CHAPTER 20

Gender, Hierarchy, and Science

MARY FRANK FOX

1. INTRODUCTION

In the study of gender and society, science is a strategic analytical research site—because of the hierarchical character of gendered relations, generally, and of science, particularly. Gendered relations are hierarchical inasmuch as women and men are not simply social groups neutrally distinguished from each other, but rather, are differentially ranked and evaluated according to a standard of masculine norms and behavior. Science, in turn, is fundamentally hierarchical. It is an institutional medium of power, marked by immense inequality in status and rewards, with the valued attributes of science being those more ascribed to men compared to women.

In the classifications of the National Research Council and National Science Foundation, the eight science fields are physical, mathematical, computer, environmental, life sciences, and engineering, as well as psychology and social sciences. In this chapter, science refers primarily to these fields, excluding psychology and social sciences—except in the national data or specific samples on career-attainments, where data are both aggregated across and disaggregated by the eight fields and are specified as such.

My aims are to analyze the hierarchical gendered relations—or stratification by gender—operating in: (1) attainments within and constraints upon participation, performance, and rewards in scientific careers; and (2) arguments about the construction of scientific knowledge. We shall see that science both exemplifies and expands gender stratification within society.

MARY FRANK FOX • School of History, Technology, and Society, Georgia Institute of Technology, Atlanta, Georgia 30332-0345

Handbook of the Sociology of Gender, edited by Janet Saltzman Chafetz. Kluwer Academic/ Plenum Publishers, New York, 1999.

1.1. Science as a Focal Case

What warrants the focus upon science? In the sociology of gender, science is a focal case because science is an agent of power, with consequences for the present and future human condition (see also Cockburn, 1985; Wajcman, 1991). Grounded in abstract and systematic theory and rationality, science is a prototype of professional claim to "authoritative knowledge" (Fox & Braxton, 1994, p. 374). Science defines what is "taken for granted" in daily lives and activities by literally billions of people (Cozzens & Woodhouse, 1995, p. 551). To be in control of science is to be involved in directing the future, and this is highly valued (Wajcman, 1991, p. 144). Tellingly, other occupations (from law to librarianship) have tried to mimic scientific authority and practice in their strategies for professional dominance and control (Derber, Schwartz, & Magress, 1990, p. 33).

1.1.1. Science, Power, and Social Institutions. As a agent of power, science reflects and connects with central social institutions, especially education and the state. Mathematics and its integral relationship to science operate as critical filter subjects in progression through educational levels. In higher education, science has been central to the development of the modern, complex university. Further, science and the political order sustain each other—with the "scientific ethos" of merit and equity operating as part of the belief system that underlies public support of science. The institutional connections between science, education, and the state, and the belief systems underlying them, point to the importance of science as an agent of power, and as a critical case in the study of gender and society. In understanding the relationship between gender and science, we need to apprehend the connections between science, power, and social institutions, addressed in the following sections.

1.1.1.1. Science and Education. When the church controlled education, Latin was the "filter," the foundational subject that needed to be mastered, and that operated as a sieve in successive filtering of students through educational levels. By the eighteenth century, the church had lost its dominance over education. The rising bourgeoisie gained influence, and Latin began to give way, initially to philosophy and logic, and then to science and mathematics as prominent subjects. Science and mathematics began to function as "proofs of competence" and a means of upward social and occupational mobility, based upon meritocratic performance (see Artz, 1966, pp. 66–67; Hacker, 1989, pp. 60–66; Noble, 1977, pp. 20–32; Schneider, 1981). In the process, mathematics tests came to serve as determinants of educational success or failure (Hacker, 1990, p. 141). Proficiency in math and science came to be used as indicators—both cultural and technical—of rationality (Hodgkin, 1981), and of self-discipline and "habits of industry" (Cardwell, 1957).

The ascendance of math and science as prominent features and filters in the educational system has gendered significance. Technical, particularly engineering, education in the United States became situated, directly and indirectly, within a masculine, military model. In direct modeling, engineering education was founded in the United States at the Military Academy at West Point (1821), patterned on the French Ecole Polytechnic.[1]

[1] The term "engineering" had its origins in the fifteenth century, and denoted the design of devices for warfare. In 1747, the first formal school of engineering, the Ecole Nationale des Fonts et Chausses (National School of Bridges and Roads), was established in France. At the end of the eighteenth century, engineering began to acquire standing as a discipline, and the qualifier "civil" engineering was applied to indicate its extramilitary applications (for an overview of "the birth of engineering," see Ambrose, Dunkle, Lazarus, Nair, & Harkus, 1997, pp. 13–14).

Indirectly, the military institutions constructed technical "competition, merit, and especially discipline and control [that] defined both masculinity and success" (Hacker, 1989, p. 66). More currently, engineering faculty interviewed about the importance of calculus and other forms of mathematics in the curriculum believed that it had "little relevance for job performance," but stressed it as important "to show that you can do it" and "to develop a proper frame of mind" (Hacker, 1990, p. 149).

Science also structured higher education more broadly. In the United States, science and higher education have evolved, in fact, as "reciprocal developments" (see Fox, 1996, pp. 266–268). First, from the nineteenth century onward, science acted to break up the generalist curriculum that trained graduates for ministry, law, or government service. Science helped introduce to the curriculum lectures, seminars, and independent work that largely replaced classical pedagogy emphasizing drill and recitation. Second, science paved the way for graduate education across fields, and in like manner, led the way in securing federal support for research and training. Third, with specialization, federal support for research, and winning of autonomy in research—forces largely related to developments in science—the university became decentralized. Power in making appointments and in controlling research funds moved from central administration to academic departments. Such decentralization has come to define the complex university, which continues to dominate higher education in the United States. Within academia—and for the public support and funding essential to it—science became a model (albeit frequently faltering) of research expertise and a standard for research training and apprenticeship.

1.1.1.2. Science and the State. As with education, a strong institutional connection between science and the state points to science as an operant of power—and grasping this connection is important to understanding science as a focal case in the sociology of gender.

The connection between science and the larger political order is such that science and the larger political order are created and re-created, reciprocally—so that they sustain each other (see Cozzens & Woodhouse, 1995; Jasanoff et al., 1995, pp. 527–531). The root is this: science costs, and the government finances. The state, in turn, has a strong stake in science.

Science is supported largely through public funds, distributed through federal agencies. In 1989, 20 U.S. federal agencies each spent more than 50 million dollars on research, with six agencies—National Institutes of Health, Department of Defense, National Aeronautics and Space Administration, Department of Energy, National Science Foundation, and Department of Agriculture–accounting for 90% of all federal support for research (Morin, 1993, Table 4-1).

Under the "social contract for science"–an arrangement originally outlined by Vannevar Bush (1945/1990)—the federal government provides funds for basic research and scientific training, and agrees not to interfere with scientific decision-making, in exchange for unspecified benefits to the public good expected to result ultimately from science. In practice, however, scientific research and resulting knowledge are infused with the assumptions and interests of both scientists and their federal sponsors (Cozzens & Woodhouse, 1995). The shaping of scientific research by sponsors and their public and congressional constituencies is manifest in areas such as oceanography, funded by the Office of Naval Research, "the war on cancer," and research attention to AIDS and to Alzheimer's disease, funded by National Institutes of Health. Scientific products and attainments have been taken as gauges of national resourcefulness, power, and prestige.

1.1.1.3. The Ethos of Science. Underlying the public support of science is an ethos that helps justify the federal investment and also makes science a strategic case for analysis of gendered hierarchies. As articulated over 50 years ago by Robert Merton (1942/1973), the normative structure of science has an ethos of "universalism," which prescribes that social relations be governed by "uniform terms." This is contrasted with "particularism," relations governed by "particular properties" of people. Universalism entails two connected requirements: (1) When a scientist offers a contribution to scientific knowledge, the scientific community's assessment of the validity of that claim should not be influenced by the scientist's personal or social attributes (such as race or gender). (2) Relatedly, a scientist should be rewarded for contributions, with "careers open to talent" and with characteristics such as race and gender irrelevant for making claims and gaining rewards.[2]

Science has been characterized both as a universalistic institution and as one in which universalistic standards fall short (see Cole, 1992, pp. 157–176; Mitroff, 1974; and Mulkay, 1976 for a review of this debate). At the same time, however, it is well established that science is an institution with immense inequality in career attainments and rewards (Zuckerman, 1988, pp. 526–527). Whether the inequality is "equitable" or "inequitable" depends upon the extent to which it can be explained by normatively justifiable—largely merit or achievement-based—criteria (see, e.g., Fox, 1981). For the purposes here, the "scientific ethos," with its belief-system of race-, gender-, and ethnic-neutrality, heightens the strategic value of science as a focal case for analysis of gender stratification in career attainments, and in arguments about the construction of scientific knowledge.

2. GENDER, HIERARCHY, AND CAREER ATTAINMENTS IN SCIENCE[3]

Gender shapes participation, location, rank, performance, and rewards in science. Women have long been "in science," but not central to science, in significant or influential roles (see accounts in Rossiter, 1982; Zuckerman, Cole, & Bruer, 1991). Before World War II, in the United States, women with doctoral degrees[4] in science were often unemployed, and if employed, had prospects limited to either working in a dependent position as a research associate in a laboratory controlled by the principal investigator, or teaching in a women's college where human and material resources for research were modest to negligible (Rossiter, 1982).

2.1. Participation

Over the century, levels of women's and men's participation in science are difficult to track precisely, because data on employment levels by gender are not available systematically over time. However, data on doctoral degrees awarded are, and they indicate the proportions of women compared to men who were professionally trained, and thus qualified for participation.

These proportions do not represent a simple, linear trend of increasing improvement

[2] See Long and Fox (1995) for a current assessment of the meaning, measurement, conditions for, and problems of "universalism and particularism" in scientific careers.

[3] Data and discussion on gender and career attainments draw from Fox (1995, 1996) and Long and Fox (1995).

[4] This chapter focuses upon doctoral-level scientists, because it is for this group that issues of research and research productivity and impact are most pertinent.

in degrees attained by women. The proportions of doctoral degrees awarded to women compared to men in the United States[5] in the 1920s (12.3%) and the 1930s (11%) are higher than the proportions in the 1940s (8.9%), the 1950s (6.7%), or even the 1960s (7.9%).[6] It was the 1970s before the proportions of doctoral degrees awarded to women (14.9%) equaled or surpassed the pre-1940 proportions. Continuing gains were made in the 1980s, and for the period 1980–1988, women earned 26% of all doctoral degrees in science (Fox, 1995, p. 206).

In 1993, women were 20% of the employed doctoral level scientists in the United States compared with 14% a decade earlier (CPST, 1997, Table 4-16). Employment of women is disproportionately low in the scientific workforce of most industrialized nations. Although less is known about participation by gender in developing countries of Africa, Latin America, and Asia, the trends show women's proportional participation to be as low or lower than in industrialized nations (Rathgeber, 1995).

With the exception of Asians, participation of U.S. ethnic and racial minorities is disproportionately low in science. In 1993, 2.1% of doctoral level scientists and engineers were African-American, 11% were Asian, 0.37% were Native American, and 2% were Hispanic (CPST, 1997, Table 4-16). Beyond their low rates of participation, relatively little is known about the conditions and experiences of racial/ethnic minorities in science. Racial and ethnic minorities have been regarded by researchers as a "statistical rarity" (Bechtel, 1989), groups for whom detailed, reliable data have been difficult to obtain and for whom inferences have been difficult to make (Cole & Cole, 1973, pp. 152–153). Few studies include racially comparative groups, and much remains to be known about the status and attainments of racial and ethnic groups in science. What we know about women as an aggregate, which of course, includes both white and nonwhite women, is much broader (Long & Fox, 1995, pp. 48–49).

As to why so few women "choose" science compared to other areas such as arts, humanities, and social services, the answer lies in a complex set of factors that are difficult to untangle. Given limitations of space and focus, these factors can only be briefly addressed. They include: (l) social constructions of what is regarded as appropriate work for women, and thus issues of social and gender identity; (2) an educational "pipeline" for science fields that starts early in life and forms a tracked and ordered sequence of study; (3) perceived barriers for women in science compared to other fields; and (4) inequitable resources and opportunities offered to women compared to men in both education for, and professional attainment in, science (Evetts, 1996; Hanson, 1996).

Beyond their rates of participation, women and men employed in science are differentiated in the fields they occupy, the places they work, and the ranks they hold, as well as their levels of research productivity, addressed in the following sections.

2.2. Fields

Between fields, the distributions of women and men are highly uneven (Table 20-1). In 1993, the vast majority (82%) of women were in three fields—life sciences, psychology,

[5] National data on scientific personnel are compiled by the National Research Council (Survey of Earned Doctorates, and Survey of Doctoral Recipients) and National Science Foundation (Survey of Graduate Students and Postdoctorates in Science and Engineering). In this chapter, data referred to are for U.S. scientists, unless otherwise indicated.

[6] Although the number of degrees awarded to women increased in post-1920 decades, the point is that the women's *proportion* of total degrees awarded *decreased.*

TABLE 20-1. Employed Doctoral Scientists and Engineers, by Field of Doctorate and Gender, 1993

Field	% Female	*N*	Men	Women
Physical science	10.0	98,530	24.0%	10.5%
Computer science	12.1	27,940	6.7	3.6
Environmental science	.7	3,850	1.0	0.4
Life science	26.3	120,730	24.1	33.9
Psychology	40.6	71,020	11.4	30.9
Social science	24.9	65,660	13.4	17.4
Engineering	4.3	75, 120	19.5	3.4
Total employed*	20.0	462,870	100.0%	100.0%

*Entries may not add to totals due to rounding.
Source: Commission on Professionals in Science and Technology. (1997). *Professional women and minorities: A total resource data compendium* (12th ed.). Washington, D. C., calculated from Table 4-11.

and social sciences. In contrast, only half of men were employed in these fields. Men were twice as likely as women to be in physical, computer, and environmental sciences, and six times more likely to be in engineering.

These distributions of women and men by field suggest nonuniform processes of selection by field (both self-selection and selection by institutions). However, the factors governing employment by field, particularly the higher proportions of women in life sciences and men in physical sciences, are not well understood (Zuckerman, 1987, p. 128). Even less is known about gender distributions by research subfield, such as new compared to established, high-growth compared to low-growth, and more theoretical (basic) compared to less theoretical (applied) areas, and the consequences of such distributions for resources acquired and impact made in science (Fox, 1995, p. 209).

2.3. Locations

Within science, women and men are employed in different sectors. As of 1993, doctoral-level women in science were more likely than men to be located in educational institutions (52% vs. 47%), and less likely to be in industry (21% vs. 33%). The higher proportion of women compared to men in educational institutions and the lower proportion in industry reflect the disparate proportions of doctoral level women and men in engineering, in particular. Compared to other fields, engineering is more likely to be practiced in the industrial sector.

Education is the predominate sector for doctoral—level scientists—and the vast preponderance (over 90%) of those in education are in higher education. Stratification in science is linked to stratification in higher education. Key here is that the activities and resources of science departments—their research projects, graduate training programs, and external funding—contribute heavily to the prestige-, revenue-, and ranking-levels of academic institutions. Universities with active research programs, strong graduate education, and external funding have the highest ranking. Those with undergraduate only programs have lower ranking, although these vary with the selectivity of admissions and credentials of the faculty. Comprehensive colleges, which evolved from teacher's colleges, have vaguer identity and lower distinction (Clark, 1987).

The data on women's and men's location within types of academic institutions are for broad classifications: universities, 4-year colleges, medical schools, and 2-year colleges. The university category, for example, is aggregated across type of institutions, except medical schools. What the data show (Table 20-2) is that in 1987 (the most recent year for which these data are available), 70% of the men were concentrated in universities (excluding medical colleges); in contrast, 57% of the women worked in these locations. Women were more apt than men to be in medical schools—21% of the women compared to 13% of the men were employed in these settings. This may reflect the concentration of women in life sciences and the fact that microbiology programs are often located in medical schools; it may also reflect the large number of low-ranking, off-track positions (instructorships, lectureships) in those settings. Few scientists were in precollege settings, but women were three times more likely than men (4% vs. 1.3%) to work in these lower-prestige institutions (Fox, 1996, pp. 269–270).

The difference in the proportion of women and men scientists working in universities, which must be considered in combination with their ranks within them, is notable because it is in universities that time, equipment, and facilities for research, and graduate students' involvement in research projects, are concentrated. These resources provide the ways and means for research performance, to be discussed subsequently.

2.4. Rank

In academia, ranks are clearly, and in most cases uniformly, specified as professorial levels and thus revealing of career attainments by gender. Because of the variable, nonuniform titles for scientists across nonacademic locations, it is difficult to determine patterns of gender and rank for these locations.

In considering academic rank, we need to look at distributions of women and men by rank—that is, the proportion of women and of men who hold levels of professorial positions in science. It is also important to consider women as a proportion of faculty at each rank. This proportion reflects women's participation or nonparticipation relative to men by rank, and the availability of women at higher ranks for matters of influence in teaching and research. Thus, while a given department may have three women, and the distribution is one woman at each rank, what is equally, or more, important as an indicator of status by gender is the proportion of faculty that women represent at each rank.

Considering first the distributions of women and men by rank, we find gender inequalities at the upper and lower ranks. Most notably, in 1993, 44% of the men compared

TABLE 20-2. Doctoral Scientists and Engineers Employed in Academe, by Type of Institution and Gender, 1987

Type of Academic Institution	% Female	*N*	Men	Women
Pre-college	41	4,019	1.3%	4.0%
Two-year college	23	5,226	2.2	2.9
Four-year college	20	31,693	13.7	15.5
Medical school	27	31,711	12.5	20.7
Other university	16	153,154	70.3	57.0
Total academe*	19	225,803	100.0%	100.0%

*Percents may not add to 100 due to rounding.
Source: National Research Council. (1991). *Women in science and engineering: Increasing their numbers in the 1990s*. Washington, D.C.: National Academy Press, Table 6.

to 17% of the women were full professors; 35% of the women were at the level of assistant professor or lower, compared to 15% of the men (CPST, 1997: calculated from Table 5-1).

Second, examining the proportion of women compared to men at each rank, the pattern is one of marked disparity by gender (Table 20-3). Across science and engineering fields, the higher the rank, the lower the proportion of women. As of 1993, women were 32% of the assistant professors, 22% of the associate professors, and 10% of the full professors. While this pattern prevails across fields, certain fields have stronger gender disparity by rank. Just as women are concentrated in three fields—life science, psychology, and social science—so correspondingly, in these fields we find higher proportions of women at each rank. In life sciences, psychology, and social sciences, women were 38%, 47%, and 32%, respectively, of assistant professors; and 28%, 33%, and 26%, respectively, of the associate professors.

However, for each field except psychology, the proportions of women at the rank of full professor are meager. In half of the field-categories—that is, in physical, mathematical, and environmental sciences and engineering—women are 6% or fewer of full professors. Only in psychology are women more than 13% of the full professors.

Despite the number of women with doctorates earned in the 1970s and 1980s and the passage of years for these women to have matured in professional terms, the proportion of women who are full professors has not kept pace with the growth of women with doctorates. In 1973, women were 4% of the full professors in science and engineering

TABLE 20-3. Doctoral Scientists and Engineers in Academic Institutions, by Field and Rank, 1993

Field	Total*	Full Professor	Associate Professor	Assistant Professor
Physical sciences	30,030	12,690	5,690	4,670
% Women		3.5	10.2	20.6
Mathematical sciences	13,832	5,827	4,407	2,328
% Women	8.6	4.6	10.2	14.8
Computer specialties	2,453	362	807	1,064
% Women	13.3	8.0	11.4	15.7
Environmental sciences	5,370	1,890	1,395	728
% Women	11.8	5.6	6.8	23.4
Life sciences	62,100	19,780	13,860	13,040
% Women	27.8	12.6	28.4	35.9
Psychology	21,395	7,695	5,200	3,987
% Women	35.8	20.5	33.4	46.5
Social sciences	41,859	16,368	12,298	8,478
% Women	23.4	11.2	26.3	32.1
Engineering	20,900	9,240	4,960	4,180
% Women	4.3	1.5	3.2	11.7
Total, all fields	190,640	72,020	45,160	38,380
% Women	21.7	9.8	21.9	32.3

*Total includes instructor/lecturer, other faculty, "does not apply," and "no report."

Source: Commission on Professionals in Science and Technology. (1997). *Professional Women and Minorities: A Total Human Resource Data Compendium* (12th ed.). Washington, D.C.: Table 5-1.

fields, in 1987, that proportion was 7%, and in 1993, still just 10%; and these figures are inflated by the numbers of women in psychology (also see Gibbons, 1992).

Even allowing up to 15 years from doctorate to full professor, women's degrees are not translating into expected rank over time. Such discrepancies are documented in chemistry, in mathematics, indeed across fields in higher education (American Statistical Association, 1993, p. 4; University of Wisconsin, 1991, p. ix; Vetter, 1992, pp. 37–38). In chemistry, for example, at doctoral-granting institutions between 1985 and 1990, women went from 11% to 18% of assistant professors; from 9% to 13% of associate professors; but only from 3% to 4% of full professors (Roscher, 1990, pp. 72–73). These proportions are to be considered against the growth in women's share of doctoral degrees awarded in chemistry: 7.7% in 1970, 11% in 1975, 17% in 1980, 20% in 1985, and 25% in 1990 (National Center for Education Statistics, 1993, Table 240; Roscher, 1990, Table 11)—and the maturation of the cohorts over the period.

These data on gender and rank and those on discrepancy between the availability of women with doctorates and rank over time do not control for research productivity. Studies that do, however, indicate that academic rank may be the area of greatest gender disparity in scientific career attainments. Accordingly, Cole (1979) found that for scientists at each productivity level considered, men had higher average rank than women. This held for scientists in institutions at varying levels of prestige. Further, with a sample of biochemists who received Ph.D.s between 1956 and 1967, Long, Allison, and McGinnis (1993) found that rates of promotion from assistant to associate to full professor were lower and slower for women than for men. Being in a prestigious department delays promotion for both genders, but the effect is stronger for women. In addition, in their study of recipients of prestigious postdoctoral fellowships between 1955 and 1986, Sonnert and Holton (1995a) found that women's lower rank cannot be explained by their lower productivity, because women's rank is lower at each level of productivity. The disadvantage in rank for women was concentrated in fields outside of biology, that is, in physical sciences, mathematics, and engineering. This highlights again the issue of gender patterns by field in science.

2.5. Research Productivity

Research productivity refers to actual *outcomes* of research—in basic science—publications. Publication productivity is not strictly equivalent to research productivity, but the one (publication) is an indicator of the other (research). No guarantee exists that a big producer of publications makes a significant contribution or that a given nonpublisher makes no contribution. However, in the aggregate, the correlation is high between quantity of publications and impact, assessed through awards and recognition in science (see Blume & Sinclair, 1973; Cole & Cole, 1973; Gaston, 1978).

In the analysis of gender and career attainments in science, publication productivity is important for three reasons. First, publication is an important social process of science, because it is through publication that research findings are communicated and verified, and that priority of work is established (see Fox, 1983). Second, and accordingly, until we understand productivity differences, we cannot adequately assess other gender differences in location, rank, and rewards, because they are related to—although not wholly explained by—productivity (Fox, 1991). Third, as discussed in the Introduction, the "ethos of science" is that "merit governs rewards in science," and that factors such as gender and race are illegitimate determinants. Because publication is a indicator of merit in and contributions to science, it is important in assessing whether science abides by or abrogates its manifest value-system. The extent to which science is "universalistic," with contributions to knowledge governing rewards, or "particularistic," with personal factors, such as race and gender, accounting for rewards, has probably been the most widely debated issue in the sociology of science (Cole, 1992: Long & Fox, 1995; Zuckerman, 1988).

What do we know about the publication productivity of women and men? First, as described in Fox (1995), numbers of studies indicate that women publish less than men. Across fields, women publish about half as much as men in a given period. Over a 12-year period, across the fields of chemistry, biology, psychology, and sociology, Cole (1979) reports that the median number of papers published was eight for men and three for women. In a sample of women and men scientists matched by field and year of Ph.D., as well as doctoral department, Cole and Zuckerman (1984) found that women published 6.4 papers, compared to 11.2 for men. Although particular levels of gender difference vary by field, women are found to publish significantly fewer papers than men in chemistry (Reskin, 1978), biochemistry (Long et al., 1993), ecology (Primack & O'Leary, 1989), and psychology (Helmreich, Spence, Beane, Lucker, & Matthews, 1980), as well as four social science fields (Fox, 1995). For biological and social sciences, the gap between women's and men's number of publications has been narrowing more recently (Sonnert & Holton, 1995a; Ward & Grant, 1995).

Second, while women and men publish at different rates, the distribution for both is strongly skewed: low, even null, performance is most frequent, and high, or even moderate, performance is rare (Fox, 1995). To put it differently, the distribution of productivity is such that most work is produced by a few, while the majority publish little (Cole & Zuckerman, 1984). This pattern of highly variable and strongly skewed productivity, documented nearly 75 years ago in Lotka's (1926) analysis of physics journals, is characteristic of both men and women in science.

Publication productivity is both cause *and* effect of gender disparity in career attainments. That is, it both reflects women's depressed rank and prestige of institutional locations, and it partially accounts for that status (Fox, 1991). "Partially" is the key term: holding constant levels of publication productivity, women's attainments in science, especially rank, remain lower than men's, as discussed previously. Although understanding is incomplete of the processes leading to gender disparity in career attainments, the evidence is that "universalism falters in science" and that "women are less able to translate their productivity into resources and recognition" (Long & Fox, 1995, p. 68).

3. GENDER, HIERARCHY, AND KNOWLEDGE IN SCIENCE

In positivist[7] tradition, the scientist is depicted as a "model of impartiality, a passive observer, collector and collator of natural facts, someone whose activities [are] unsullied by personal bias or emotion, unscarred by political and religious standing, or by cultural values . . . " (Benjamin, 1991, p. 6). In such representations, science is "other-worldly"—disembodied, extrasocial, culturally neutral, governed by it own internal logic and coherence.

[7] The essence of positivism is its tenet that the content of science is determined by "reality" or "facts."

In the 1970s, a sociology of scientific knowledge, developed in Europe, countered the positivist view that science merely reveals nature, with scientists acting as neutral agents or mediators. The work of Barnes (1974), Bloor (1976), and Mulkay (1979), for example, emphasizes ways in which social, political, and economic interests of particular groups construct scientific findings and generalizations. Sociologists of scientific knowledge have been slower to point to ways in which science and technology reflect and reinforce the interests of—and systems based upon dominance by—gender (Harding, 1983).

A feminist analysis, which asserts that "evidence is a question of interpretation, and theories are accounts of and for specific kinds of lives," including those of women and of men (Harraway, 1989, p. 8), has *popular* roots in the women's health movement of the late 1960s and early 1970s, and classic volumes associated with it (Boston Women's Health Collective, 1971/1976; Ehrenreich & English, 1973). The women's health movement has challenged scientific medical knowledge, as produced by men and applied to women; knowledge that has been thought to define women in ways that supported female subordination and inferiority. More specifically, the movement has challenged a "sexual politics of sickness and health," that constructed women as "weak, dependent, and diseased," female functions of menstruation, pregnancy, and childbirth as "pathologies," and menopause as "terminal illness," "the death of the woman in the woman" (Ehrenreich & English, 1978, pp. 92–100). Parallel critiques have posed correspondence between women's subordination and the domination of "nature," that is, land and earth as feminine entities, subject to exploitation and control by men (Kolodny, 1975; Merchant, 1980; Ortner, 1972).

With this feminist analysis of medicine in particular, critical "floodgates" opened:

> If medical knowledge—as one form of scientific knowledge—was patriarchal, then what about the rest of science, in which men were similarly dominant? What about other forms of systemic knowledge? Was the whole intellectual realm gender-biased? Was there more than one kind of rationality? Was there a 'male' and a 'female' rationality? Or was 'rationality' itself a tainted concept denoting a blinkered and limited approach to understanding the human condition? (McNeil, 1987, pp. 29–30)

The critique of medicine has encouraged resistance to other knowledge and expertise as power relations between men and women. This has included challenge to dogmas of psychiatry: theories and concepts such as "female masochism," female achievement as "castrating" and "unwomanly drives to power," and of periodic maternal absence as "deprivation of children." Further, speculation has arisen about the ways in which gender may shape the meaning of scientific knowledge more broadly—the ways in which scientific questions are framed, data interpreted, and applications made.

These considerations of mind, nature, and masculinity (Fox, 1986) are represented especially in the work of Evelyn Fox Keller (1985, 1995, and elsewhere), who maintains that science is inherently masculine in character, not just male dominated in numbers. The consequence, Keller argues, is not simply an exclusion of women, but a schism between masculine and feminine, subjective and objective, understanding and control. She argues, for example, that the tension between scientific explanations that stress hierarchies and unidirectional causal paths and those that stress multiple interactions and multidirectional pathways stem from different and gendered views of nature, domination, and control (Keller, 1985).

Analyses of gender and scientific knowledge have flourished at a philosophical level (although not at an empirical level), and have been the basis for theorizing about the possibility of a more diverse—including a feminist—science. What might such science look like, and how would it be practiced? Would a different agenda of problems or methods be pursued? What values might prevail?

Keller's (1983) biography of geneticist, Barbara McClintock, portrays a struggle between ideology and practice in the production and interpretation of science. In doing so, it depicts the science of a woman who was a theoretical and methodological maverick in genetics. McClintock challenged the "master molecule theory" of genetic control within a hierarchical organization. She integrated (rather than divided) subject and self in scientific investigation, and respected "difference" in the organism (maize) rather than aiming for a cosmic unity of control. McClintock offered a different view of nature, a view of subject and object that were outside the mainstream and, Keller argues, outside of gender-defined definitions and boundaries. After being largely underappreciated, McClintock was awarded a Nobel Prize in her 80s for work she had began 40 years earlier.

In interviews with women and men scientists, few report that they believe a "male" or "female" scientific method or orientation operates (as in profiles in Sonnert & Holton, 1995b and Zuckerman et al., 1991). However, in systematic case studies, a pattern of gendered *behavioral practice* is perceived by the scientists interviewed and observed by the investigators, Sonnert and Holton (1995b): "women are more cautious and careful in their methods and pay more attention to detail" (p. 152). This tendency is a response to the conditions experienced, with women reporting the need to "prove themselves," "avoid failure and criticism," "be meticulous," "do more comprehensive work" (pp. 152–153). This suggests that women have—and take—less latitude with error or mistakes in their work. Such practices are consistent with women's lower rate of publication productivity, and also with women's citation rates, which, *per article*, are as high or higher than men's (Sonnert & Holton, 1995b; p. 153; see also Long, 1992). Compared to men, the pattern for women may be "lower quantity and higher quality."

Critiques of medicine and biology have maintained that in studying certain subjects, particularly bodies, health, and sickness, male scientists reveal themselves as much as "men" as "scientists" (McNeil, 1987, p. 31). Meanings of gender and gender hierarchies are reflected in this knowledge, and in turn, the scientific knowledge reifies patterns of male superordination and female subordination. It is less clear how such meanings may operate outside of life sciences, in areas of chemistry and physics, for example. Further, although speculation has flourished about the possibilities of diverse, including feminist, science, the inquiry has been at a philosophical level, and empirical studies have been few. Case studies, such as Sonnert's and Holton's, are useful is disclosing how gender influences modes of scientific behavior. As to whether gender influences theories of the natural and physical world and patterns and approaches of inquiry remains an ongoing question.

4. SUMMARY AND CONCLUSION

Science is an institutional medium of power that connects with central social institutions, particularly education and the state, and is marked by immense inequality in status and rewards. It is a fundamentally hierarchical institution, and its valued attributes of rationality and control have been more ascribed to men than to women. Science represents a strategic site for study of gender in hierarchical context—and in summary, it reflects and supports gender stratification in these ways:

1. Science is disproportionately done by men, and moreover, controlled by men. Compared to women, men are more likely to be located in universities than in four year colleges; to be in more powerful fields—physical, mathematical, environmental, and computer sciences and engineering[8]; to hold high rank; and to experience higher levels of research productivity, as both cause and effect of their status. Thus, gender shapes participation, location, rank, and performance in science.
2. Because science is a source of power and is characterized by such gender divisions and hierarchies in participation, location, rank, and productivity, it *exemplifies* gendered relations. Owing to its powerful domains, science not only reflects, but also serves to *expand* gender stratification in society.
3. Historically, in areas of medicine and biology, especially, science has defined women in ways that have supported female subordination and inferiority and male superordination—and has done so from a position of "authoritative knowledge." In this way, science has been an agent in constructing and supporting hierarchical definitions of gender.
4. The extent to which gender shapes the content and methods of science, including the ways in which questions are framed, approaches are taken, and interpretations are formed, remains open to inquiry. If the authority of a dominant scientific culture defines the cognitive content of science, and if that authority is gender-specific, then the connection between gender and science will prove to be yet more profound than analyzed here.

In conclusion, it is notable that research, policy, and practice on issues of women and men in science have focused frequently upon "increasing the numbers of women in science" (Fox, 1998). Gender disparity in participation is a complex issue, and a justifiable concern for reasons of utilization of underrepresented groups as human resources, and for social equity. However, increasing numbers of women will not necessarily change patterns of gender and hierarchy in science.

Women have long been present in science, although not in valued, highly rewarded, or even visible roles. Accounts have documented how the contributions of both outstanding and little-known women scientists have been marginalized, misunderstood, or miscredited to others (see, particularly, Rossiter, 1982; Sayre, 1975). Further and relatedly, for science as for other professions, the relationship between gender, education, and status is complex—not a simple matter of increasing education and increasing social and economic status. We have seen that the proportion of women who are full professors has not kept pace with the growth in the number of women with doctorates in science, and that women's educational attainments do not translate into career attainments, especially advancement in rank, on a par with men's. The idea of education, by itself, as emblematic of progress for women in science is questionable (Fox, 1996, p. 278).

In addition, to the extent that increasing numbers of women are present in science but hide their "difference," gender neutrality, and, in turn, a hidden "male norm," are likely to prevail (Cockburn & Furst-Dilic, 1994). For example, if women attempt to conceal, obscure, and "overcome" certain observed (Sonnert & Holton, 1995b) behavioral styles, such as tendencies to confirm and integrate research findings before releasing

[8] However, women are disaproportionately located in life sciences, fields that have flourished in the past three decades.

them for publication, the pattern of proliferation of fragmented pieces of published work may continue to constitute an unchallenged standard for scientific productivity.[9] It is not the mere "difference" in any style that is critical, or that men and women in science differ widely in their practices. Rather, what is important is the power to determine and maintain what is a valued standard and what is not, and the adherence of groups to such designated standards.

In science, as in any other institution, some groups benefit from existing arrangements, and others do not. Men in science have been more likely than women to benefit in institutional locations, rank, promotion, and access to human and material resources, as well as a culture and climate that reflects their understandings and interests. Because there are beneficiaries, strong incentives exist to preserve current arrangements. These include arrangements such as autonomy of the advisor in relationships with students; relatively nonsystematic criteria in hiring, promotion, and allocation of rewards; and limited accountability in evaluation of students and faculty (see Fox, 1998). Such organizational arrangements have advantages for the institution: they enable flexible and rapid response to problems by individual groups, for example (Harrison, 1994). However, the same factors (individual autonomy, nonsystematic processes, limited accountability) have also been found to activate "particularistic considerations"—bias in the allocation of rewards on the basis of "social similarity" (including race and gender) to those who currently dominate[10] (see Fox, 1991; Long & Fox, 1995, pp. 62–64).

The prevailing focus and attention upon "increasing numbers of women in science" are understandable. Increasing the presence of women, and other underrepresented groups such as African-Americans and Hispanics, can occur without changing the conditions of work or the current distribution of power in science. The challenge ahead is not simply an attempt to increase the flow of women through the proverbial "scientific pipeline" and fit them to existing structures. Rather, it is to better understand—and possibly be so bold as to modify—gendered hierarchy, practices, and processes, and their consequences for scientific organizations, occupations, and institutions.

Acknowledgments

I thank Janet S. Chafetz and Donna Hughes for their reading of, and comments on, this chapter.

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[9] It should be noted that federal funding agencies have taken steps to discourage over-proliferation of fragmented work by limiting, in grant proposals, the listing of principal investigators' publications to their most relevant papers.

[10] Particularistic considerations are more likely to operate in fields with low, compared to high, consensus about research issues, methods, and course curricula. Consensus is lower in social—compared to natural, physical, biological, mathematical, and engineering—sciences. In turn, particularistic variables account more for outcomes in careers (Hargens & Hagstrom, 1982), in editorial policies and practices (Beyer, 1978; Yoels, 1974), and allocation of grants (Pfeffer, Salanick, & Leblebici, 1976) in social sciences. These (cited) studies of consensus and outcomes, however, have not focused upon particularistic factors of race and gender, but rather upon those of personal ties and networks.

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