argue that only in democratic departments does the notion of critical mass really work. We have found that 'critical mass' is meaningless when women are isolated and unknown to each other, when affiliation with other women is too stigmatizing, or the female faculty model available reflects an archaic, male stereotype impossible to emulate or incorporate into a contemporary professional identity. True critical mass occurs because an informal grapevine attracts more women students and staff who are then integrated into the department as a whole. Rather than a simple statistic of 15% or more, a number that we have found frequently and erroneously reflects a large proportion of foreign students rather than American women (erroneously, because if 90% of that 15% are foreign students who remain in their own subculture, women of each nationality may be very isolated), the true power in the number reflects a department that is cohesive, inclusive and not isolating. Without the anxiety of exclusion and lowered status, women faculty members are not as inhibited in acting on behalf of female students and, therefore, are able to serve as authentic role models. Moreover, their energy is not as depleted by defensive operations around tenure, the burden of tokenism and apprehension of interrupting their careers to have children.

A key factor in overcoming the problems posed by the paradox must be university-wide policies on child-care, parental leave, recruitment and retention, and slowing of the tenure clock. At the departmental level, junior faculty who assume responsibilities as mentors and role models functions should be credited in tenure reviews. Tokenism must be eschewed: many departments aggressively court a few female stars while most women languish in continued discrimination.

Nevertheless, the ability of departments to defend traditional academic practices as 'gender neutral' should not be underestimated nor should willingness to reform be overestimated. For departments unable to reform themselves, outside pressures provide the necessary incentive. A representative of WISE (Women in Science and Engineering at Columbia University) recently suggested that the National Science Foundation cut off grants to universities without a minimum number of female faculty members in science and engineering departments. Indeed, NSF has mandated that absence of women at conferences that it funds will be taken as prima facie evidence of discrimination.

Law suits to redress discriminatory acts are expensive and time-consuming, even when successful. Until quite recently, courts were generally unwilling to review academic decisions on substantive grounds; only matters of procedure were typically subject to judicial review. Gender discrimination has now been accepted as a valid basis for law suits challenging academic decisions, following widespread acceptance of its legitimacy in other workplaces. Jenny Harrison, a mathematician at the University of California, Berkeley, was recently granted tenure after such a suit. The recognition she received for a series of significant results made the initial negative decision a matter of some embarassment to the mathematical community. Special dispensation for academic institutions, whether in the courts or Congress Legislatures, is disappearing as universities are held to ethical, legal, and financial standards common to all public institutions.

Participation of all groups in society is a basis for the public support

of science. The legitimation of science, the moral injunction to achieve equity and the strategic interest of each nation in utilizing talent to its fullest extent are reasons for change. In the U.S., Neal Lane, the former director of NSF, has called upon the research community to act in its own interest and make a conscious effort 'to integrate itself into the larger community' by more closely reflecting the demographic composition of the population. Equal representation of women and men in scientific professions would counter the elitist image of science and hopefully earn increased support for allocation of public resources to science.

The most important change required is a broader, more flexible, model of the relationship between work and personal life to make scientific as well as other highly demanding professions equally open to all persons of talent, irrespective of gender. The relationship of scientific work to other spheres of life needs to be rethought, to make it more compatible not only with female aspirations and socialization but with emerging male wishes to find a better balance between career and personal life. As Alice Rossi perceptively put it, 'marriage, parenthood and meaningful work are major experiences in the adventure of life. No society can consider that the disadvantages of women have been overcome so long as the pursuit of a career exacts a personal deprivation of marriage and parenthood, or the pursuit of happiness in marriage and family life robs a woman of fulfillment in meaningful work.' How can this goal be achieved?

BEYOND POLICY INTERVENTIONS

Policy change cannot affect inherent attitudes and prejudices. Change of that nature appears to emanate from those in power within the department. They become the role model for the role models. In order for women to cope with the vicissitudes of gender discrimination, they require the armament of the reality about the paradoxes within the culture of science. We believe that prior to entering graduate school young women need the opportunity to interact informally with senior graduate students and faculty members who can talk candidly about

these issues. Workshops could be organized to provide knowledge of the unwritten rules and the strategies required to thrive, as well as a first-hand experience of the interpersonal connections and acceptance that are possible among scientists. In contrast to repeated concerns that bringing the difficulties for women in science out in the open will only dissuade them from pursuing science, we suggest the opposite.

Making potential problems more immediately recognizable, and solutions and strategies more attainable, is empowering and inhibits the debilitating process that all too frequently occurs only after the student is in a graduate program and has no means to identify what she is experiencing. That is when the enervating feelings of anxiety, shame and self-blame begin. We also believe that venues for bringing these issues out in the open are as imperative for upcoming junior faculty members as they are for graduate students. Not to speak forthrightly is only a re-enactment of the denial that occurs in those departments in which marginalization endures. In such departments rationalizations are pervasive and change does not occur. Most of all, if it is true as it has been suggested that women really do need to respond better to negative 'kicks' (Sonnert and Holton, 1996), they will first have to know what those kicks may be.

Our research strongly indicates that until the social context alters, women will have to understand the critical role of their advisor before the choice is ever made. Women need to know those personal and professional characteristics of this uniquely important individual who will either enhance or diminish their chances of attaining goals and developing a professional identity. This is crucial since a professional identity is inextricably linked to a 'social identity' in which the esteem of others provides recognition and serves to enhance self-esteem (Berger, 1967).

In contrast to earlier assumptions in which all women academics were perceived and touted as automatic role models and mentors, young students need to understand and be able to identify the attributes necessary in a good mentor of either sex. In this respect, the notion of 'gender differences' is again called into question: some male

advisors can be excellent mentors for all of their students regardless of sex. We believe that there is evidence that adherence to cultural prescriptions and proscriptions around notions of gender depends on the individual and, therefore, is not immutable.

Rather than rely solely on quantitative analysis which frequently masks what is really going on in people's lives, we have attempted to understand the real experiences of women scientists as they have shared their understanding of their experiences. We believe that multiple paradoxes abound, potentially double-binding women at every juncture within the pipeline. It begins with marginalization and isolation and the demand for autonomous, independent functioning within an activity which is, for men, highly social and socializing. It is exacerbated when adaptive attempts for affiliation through women's groups are labeled as indicating 'special needs'. It is compounded when similarly isolated women faculty members are offered up as a solution to institutional problems.

It needs to be recognized that some of the solutions and mechanisms employed by successful women scientists of an older generation are no longer relevant in a different historical and social context. Until these and many other paradoxes for women in science can be freely examined and articulated without the subtle threat that an inherent and innate 'difference' will be exposed, the contradiction between what too many in the scientific community choose to believe exists and what actually occurs will continue to impede the growth and development of too many gifted women.

The late Betty Vetter, founder of the Commission on Professionals in Science and Technology, pointed out the waste engendered by persisting barriers that cut short scientific careers in which there has been considerable personal and public investment. It is high time to remove the barriers that impede women and minorities from successfully negotiating the 'critical transitions' of scientific and engineering education and career. Norms of science 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 feminine is automatically conceived of as antithetical to 'good science' (Keller, 1980).

Under these conditions, with impersonal evaluation a component of the social structure of science, Maria Mitchell's exhortation (quoted in Enna, 1993) would become a reality: ' . . . no woman should say, "I am but a woman!" But a woman! What more could you ask to be?'