15 International comparisons

In recent years the question 'Why are there so few women in science?' posed more than a quarter of a century ago by sociologist Alice Rossi, has been raised by her counterparts throughout the world, including the late Virginia Stolte-Heiskanen (Finland), Esther Hicks (the Netherlands), Fanny Tabak (Brazil), Mary Osborne (Germany) and Pnina Abir-Am (U.S.), among many others. Several intriguing anomalies in women's experience in science emerge from analysis of a range of contrasting national and social circumstances in the work we draw upon here. For example, female scientists and engineers in India have been found to be more productive than their male counterparts, as measured by numbers of research papers and patents produced, while Venezuelan women researchers are slightly less productive than men (Lemoine, 1994).

Women have attained greater access to higher-level positions in some southern European countries than in northern Europe (Talapessy, 1994). The nuclear family, characteristic of advanced industrialized societies, in the absence of substitute support structures, typically places a strain on women scientists. The traditional extended family, still commonplace in developing countries, provides significant support for female scientists in countries such as Brazil and Mexico.

Seeming contradictions are intertwined with unexpected findings about gender and science. Women have made the greatest gains in participation in technical fields under conditions where science is relatively low in status in comparison to other professions, for example in Turkey. A shortage of men due to their diversion into military service has also opened up scientific careers to women, in the United Kingdom (Mason, 1991) and Portugal (Ruivo, 1994). A rapidly expanding higher education system, propelled by industrialization and

modernization, also works to open up scientific education, and to a lesser extent, scientific and technical careers, to women. Conversely, a declining academic economy also results in a feminization of the university as men leave for higher-paying positions in industry, especially in fields such as computer science (Lopez, 1995; Carrasco, 1995).

Using the available literature, and through interviews with researchers on women in science in a number of countries, we compare women's experience in science in developing and highly industrialized countries, in northern and southern Europe, and in socialist and capitalist contexts. We address the following questions. Is women's limited participation in science an inevitable feature of the persistence of traditional gender roles? What difference does social structure make? Under what conditions do barriers to women in science fall (or at least shrink)? The paradox of women's participation in science is that their numbers appear to increase most under contrasting conditions of system expansion and economic decline, with even the advances reflecting, to some extent, continuing inequalities among men and women in science.

WOMEN SCIENTISTS IN DEVELOPING AND SEMI-INDUSTRIALIZED COUNTRIES

In developing countries, with the notable exception of a few nations, there are many fewer women in science and engineering fields in higher education than in health, education and law (United Nations, 1995) Although cross-national data on women in universities are limited, an international research consortium of agricultural research institutes provides an interesting indicator of women's participation in scientific careers. Some women were on the non-scientific staff or at the trainee level but few could be found at the senior scientific level or in managerial posts. Nevetheless, there are intriguing anomalies such as mathematics where women can be found in university positions at higher proportions in such countries as Columbia, India and the Philippines than in many developed countries.

Turkey: Class is stronger than gender

In Turkey, the question of women in science can almost be reversed and instead of asking 'why so few?' one author has asked 'why so many?' (Oncu, 1981). The answer lies in part in the country's history of westernization in which advancement of women was part of the 'kemalist' ideology. Despite its association with modernization, science was not as closely connected to the centers of power in society as law and political science, fields in which women continued to have extremely low rates of participation. The answer is also class-based. The creation of large numbers of professional positions with the founding of the modern state meant that there were insufficient upper-class or upper middle-class men to fill them – hence the openness of technical fields to upper-class women who were typically encouraged by their fathers to pursue high-level careers.

An ideology of modernization combined with the carryover of a traditional support structure for child care, or simply the financial ability to obtain assistance, enhanced the ability of well-to-do women to pursue scientific careers. However, the attenuation of the founding ideology of the state since the 1950s, combined with the expansion of the university system during the 1980s into more traditional provincial areas of the country, has produced an unanticipated reduction in the participation of women in academic science (Acar, 1991). Nevetheless, even in the metropolitan universities where women have long had high rates of participation and access to high-level positions, there are still strong differences between men and women. For example, women report that they tend to be excluded from informal sources of communication.

Despite the ameliorating factors discussed above, women experience conflict between work and familial roles. An indirect indicator is that a higher proportion of women scientists than men are single and without children. A significant number of women, especially those who rise to high-level positions, are apparently following the 'male' model of science. Behind the façade of higher rates of participation and promotion in some sectors of the Turkish

academic system, female scientists in Turkey face many of the same informal and subtle barriers found elsewhere.

Brazil: The significance of traditional gender roles

Despite differences in level of development, academic tradition, or world region, women face similar disabilities in pursuing scientific careers. A recent examination of the situation of female scientists in Brazil exemplies this conclusion (Tabak, 1993). From 1970, data were collected at five-year intervals on female participation in the hard sciences at the Federal University of Rio de Janiero. In addition, three focus-group interviews were conducted with women scientists. The number of senior female faculty members in the hard sciences at the university is negligible.

In Brazil, as elsewhere, women encounter a workplace with a rigid structure that does not take into account their need for flexibility so that they can combine career and family. Similarly, an authoritarian 'male' style of laboratory leadership, which discourages cooperation, is commonplace. In addition, women were often excluded from career opportunities, such as invitations to participate in conferences. Some conference organizers simply assume that they would not want to come since they had small children at home.

These unequal conditions in the workplace are an overlay on unequal gender roles in the larger society and a 'machismo' ideology that works against women in science by condoning sexual harassment and legitimating their lack of promotion to higher positions in the scientific community. There are also tensions created in a patriarchal society by women's occupational success. If their husbands are not as successful as they are it creates a difficulty and tends to lead to separation. In one instance a woman completing her Ph.D. dissertation did not appear at a party in her honor, as her husband had left that evening. A supportive husband sharing in the tasks and responsibilities of the household was important to Brazilian female scientists' ability to carry on research but was not always available.

Male bias toward women in science is exacerbated by women who

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follow the 'male' model themselves and act negatively toward female colleagues who do not follow this model. The single female member of the Brazilian Academy of Sciences does not believe that women face any special difficulties. On the positive side, the Brazilian National Research Council has taken an interest in gender issues and monitors women's enrollment, graduation rates, participation in professional careers and access to positions at universities and research institutes.

Mexico: The effects of gender socialization

In Mexico, women's participation in science increased to the level of 24.3% by 1990 propelled by the growth of female students in higher education (Blazquez, 1991). From 1969 to 1985, as higher education enrollment expanded more than fourfold, the rate of growth for women was almost three times that of men, with women constituting 44% of the undergraduate population in 1990. Although the data are not broken down by disciplines, a good indicator of the growing participation of women in graduate education is the increase from 23% to 33%, from 1971 to 1989, of scholarships awarded to women by CONACyT, the national research funding agency. Of course, these figures also show a gap between the increase in the proportion of women at the undergraduate level and the lower but still significant number at the graduate level. A gender analysis of two of the country's leading scientific institutions showed that women represented 26% of the researchers in the schools and centers of the National Polytechnic Institute and 30% of the scientists at the Autonomous National University of Mexico (UNAM). However, women represent only 2% of Mexico's scientific managers and policy makers.

In several ways the experience of women in science in Mexico is similar to Turkey. Most female scientists grew up in well-to-do, highly educated families. As children they received two cultural messages: (1) a traditional gender expection to marry and have children complemented by (2) strong encouragement to become highly educated themselves. Parental advice to advance the knowledge of their future children placed the education message in a traditional

gender context. However, by the time these future female scientists arrived at the university, the message to educate oneself had taken on a life of its own. Women expanded upon the injunction to become cultured by developing the goal of contributing to the advancement of knowledge themselves. In doing so, these women did not neglect traditional gender roles, they merely tried to make them compatible with their new career goals. This process was aided by the circumstance that many female scientists married men who were researchers themselves. Also, as in Brazil, the extended family was often available to assist with child care (Blazquez, 1996).

Women very seldom are found in high level scientific posts in Mexico. Even when women attain such positions, a man is still usually in charge and handles external relations while the woman manages the internal aspects of the organization. One reason offered for the lack of women in high positions is that they are typically not interested in engaging in the politicking required to achieve senior status. Many women, no doubt, eschewed this informal aspect of scientific advancement because of the constraints on their time imposed by family obligations. However, another factor, the particular nature of women's scientific formation, an indirect effect of discrimination, can also be inferred to play a role in their concentration on scientific research itself rather than its ancillary political and organizational aspects. To be taken seriously as a potential scientist, women had to demonstrate a greater knowledge and research ability than their male counterparts (Blazquez, 1996). To do so meant an extreme concentration on securing their knowledge base, with a concomitant effect on their style of research. Women typically develop their research findings more fully than men before publishing, a phenomenon that has also been noted in the U.S.

Portugal: The loss of males

Under certain conditions of great exigency, women's rapid entry and advancement in the scientific system has proved possible, at least to some point. In Portugal, colonial wars in the 1960s and early 1970s

removed large numbers of men from the university system temporarily, opening the way for women's participation even in disciplines heretofore largely male-dominated. By the 1980s, this enlarged pool of female graduates in the sciences had been translated into a high rate of Ph.D. production, with women the majority of new Ph.D. recipients in such fields as chemistry (77.8%), mathematics (54.5%), physics 58.8% and biology (71.4%) (Ruivo, 1987: 387). Nevertheless, women had not yet gained entry into the higher levels of the research or science policy-making systems.

One hypothesis for this difference between increase in participation at the lower levels and continued exclusion at the higher levels was women's lack of social power in Portugal. On the other hand, in industrialized countries with lower rates of Ph.D. production and presence in the mid-ranks of researchers, some women have attained high science policy positions, perhaps owing to the general increase of women's social power in these countries (Ruivo, 1987). Another hypothesis to explain the increase in women's participation in science in semi-industrialized countries is that science is still viewed as a cultural endeavor, with little relevance to the economic and political centers of power. In societies where men retain virtually total control over the levers of power, women's participation in areas of society that are considered marginal locally, if not internationally, may be unexpectedly high. This produces such anomalies as higher rates of participation of women in some scientific occupations in southern than northern Europe. Nevertheless, women in southern Europe experience some of the same disabilities female scientists encounter elsewhere, along with an additional cultural overlay of resistance to their full participation at the higher levels of science.

Greece: Traditional gender roles

The condition of women in science in Greece is influenced by two factors: (1) the traditional weak position of women in Greek society; and (2) newly emerging government initiatives for expansion of research capacities to further economic development. Although three

out of five persons entering an expanded university system in the late 1980s were female, this has not yet translated into changes in the composition of research groups or participation in higher degree studies. Most women continue in traditional female fields such as languages. Although there has been some increase in women entering medicine and dentistry, these are not research-intensive fields in Greece. One hopeful sign for the future is the increased number of women pursuing degrees in mathematics, an important precondition for access to technical careers.

Greece appears to be in an earlier stage of the transition noted in Portugal. In the Portuguese case, a significant increase in female university enrollment occurred earlier in the 1960s and spread more rapidly to the sciences due to the high proportion of men called into the military. In Greece, as elsewhere, the paucity of women in high science policy positions, and the lack of programs to encourage women to pursue research careers in science and technology, retard change. Neverthless, an underlying condition driving change is present: the need to develop human resources to make the transition to a higher-tech economy. Sooner or later, the realization that half the potential talent is not being fully utilized will help drive change and improve the condition of women in science and engineering in Greece, as it has in other industrializing countries.

There are also particular characteristics of the Greek higher education system that work against women's increased participation in academic science careers. For example, geographical mobility, a factor long noted as a prerequisite for success in traditional 'male'-oriented science systems, in the Greek context means not just relocation to another university or region as in the U.S. but typically to another country for advanced education. This higher geographical barrier exists because Greek universities have not yet organized formal graduate programs, with course work and so forth. Since national degrees are not yet taken seriously, acquisition of a foreign doctorate is virtually a prerequisite for appointment to an academic position in the sciences. This is yet another instance of a seemingly meritocratic

practice working against women in science. Family pressure for young women to stay close to home is an overlay on other pressures that reduce geographical mobility. The highly politicized nature of the Greek academic and science system also works to exclude women, who are largely left out of political decision making (Cacoullos, 1991).

GENDER DYNAMICS IN HIGHLY INDUSTRIALIZED COUNTRIES: THE EUROPEAN EXPERIENCE

Despite variations in culture and politico-economic systems across Europe, female participation in the labor market and in higher education has risen considerably, yet the common contradiction of women in science and other high-status professions persists. Science follows the general rule that 'the higher one goes up the ladder of the occupational status hierarchy, the fewer the women' (Stolte-Heiskanen, 1991: 3). Moreover, despite the existence of extensive social support systems in many European countries, female scientists still face the inflexible constraints of the scientific research system, including the coincidence of child-bearing and child-raising years with the expected period of high research productivity.

There is a self-defeating dynamic at work at the intersection of gender and human resource policy in science and technology. All European countries give high priority to the production of new knowledge and the education of knowledge producers, yet they do not realize the full value from their investment. Although these human resource policies are not directly focused on gender, since women constitute at least 50% of the potential target of the policy initiatives there is inevitably an impact. The expansion of higher education during the past forty years has opened up new opportunities for women and men. Although women are increasingly being educated in formerly male-dominated fields in the sciences and engineering, improvements in access to educational qualifications have not opened up career opportunities to the same degree (Stolte-Heiskanen, 1994)

There is a lag between the attainment of equality in access to education, and its translation into jobs and especially into higher-level

scientific positions. A comparative study of research groups in six European countries found that the small proportion of female unit heads made comparison of male and female leadership impossible to analyze quantitatively. The fewest women were found at the highest level and the greatest number at the lower levels of the group where 'the sex distribution is more even, or even reversed' (Stolte-Heiskanen, 1983: 65). In parallel with U.S. findings (Rossiter, 1978), improvement in women's participation in scientific research groups was greatest in faster-growing areas such as biology and chemistry and least in slower-growing fields such as physics and mathematics. One notable national difference, the tenfold greater number of women in mathematical and engineering research groups in Hungary than in Austria, both former members of the same political unit in the not too distant past, illustrates the historical variability of women in science and its amenability to policy influence (Stolte-Heiskanen, 1983: 66).

Austria

Research on women in science in Europe confirms that a 'pipeline' policy of insuring access to scientific training is a necessary but not sufficient condition to overcoming the barriers to participation of women in science. For example, in Austria women gained access to higher education a century ago but only in the decades following the Second World War, when there was a push to raise the level of Austrian science to higher international levels, did women's participation increase significantly as a result of general policies to expand the proportion of the population participating in higher education. However, in academic research settings women predominate at the lower levels as assistants but at the upper levels represent only a very small proportion (1.5%) of the directors of research units in the natural sciences (Gaudart, 1991: 18).

From the 1960s, as the result of pressure from the Austrian women's movement, the issue of women in higher education and as a topic of research and teaching came to the fore and became linked to a related debate on the role of research in national development. A new Ministry

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of Science and Research was established in 1970, headed by a woman, Hertha Finberg. Having a woman in a leadership policy position helped insure attention to the promotion of women at the working level of the research system. The national organization of university heads, the Rectors Conference, also directed by a woman, established a working group to remove barriers to women pursuing careers in academic science at the highest levels. Although most professorships in the sciences and most university managerial positions are still held by men, the hopeful trend is the transformation of the 'anti-feminine climate in, and masculine dominance of, academic circles' (Firnberg, 1987, quoted in Gaudart, 1991).

Finland: A 'motherhood myth'

Another small European country, Finland, also experienced an upsurge in the percentage of women enrolled in higher education in the mid-1980s, reaching 52% of the student population. Yet the proportion of women in teaching positions lagged very far behind. Females held 3% of the associate professorships in engineering in 1986 and 2% of those in the natural sciences. Women represented 4% of professors of natural science while the percentage in engineering was too low to register. Women were fairly well represented in lower-level teaching positions: 24% of the teaching assistants in the natural sciences were female, as were 15% of the engineers. The percentage of lecturers was 16% in engineering and 9% in the natural sciences. At each step of the career ladder, women are older than men as a result of time devoted to their families (Stolte-Heiskanen, 1991).

A majority of female Finnish scientists are married and more than half have children by the time they receive the Ph.D. (Luukkonen-Gronow, 1987). Not surprisingly, with each additional child, the time available for professional work decreased. Women scientists reported that, even though they had to cope with most household and child-rearing tasks, family life provided the sustenance to make up for the 'disadvantages and emotional stress experienced in their professional environment' (Luukkonen-Gronow, 1987). Beyond the general 1987

Equal Rights law, there are no specific policies to improve the condition of women in science. Although an official committee established in 1981 to address problems in women's research careers put forward a series of recommendations for increased appointment of females to research posts and provision of social services such as day-care centers for children, follow-up actions were not taken (Stolte-Heiskanen, 1991).

Some movement towards equality in household tasks has been identified but with ambiguous effect on scientists' family life. A seven-country comparative study showed that Finland had the most equal division of domestic labor. Nevertheless, research on younger Finnish women scientists found that 'women primarily bear the burden of responsibility for the reproductive activities of the family' (Luukkonen-Gronow and Stolte-Heiskanen, 1983: 273). Apparently, the women studied were well aware of this eventuality and had adopted the strategy of scheduling their first child during the writing of the MA thesis, a phase presumed to be more compatible with pregnancy, and their second child before beginning their careers. Of the scientists interviewed, 79% of the women and 51% of the men stated their belief that the main reason there were not more women in science was the difficulties that reproductive and familial responsibilties engendered for a research career. The authors suggested that these scientists were buying into a 'motherhood myth'. Nevertheless, their own data showed the obstacles that women had to overcome to maintain their scientific productivity on a par with men.

Italy: Persisting marginality

As with other European countries discussed thus far, Italy experienced a marked increase in the participation of women in higher education during the post-war era. Although women entered the initial career levels of the university system in similar proportions to men, their participation declined rapidly at the upper levels. Women also held few leadership positions in the laboratories of the national research system. A qualitative study of the work histories of sixty male and

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sixty female Italian researchers, undertaken in 1988, provides some provocative clues to understanding this divergence between educational and employment achievement. The study first showed that men and women scientists demonstrated similar levels of productivity in their scientific output across different types of publications (national, international, conference presentations etc.) and thus ruled out differences in research achievement as an explanation of career outcomes (Palomba, 1993).

Nevertheless, the researchers concluded that gender-related effects were indirectly responsible for the virtual exclusion of women from upper-level positions in Italian scientific institutions. Interviews with female researchers revealed that they were straining, albeit successfully, to pursue their research programs while fulfilling traditional domestic roles and meeting family obligations. Male researchers, on the other hand, were freed up by these same traditional family environments to successfully pursue their research while also having the time to engage in the 'laboratory politics' necessary for ascension into managerial positions. Like their Mexican counterparts, Italian female scientists concentrated their work efforts on their science, maintaining their research productivity at a high level, while devoting their political and managerial talents to balancing the demands of research and family. The persistence of traditional sex roles contributed to a gendered division of labor in the scientific community, largely excluding women from managerial and policy roles.

The Netherlands: A continuing dilemma

Why are there so few women in upper-level scientific and technical positions in the Netherlands? A study of the female professoriat in Dutch universities found that many of the women who have achieved high academic positions in the sciences and engineering are childless. 'Ironically . . . they are implausible role models for the potential combination of career and family. Indeed, the majority were of the opinion that a research position and a family is a difficult to impossible combination' (Hicks, 1991). The incompatibility of the 'male' model of

science, with its long hours, and the policy goal of opening up scientific research careers to larger numbers of women comes up against the strictures of the traditional sexual division of labor. Combining two careers with stringent demands – scientific research and motherhood – is a difficult task. Only a few women may be able or willing to pursue both roles simultaneously, at least as they are structured at present.

Men's long hours in the laboratory are made possible by female responsibility for the 'private sphere'. Women's research time is truncated unless they give up that private sphere. Since most women are unwilling to do this, the prospect of overcoming their small numbers at the top is highly dependent upon '. . . erosion of the norm that women have sole responsibility for family and household maintenance' (Hicks, 1991). The restructuring of the scientific work role, making the emerging 'female' model (limiting time at the workplace) the norm would also appear to be a prerequisite for change. Other partial alternatives include Alice Rossi's idea for a 'technical fix', professional household care firms that remove some of the burdens of home maintenance from both men and women. Expanded child-care facilities would also reduce the '. . . alienating choice between home and profession' (Hicks, 1991: 186). Perhaps ironically, it may be easier for an upper middle-class female scientist to pursue a demanding scientific career in a Third World country where a personal support structure of extended family and servants is assumed. Indeed, the most difficult career point for many female scientists from developing countries is the years they spend in a developed country, bereft of such assistance.

Israel: A few women at the pinnacle

Despite obstacles in their path, a small number of women do attain the highest level of formal position in academia: the full professorship. In Israel, where traditional expectations of female responsibility for child care are strong, a recent study found no diminution of scientific productivity, according to such measures as number of papers published, due to combining a demanding career with family roles

(Toren, 1991). Approximately two-thirds of the Israeli female full professors were natural scientists. Among the explanations for the lack of negative impact of heavy child-raising responsibilities is, of course, the fact that the smaller number of female full professors may have higher abilities than their larger number of male counterparts. Child-raising was noted to decrease participation in international meetings and the ability to take advantage of fellowship and research opportunities abroad, both activities especially important to advancing a scientific career in a small peripheral country. The unexpected high productivity of these female full professors demonstrates the invalidity of myths that propound an inherent contradiction between demanding scientific work and marriage and family.

Denmark: The difficulties of balancing

Although many women scientists develop creative strategies to overcome the handicap of burdens placed upon them by their having primary responsibility for raising children, this should not be taken to mean that they do not experience career and personal difficulties along the way. A recent study of tenured female scientists in Denmark illustrates the impact of motherhood on a successful scientific career. A first-order effect, similar to the one identified by Cole and Zuckerman among female scientists in the U.S. (1987), is that '. . . they sleep less and skip many leisure activities' (Nielsen and Elkjaer, 1991). A second-order effect is the loss of research opportunities because their work schedules are 'reduced to normal working hours'. In contrast to the Israeli cultural pattern of having children early, some female scientists in Denmark report that they delayed having their first child and ascribed part of their career success to their ability to arrange child care. In Denmark as in Israel the traditional ideology of the family is strong, with women having primary responsibility for maintenance of the emotional relations of marriage as well as more mundane household tasks. These Danish women scientists, who aspired to successful careers and family life in tandem, had to juggle the demands of both research and motherhood in contrast to their male

counterparts whom, they felt '... can better devote themselves to research, because they are not mainly responsible for the family'.

WOMEN IN SCIENCE IN SOCIALIST COUNTRIES

What difference does a socialist system make to the position of women in science? As in Austria and Finland, the former German Democratic Republic experienced a similar sharp increase in females educated in science and engineering after the Second World War. However, the increased flow of women through the 'pipeline' did not readily translate over time into anywhere near similar proportions of women occupying leading positions in scientific institutions. Even when their numbers grew close to parity (40%), this was not reflected in attainment of significant numbers of higher-level positions. Greater numbers, by themselves, did not bring about change. Nor did the availability of social support such as child-care facilities and generous family leave policies. Instead, the persisting patriarchal culture of the scientific workplace, with inappropriate patterns of communication and work organization for women, was identified as the problem that impeded career advancement (Radtke, 1991).

Similarly, in Bulgaria, where access to a scientific career improved greatly during the post-war era, coincident with the period since the Socialist Revolution, nevertheless there remained the overall delay in the promotion of women within the scientific system. Also, a gender division of intellectual life persisted, including a continuance of a traditional association of women with teaching. Female scientists report that they face a heavy load of family duties, with some assistance from their mothers for child care. Again this household burden makes it difficult for women to combine scientific achievement with administrative advance. Two out of three roles appear to be possible in tandem: for female scientists it is typically research and family; for males, research and politicking. Even when women achieved some measure of advance into higher-level policy positions within the Bulgarian Academy of Sciences it was typically accomplished through election to the position of scientific secretary, a

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In the former Soviet Union the proportion of female scientists reached 40% during the 1970s and 1980s (Koval, 1991). Indeed women represent 58% of the engineers and 67% of medical doctors. Nevertheless, '. . . there is a hierarchical difference in the division of labor between the sexes.' As found elsewhere, men monopolize the decision-making positions while women predominate among the second level as assistants. Again family duties and child-rearing are an overlay on career responsibilities. Women are also viewed by men as less able to do science with the consequence that their lack of career advancement becomes a self-fulfilling prophecy.

Participation of women in scientific research groups was found to be highest in socialist Hungary and Poland where the integration of women into research positions, if not promotion to leadership roles, was a general policy tenet. Women attained high rates of participation in many science and engineering fields in Eastern Bloc countries during the socialist era but are losing their positions at higher rates than men during the post-socialist era. However, even during the socialist period when official ideology prohibited direct discrimination, female scientists typically filled the middle ranks of support researchers working under the direction of a male laboratory chief.

Despite significant variation in the organization of scientific institutions, differing socio-economic systems appeared to have little effect on the condition of women in science. In both capitalist and socialist countries, women were deterred from promotion to the managerial and policy levels of science and found that their family life provided satisfaction that at least partially made up for problems in work life. There was a common deficit of female scientists in the higher levels of research organizations. The exception to this rule in both systems was associated with the position of science in society. Even when, as in the former Yugoslavia, women achieved significant positions in scientific research institutions, this advance was associated with a decline in the position of science in society. 'As it

became less and less prestigious, science opened up to women' (Blagojevic, 1991: 75).

MOVEMENT TOWARD CHANGE

The situation of women in science in Spain exemplifies the principle that women make significant advances in a rapidly expanding system. In the later 1980s, a period of substantial growth in R&D investment, the number of women researchers increased by 180% in comparison to an increase of 88% for male researchers. Female researchers were, of course, starting from a much smaller base but, when opportunites expanded, it is interesting to note that women actively took advantage of them to pursue careers in research science. As in other countries, the proportion of women in research training programs is significantly higher than the proportion in research positions. Thus, it will be possible to expand upon the successes of the late 1980s when women's share of research positions grew fom 22% to 26%. Whether such expansion will actually take place, without a continued increase in research funds is debatable.

The entry of women into the engineering professions in Spain has not taken place without some ironic contradictions. A tightening of admissions procedures led to an increase in the proportion of women in telecommunications engineering. Although their numbers were still low, some improvement was generated by policies that limited places and favored secondary school students with higher grades. Since the relatively small number of women tended to get better grades than men in science subjects, '...whatever the original intentions behind the admission policy, the priority given to overall academic criteria has in fact led to a feminisation of the student body enrolled in university technical programmes' (Alemany, 1991: 219). Despite academic harassment by men, women do significantly better than men in examinations and show a 'greater commitment to [their] studies' (*Ibid.* 224) in electronic engineering, in part, they are impelled to achieve in order to counter the effects of discrimination.

The rapid increase in educational attainment of women in science in

southern Europe has given rise to expectations that there will be a quick throughput into the staffing of the academic system. However, the experience in northern Europe where numbers of trained women have been available for a longer period of time suggests that this will not necessarily be the case, at least not without some intervention to open the system up to fuller participation by women. The gap between men and women in science in both Germany and England expands at the point of entry into the first real academic position after post-doctoral training (Osborn, 1993; Moxham and Rogers, 1993).

THE U.K. EXPERIENCE

In the United Kingdom, this bifurcation point leads to the formation of a dual track system of independent and dependent tracks in academia. A higher proportion of men enter the independent track where they attract research funds, grow research groups, and pursue their own research interests. A dependent track, existing in parallel and symbiotic association, has a higher proportion of women. Members of this lower-status track are limited to short-term posts where they become dependent on the research funds of others as subordinate members of their research teams (Moxham and Rogers, 1993).

Women are marginalized by the persistence of these '. . . gender-related hierarchical structures' that inhibit them from pursuing independent scientific careers. Reistance to women increases with the height of the academic ladder. More than twice as many men as women become senior lecturers and, as late as 1991, there were no female full professors of chemistry (Mason, 1991). The intensity of feeling against admitting women into the inner circles of science can be seen in the decades-long struggle to open the Chemical Society to women (Mason, 1991). This battle was finally won in 1920, after women unmistakably demonstrated their competence during the First World War by filling positions formerly held by men.

Nevertheless, covert resistance to women in science persists to this day and is expressed in the drastically lower levels of women in high academic and science policy positions. For example, only 22 of the

almost 500 professors of biology in the U.K. are female. The issue of paucity of women in senior positions, even in fields such as biology in which women had achieved significant representation, was taken up in *The Rising Tide* (Lane *et al.*, 1994), a report identifying actions to allow women to realize their potential in science and technology in Britain. Following upon an earlier science policy report, *Realising Our Potential*, recommending the increased utilization of science and technology to enhance industrial competitiveness, *The Rising Tide* also linked its recommendations to an economic theme.

Not only did the loss of female technical talent impede 'national wealth creation' but continuing gender bias was also counter to ideals of equity. The authors proposed a dual strategy of a push from below and a pull from above, modeled upon successful initiatives elsewhere, as the means to accomplish change. Thus, the Committee suggested extending to England the Scottish format of secondary education that, on the one hand, did not require early specialization, and on the other, placed science courses in a broader context. Both policies had been found effective in encouraging a larger number of young women to take the preparatory educational steps toward scientific and technical careers. *The Rising Tide* also proposed that government set targets of 25%, introducing external pressure on academic and governmental institutions to promote women and include them in policy-making bodies in signifcant numbers.

Many policies that would improve the condition of women in science are also applicable to other professions and, indeed, all working women and men. Expanding U.K. child-care facilities and teleworking opportunities were among the proposals with such broader implications. Proposals of even a prestigious government sponsored commission are likely to remain just that, unimplemented recommendations on paper, without a build-up of political pressure and highly publicized protests from those most affected and their supporters. One recent example is the 'Oxford Revolt' in which business as usual in the distribution of academic positions was rejected by female academics who protested in favor of specific measures to

increase women's participation in the professoriat of Oxford University.

Follow-up to the *Rising Tide* report suggests that the issues of women in science will not go away without steps taken for their satisfactory resolution. A 1995 Forum on Gender Policy for British Science, sponsored by the Science Policy Support Group in London, signaled that the issue of women in science has been raised from the isolated concern of a few pioneers to a general matter of science policy. Nevertheless, government attention has its limits. The representative of the Conservative government at the conference expressed interest only in policy measures that could be undertaken at no financial cost. However, the broader significance of the report and associated events is that women scientists are organizing themselves to represent their interests. One of the leaders of the Committee on Women in Science, Engineering and Technology (SET) and chair of its working group, Cambridge Zoologist Dr Nancy Lane, prefaced a call for new policy ideas with a report on her meeting with the then British Prime Minister, John Major.

The ability of female scientists to access the highest level of political leadership is an indicator that the issues of women in science are moving to center stage in U.K. science policy making. The Forum participants came up with a range of ideas to build upon the recommendations of *The Rising Tide*. Valerie Ellis called for the systematic introduction of networking and mentoring in the workplace to assist women scientists to overcome the constraints that tend to limit them to lower positions. A call was made to take gender differences into account in the teaching of science in the schools by giving science more social context; girls want to understand the social contribution while boys tend to be satisfied with abstractions. The importance of organizational leadership in improving the lot of women in scientific institutions was noted by Jan Harding who presented an example of success due to a department head's commitment to change.

The fate of these and other ideas to improve conditions for women in science in the U.K. is still in doubt. Nevertheless, the issues have

received a recent spate of legitimation from policy makers such as William Waldegrave, the cabinet minister responsible for science and technology. Based upon such statements as Waldegrave's that 'It is obvious that we are not using the resources of half of our people properly', they are now part of the accepted repertoire of science policy issues (Dickson, 1993). Gender and science policy has also become the topic of academic seminars and public policy meetings well beyond traditional feminist circles. Indeed, there is now a recognized intersection between the two discourses. This is a significant advance over the polite disinterest expressed just a few years ago by science policy groups who, until recently, exemplified Nancy Lanes' statement that 'One problem is that men may not entirely understand the barriers that women scientists face.' It can no longer be said that female scientists have not publicly brought the issues of gender and science to the attention of the U.K. scientific community and its sponsors in industry and government.

A series of studies and reports produced by international, multinational and non-governmental organizations, such as the United Nations, the European Union and the Latin American and Caribbean NGO Forum, has also heightened the international visibility of the inequalities among men and women in science. In addition, individual scholars, both natural and social scientists, in various countries through their scholarship and advocacy have provided the data and analytical frameworks for these broader efforts. Organizations of women scientists and technologists such as the Third World Organization of Women In Science, The Association of Women in Science in the U.S. and Women In Science and Engineering (WISE) in the U.K. strengthen the social ties of their members and represent their interests. It is increasingly recognized that the issues of inequality of women in science and technology transcend gender and equity interests, since all the human resources in a society must be used to the full to achieve economic and social development.