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SCIENTIFIC CAREERS: Universalism and Particularism[1]

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Abstract

Science is an institution with immense inequality in career attainments. Women and most minorities, as groups, have lower levels of participation, position, productivity, and recognition than do white men. Research in the sociology of science has focused on the degree to which different outcomes have resulted from universalistic and from particularistic processes. In this paper we 1) depict the career attainments of women and minorities in science, 2) consider the meaning and measurement of universalism compared to particularism, 3) analyze the causes of differential attainment with a view to assessing evidence for violations of universalism, 4) propose conditions under which particularism is likely to occur, and 5) consider methodological problems that affect this research.

INTRODUCTION

In a theory of the normative structure of science developed over 50 years ago, Robert Merton ([1942] 1973) argued that the institution of science has an ethos consisting of the norms of universalism, communism, disinterestedness, and organized skepticism. A substantial body of research in the sociology of science has involved an assessment of the operation of universalistic standards

[1]The ordering of the authors has no particular meaning, except that the first author was initially invited to undertake this article.

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in processes of stratification in science (Zuckerman 1988:515–19). As a precept of science, universalism entails two related requirements. First, universalism requires that when a scientist offers a contribution to scientific knowledge, the community's assessment of the validity of that claim should not be influenced by personal or social attributes of the scientist and should be subject to "pre-established impersonal criteria" (Merton [1942] 1973:270). Second, universalism requires that a scientist be fairly rewarded for contributions to the body of scientific knowledge. This is summarized nicely in Merton's phrase that "careers should be open to talent" (Merton [1942] 1973:272). Particularism, in contrast, involves the use of functionally irrelevant characteristics, such as sex and race, as a basis for making claims and gaining rewards in science.[2]

Science has been both characterized as the most universalistic of institutions (Cole & Cole 1973:89, 122; Cole 1979:4; Gaston 1978) and debated as an institution in which universalistic standards falter and fall short (e.g. Mitroff 1974, Mulkay 1976; see Cole 1992:157–76 for a review of the debate). While debate persists about the scientific community's adherence to Merton's ethos of science, it is unquestionably true that science is an institution in which immense inequality exists in career attainments (Zuckerman 1988:526–27). The fundamental link between the ethos of science and inequality in science is seen in the distinction between inequality and inequity. To what extent is the inequality in science equitable or inequitable? To what extent can the inequality be explained by normatively justifiable, universalistic characteristics as opposed to unjustifiable particularistic characteristics.[2] In this way, stratification has been regarded as a "strategic starting point" (Cole & Cole 1973:15) for inquiry into the social system of science. Moreover, we suggest that understanding the differences in attainments across underrepresented groups in science such as women, blacks, and Hispanics is critical for understanding stratification in science. On another level, understanding stratification in science by sex and race/ethnicity is important for addressing the underutilization of these increasingly important groups.

In this paper, we: 1) depict the career attainments of women and minorities

[2]In Parsons & Shils's (1951) delineation of universalism versus particularism as modes characterizing social relations, they distinguish not only between universalism (relations governed by uniform terms) and particularism (relations governed by particular properties) but also between ascription (priority given to attributes of parties) and achievement (priority given to actual or expected performance of parties). However, in Merton's theory of the normative structure of science and in subsequent work that supports or criticizes his model of the ethos of science, 1) universalistic and achievement standards and 2) particularistic and ascriptive standards tend to be grouped into two categories, rather than the four of Parsons & Shils's paradigm. This occurs since many of the most important attributes leading to particularism, for example, race and sex, are also ascribed characteristics.

in science; 2) consider the meaning and measurement of universalism in comparison with particularism; 3) analyze the causes of differential attainment with a view toward assessing evidence for violations of universalism; 4) propose conditions under which particularism is likely to occur; and 5) consider methodological problems that affect this research area.

DIFFERENTIAL ATTAINMENT IN SCIENTIFIC CAREERS

Scientific occupations are among the most prestigious in American society. The Nakao-Treas prestige scale for the 1980 census classification of occupations assigns a score of 73 to physical and biological scientists, a score exceeded only by 74 for lawyers and 86 for physicians (Nakao & Treas forthcoming). Yet within science, as in certain other occupations such as law (Epstein 1986), a complex hierarchy exists allowing for great variation in career attainments. The focus of this section is on variation in attainments by sex and race, as a first step in assessing the processes by which attainments are allocated.

Four dimensions of career attainments are considered: participation, position, productivity, and recognition. Participation refers to employment in science and engineering (hereafter, S/E), with advanced degrees usually a prerequisite to employment. Position refers to organizational location and to rank within organizations. Productivity includes contributions to scientific knowledge, most commonly examined through publications. Recognition refers to acknowledgment by the scientific community for contributions and achievements, with examples ranging from citing a published paper to bestowing honorific awards as prestigious as the Nobel prize. Substantial inequality exists in the distribution of each of these dimensions of career attainment, with women and minorities as groups found at the lower end of each distribution.

Participation

In 1991, 18% of the employed doctoral level scientists and engineers in the United States were women (CPST 1994: Table 4-11), compared with 12% a decade earlier. Although data are not available on the scientific employment of women over the century, data on doctoral degrees obtained are. These data are not fully comparable to those of participation, since prior to World War II the employment prospects in science for doctoral women were limited; women with doctorates were often unemployed. However, data on degrees do indicate the proportion of women who could participate in science.[3]

The trend in women's attainment of doctoral degrees is not one of consistent improvement. In the 1920s, women made up 12% of the PhDs in S/E. From

[3]Hereafter, the term "scientist" will refer solely to doctoral level scientists.

the 1920s to the 1950s there was a steady erosion, with the proportion of degrees awarded to women reaching a low of 6.7% in the 1950s and rebounding only slightly to 7.9% in the 1960s[4] (CPST 1989: Table 2-1). The climate of the 1950s is reflected in Keller's account of the "dark times" faced by women in science (1991:230). She notes that in 1956 MIT convened a committee to consider whether to continue admitting women students—the recommendation was that coeducation be terminated. It was not until the 1970s that the proportion of doctoral degrees earned by women reached 15%, finally exceeding the proportion in the 1920s. Continuing gains were made during the 1980s, so that from 1980 to 1988, women earned 26% of the PhDs in S/E (CPST 1989: Table 2-1).

Despite increasing proportions of degrees awarded to women, the employment of women is highly uneven across fields. As of 1991, 84% of doctoral women in S/E were employed in the life sciences, psychology, and social sciences. In contrast, half of the men were employed in these three areas. Men are twice as likely as women to be in physical, mathematical, and environmental sciences and in computer information sciences,[5] and nearly seven times more likely to be in engineering (National Science Foundation, 1991 Survey of Doctoral Recipients, unpublished data).

With the exception of Asians, nonwhite racial and ethnic groups are also underrepresented among employed doctoral level scientists and engineers. In 1973, 0.9% of employed scientists and engineers were black, 4.3% were Asian, and 92% were white (National Science Foundation, 1991 Survey of Doctoral Recipients, unpublished data).

Minority participation has increased over the past two decades. In 1991, 2.2% of doctoral level scientists and engineers were black, 1.9% were Hispanic, 10.2% were Asian, and 0.2% were Native American, while the 86.9% majority were white (CPST 1994: Table 4-9). It is important to recognize that Asians and Hispanics are not a homogeneous category. The participation of some groups (e.g. Japanese) may be relatively high, while that of other groups (e.g. Vietnamese) is not. Further, participation in science and engineering of native-born Asian Americans as opposed to immigrants is an issue that has just begun to be addressed (Tang 1993).

Beyond their limited participation, little is known about racial and ethnic minorities in science.[6] Researchers have regarded minorities in science as a

[4]While as noted by Cole (1979:205), the *number* of doctorates awarded to women at mid-century increased over the number awarded in the 1920s and 1930s, the critical point is that the *proportion* of female doctorates in SIE *decreased.*

[5]In 1989, 19,797 employed scientists were classified in computer science. As a result of a change in definition of computer science in the 1991 Survey of Doctoral Recipients, the number was reduced to 5376.

[6]Hereafter, the term "minorities" will be used to refer to racial and ethnic minorities.

"statistical rarity" (Bechtel 1989). As such, minorities are groups for whom detailed, reliable data have been difficult to locate and for whom inferences have been difficult to make (Cole & Cole 1973:152–53). Studies of minority scientists require oversampling to ensure sufficient numbers for analyses. Drawing samples of minorities is difficult, however, because often their minority status cannot be determined by name alone. Consequently, rosters of scientists from professional societies or dissertation abstracting services cannot be used. Drawing samples of minorities often requires data from the National Research Council's Survey of Doctoral Recipients or data from minority caucuses within disciplines (Rosenfeld 1991:41). Not surprisingly, few studies of scientists include racially comparative samples. As Pearson put it: "Despite more than a century of participation by Blacks in the professional scientific community, sociologists of science have neglected the study of Black American scientists. As a result, our knowledge of Black American scientists remains very sketchy" (1988:205). Information on women (which may of course include minority women) is far more common than for racial minorities, a point reflected in the content of this paper.

Particularly for certain minorities but also for women, levels of participation are the result of "successive filtering" (Zuckerman & Cole 1975:83). At each stage of education, the percentage of most minority students steadily erodes, so that their participation in science is substantially below parity. The underrepresentation of blacks has been attributed in part to educational attrition, which is in turn related to a lack of financial aid and perceptions of poor job prospects (Fechter 1989). Switching out of science fields into nonscientific fields for the doctorate is another form of attrition. Among a 1973-1974 cohort of doctoral recipients who had undergraduate majors in the life sciences, 50% of the blacks compared with 80% of the whites earned their doctorate in the life sciences (National Board on Graduate Education 1976, cited in Pearson 1988).

Further, receipt of a doctorate in S/E does not imply *full participation* in these fields. Historically, blacks with doctorates in science were forced to teach in high schools or in black colleges, where libraries, laboratories, and opportunities for training students were limited (Bechtel 1989). Prior to World War II, women with science doctorates faced restricted employment either as faculty in women's colleges or as research associates in university laboratories (Rossiter 1982), where they represented a "good investment" as skilled, low-cost laborers who were grateful for the work (Fox 1991). Disproportionately often, women and blacks with doctoral degrees in science found no scientific employment (Bechtel 1989, Rossiter 1982).

Unemployment is no longer a frequent condition for underrepresented groups in science. Vetter (1981) recorded that nearly 90% of women with doctoral degrees in S/E were in the labor force at any given time. Still, unemployment is more common for women. In 1991, unemployment of scientists was twice as likely for women (2.2%) as for men (1.3%). The disparity is largest for physical scientists among whom 4.2% of the women compared with 1.7% of the men are unemployed, and for environmental scientists among whom 3.2% of the women compared with .8% of the men are unemployed. The disparity is smallest for computer scientists, among whom 1.6% of the women and 1.4% of the men are unemployed (National Science Foundation, 1991 Survey of Doctoral Recipients, unpublished data). While it is presumed that career interruptions such as unemployment affect the research productivity of scientists (Rosenfeld 1991:21), little is known about the causes of interruptions and the way in which interruptions affect women and minorities.

Position

Organizational location and rank are two aspects of position that reveal differential attainment. First, men and women work in different sectors. As of 1991, women were less likely than men to be employed in industry (29% vs 38%), more likely to be in hospitals and nonprofit organizations (11% vs 6%), slightly less likely to be in government or the military (5% vs 7%), and somewhat more likely to be in educational institutions (51% vs 46%) (National Science Foundation, 1991 Survey of Doctoral Recipients, unpublished data). The higher proportion of women in educational institutions and the lower proportion of women in industry partly reflect the larger proportions of men in engineering, where employment is more likely to be in the industrial sector. If we exclude engineers, 29% of the women and 33% of the men are in industry, while 52% of the women and 49% of the men are in educational institutions.

Education remains the predominate sector of employment for scientists and engineers, and 95% of those in education are in higher education. Academia is central to science and has even been characterized as the "home of science" (Wolfle 1972). This is not just because of the large proportion of scientists employed in academia, but also because of the research and training functions concentrated there. The evolution of science and the evolution of higher education have been reciprocal developments in the United States (MF Fox, forthcoming). Consequently, much of the research and focus of this paper is on academic scientists.

Stratification in science reflects and connects with stratification in academia, particularly in the ranking of institutions. American higher education is not just diverse in its missions and clienteles (Bowen & Schuster 1986); it is also ranked according to its tasks and jurisdictions (Clark 1987). This is reflected in broad classifications of institutions. Research universities that have active research programs, federally funded research projects, and graduate training programs have the highest rankings. Institutions with largely undergraduate enrollments have lower rankings, although this varies with the selectivity of admissions and the quality of the faculty. Comprehensive colleges evolved from teachers colleges into a mixed state in which they are no longer an education school and not really a university. They often suffer from vague identity and low distinction (Clark 1987:115).

In general, the less prestigious the type of institution, the more likely it is to employ women and minorities. The proportions of women and blacks are lower in research universities, and higher in comprehensive and in liberal arts colleges (CPST 1994: Table 5-15). The pattern of lower proportions of women and blacks in universities merits attention because it is in these institutions that human and material resources are available to support research with equipment, libraries, graduate student assistantships, and collaborators. These resources in turn affect research productivity and ultimately scientific stature. For Hispanics, the configuration is not as clear, because virtually no Hispanics in these S/E fields teach in liberal arts colleges (CPST 1994: Table 5-15).

Within institutions of the same type, women and minorities have different types of academic appointments. Academic rank is a telling indicator of position in academia.

Minorities and particularly women in SIE are underrepresented among tenured faculty and overrepresented among non-tenure track faculty. Moreover, the higher the rank, the lower the proportion of women: as of 1991, women were 8.7% of the full professors, 20.9% of the associate professors, and 29.1% of the assistant professors. In the subprofessorial positions of instructor and lecturer, which usually do not have the possibility of tenure, women were almost half (43%) of the faculty (CPST 1994:Table 5-1). As we shall see, the higher proportions of women at lower ranks are not a simple function of low seniority or research productivity.

Productivity

While research productivity is not strictly equivalent to publication productivity, publication is generally taken as an indication of research (Fox 1983, 1992). In the analysis of scientific careers, publication productivity is important for two reasons. First, publication is the central social process of science. It is the way in which research is communicated, exchanged, and verified (Hagstrom 1965, Merton [1968] 1973). Second, until we understand the differences in productivity between groups by race or sex, we cannot adequately assess other differences between groups in attainments such as position and recognition (Fox 1991). To the extent that science is universalistic, attainments should be allocated on the basis of contributions to scientific knowledge, which are reflected in publication productivity.

Productivity in science is highly skewed. Most work is published by a few, while the majority publish little or nothing (Price 1963:42–44). The distribution of publication productivity is such that about 15% of the scientists account for

50% of the publications. This persistent pattern repeats across fields and applies to both women and men. It is found in chemistry (Reskin 1977), biochemistry (Long 1992), various natural and social sciences (Cole 1979), social scientists in four fields (Fox 1994), and scientists in six fields (Cole & Zuckerman 1984).

While a small prolific group of scientists accounts for a large proportion of published work, as a group women publish fewer papers than men, for reasons that are discussed below in the section on causes. Over a 12-year period, the median number of papers published by male scientists in chemistry, biology, psychology, and sociology was 8, compared with 3 for women (Cole 1979). Among scientists in six fields who were matched for year of PhD and doctoral department, women published half as many papers as men did (Cole & Zuckerman 1984). Among psychologists, men are significantly more productive than women, publishing 1.7 compared with 0.7 papers in a three-year period (Helmreich et al 1980). Women ecologists published 47% as many papers as men in their field (Primack & O'Leary 1989). In biochemistry, slight sex differences in productivity at receipt of the doctorate increased over the first decade and gradually lessened in later years (Long 1992). For chemists, however, Reskin (1978a) reports small differences. Likewise, among social scientists in four fields, Fox (1994) found small but significant differences in a three-year article count, with 2.25 articles for women and 2.5 for men. Recent data on social scientists and biologists point to convergence in publication levels for men and women (Ward & Grant 1995).

The only study of differences in productivity levels among racial groups is Pearson (1985). He reports that in the physical, biological, and social sciences blacks publish less than whites across their career and in the five years prior to the study, with racial differences being small in the period prior to receipt of the degree.

Recognition

Recognition by peers is an important indication of a scientist's contributions to the advancement of science. Recognition serves as a reward for past performance and an inducement for future performance, and in this sense it is important as a reinforcement for valued activity (Merton [1968] 1973, Hagstrom 1965:12, 21). Citations to a scientist's research are an important, albeit imperfect, measure of recognition (Zuckerman 1988:526–27). The distribution of citations is even more skewed than for publications. Of the authors in *Science Citation Index* (*SCI*) who were cited at all between 1961 and 1980, over two decades 62% were cited no more than five times, only 6% were cited as many as 100 times, and a mere 1% were cited 500 times or more (ISI 1981, cited in Zuckerman 1988:527). Out of 3.9 million articles cited in SCI in 1979, 70% were cited only once, while a mere 0.009% were cited more than 100 times (Garfield 1981)

Citations are highly correlated with publications, with reported correlations ranging from 0.63 to 0.93 (Reskin 1979, Cole & Cole 1973:121, Long 1992). While much less information exists on sex differences in citations than in publications, the evidence suggests that men and women are more similar in citations than publications (Cole & Zuckerman 1984, Long 1992). The explanation appears to be that while woman publish less, they receive more citations to each individual paper.

We know of only one study that includes citation levels by race. In this study, Pearson (1985) reports that whites have higher citation levels than blacks among physical, biological, and social scientists.

Awards in science also go to few, while the majority remain unrecognized. Among physicists, only 15% have received an award other than a postdoctoral fellowship, and 11% of the physicists received 70% of all awards (Cole & Cole 1973). At the top of the pyramid of awards, recognition is a rare event. In 1994, out of 367,440 employed scientists (excluding engineers), 0.6% have been elected to the National Academy of Science, and 95% of the members are men (National Research Council, unpublished data).

While there are female and minority scientists who have been extraordinarily successful, women and minorities as groups are less successful than white men on all dimensions that characterize participation and achievement in science. The fact of inequality demands explanations of the processes generating the inequality. In assessing these processes, the meaning and measurement of universalism, particularism, and discrimination are essential.

UNIVERSALISM, PARTICULARISM, AND ASSESSING DISCRIMINATION

Universalism dictates that the allocation of rewards and resources should be based solely on the merits of a scientist's contribution to the advancement of scientific knowledge. These contributions can occur directly through the publication of new research or indirectly through performance as a teacher or administrator (Zuckerman & Merton 1973 [1972]). In contrast, particularism involves the consideration of functionally irrelevant characteristics such as race or sex in the allocation of resources and rewards. To the degree that race and sex affect the allocation independently of scientific contributions, discrimination occurs.

In the late 1960s and 1970s, a substantial body of research developed to examine how universalism and particularism operate in the scientific career (Allison & Stewart 1974, Crane 1965, Gaston 1978, Hagstrom 1971, Hargens 1969, Hargens & Hagstrom 1967, Long 1978, Zuckerman 1977). The most ambitious example of this research is found in Cole & Cole's (1973) *Social Stratification in Science*. This research assessing universalism combined Merton's functionalism with Price's (1963) work on the distribution of productivity, as well as the emerging field of bibliometrics that benefited from Garfield's development of SCI. The assessment of universalism was heavily influenced by the status attainment approach found in Blau & Duncan's landmark study *The American Occupational Structure* (1967) and Duncan's article "Inheritance of Poverty or Inheritance of Race?" (1968). This approach assessed the influence of ascribed characteristics, such as race, and achieved characteristics, such as education, on occupational attainment.

When applied to science, the general strategy is to examine the relationship between achieved and ascribed statuses and outcomes such as prestige of employment, productivity, and academic rank. To the extent that ascribed statuses such as race and sex explain outcomes *after controlling* for performance, particularism is said to operate and discrimination occurs. In evaluating this research, four issues of meaning and measurement are critical.

Outcomes versus Processes

Sex or race differences in outcomes are not necessarily evidence of discrimination (Zuckerman 1970:241), nor are similarities of outcomes necessarily evidence of a lack of discrimination. Differential outcomes can be generated by both universalistic and particularistic processes, a point discussed by Cole & Fiorentine (1991). For example, women or minorities may on average receive less prestigious jobs because they are less productive. This would be a universalistic process. Or, women or minorities may receive less prestigious jobs than white men with equal productivity as a result of discrimination, which would be a particularistic process. Of course, both universalistic and particularistic process may be operating simultaneously. Alternatively, if there were no sex or race differences in the average prestige of first jobs, it would be premature to conclude that there was no discrimination since woman and minorities could be more productive than white men.

Appropriate Controls

The primary means for quantitatively assessing discrimination is referred to as "sophisticated residualism" (Cole 1979:29), an approach detailed by Duncan (1968). Discrimination is indicated by sex and race differences in recognition, for example, after controlling for the levels of *relevant* independent variables. Residualism depends critically on the variables that are being controlled. Different specifications of controls can result in different conclusions. Failure to control for the appropriate variables can lead to false positives and false negatives. For example, models for the prestige of the first job that exclude productivity may overestimate the negative effect of being a woman since women on average have lower productivity.

The Career as a Life Course

The career should be viewed as a series of processes with assessments of discrimination applied to each process. Life course analysis argues that the career should be studied as a series of linked events occurring over time within specific contexts. This rich and emerging approach, which has been championed by Elder (1978, 1992), offers critical insights into how the career should be studied and hence on how discrimination can be assessed. To focus on any specific outcome in the career without consideration of the prior processes leading to it can be misleading. For example, if no sex or race differences are found in election to the National Academy of Sciences after controlling for scientific productivity, we might conclude that no discrimination exists in the allocation of this award. However, this conclusion could be misleading. It is possible that the process by which resources are allocated to support productivity favor white men and disadvantage women and minorities. These processes of relative advantage may be responsible for the overrepresentation of white men in the Academy.

Uniform Costs and Differential Returns

Discrimination can most simply be indicated statistically as the effects of sex or race after controlling for relevant variables. In most types of analysis the effects of sex or race are introduced by dummy variables indicating group membership. The coefficients for these variables indicate uniform costs to all members of a group. For example, consider a model explaining the prestige of the first job. A negative coefficient for a dummy variable indicating that the scientist is a women would indicate the cost of being a woman after controlling for other variables. This cost is uniform in the sense that it is the same regardless of the levels of any other variables in the model. Discrimination can also be indicated by sex or race differences in the way in which contributions to science are translated into rewards or resources. To continue our example, discrimination can also be indicated by sex or race differences in the coefficients for productivity. If the slope coefficient for productivity is smaller for women or minorities than white men, women or minorities would be penalized by receiving a smaller return for their contributions. We return to this point in our discussion of methodological problems below.

In the following section we analyze causes of differential attainment by race and sex, with a view toward assessing the extent to which particularistic processes govern participation, position, performance, and recognition.

CAUSES OF DIFFERENTIAL ATTAINMENT[7]

We have suggested two ways in which particularistic effects of race and sex can operate. First, if variables indicating the race or sex of a scientist significantly affect an outcome of the scientific career after controlling for relevant variables, the method of residualism points to discrimination. Second, if the

[7]This section has benefited from Fox 1995 and Rosenfeld 1991.

way in which achievements translate into resources or rewards differs by sex or race, discrimination may also be indicated.

In order to apply these criteria to the scientific career, the career should be viewed as a series of linked processes developing over time, and care should be taken to assess the operation of particularism within the context of a specific career process. We consider the following explanations of differential outcomes: 1) individual level factors such as intelligence; 2) marriage and family; 3) graduate education and training; 4) organizational and disciplinary context; 5) role performance and particularly research productivity; and 6) processes of cumulative advantage that serve to reinforce other effects. Finally, we provide a general assessment of the operation of universalistic and particularistic factors related to race and sex.

Personal Characteristics

Because ability is a requisite for training and performance in science, it might be considered as an important factor in explaining success. Ability, as indicated by intelligence tests, however, does not account for attainments in science. First, while intelligence is a prerequisite for becoming a scientist, among those who have obtained the doctorate, differences in measured ability do not predict subsequent levels of performance (Bayer & Folger 1966, Cole & Cole 1973:69). Second, while we know of no studies of the relationship between intelligence and career attainments by sex, female scientists generally score higher on standardized tests (Cole 1979:62, CEEWISE 1979:23–25). Indeed, it is likely that women who succeed in obtaining a doctorate in science are a more highly select group than men in terms of motivation and abilities that lead to performance (Hornig 1987).

Marriage and Family

The loss of time available for scientific work as a result of family obligations is likely to be greater for women, since women are more likely to be the primary caretakers in families (Moen 1985). Further, it is possible that the negative stereotyping of women with children adversely affects their career chances. For example, faculty may label a female student as being less committed to her career if she tries to raise a family while in school, or faculty may negatively evaluate a woman simply because she might have children (Rosenfeld & Jones 1986, Zuckerman & Cole 1975). In assessing the evidence for the effects of marriage and family, it is important to keep in mind that female scientists are and have been much less likely to be married or to have children than are either male scientists or women in the general population (Astin 1969:26–31, Centra 1974, Fox 1994, Grant et al 1993, Long 1990). Thus, the demands of marriage and motherhood do not affect a substantial proportion of female scientists.

Marriage may constrain geographic mobility of female scientists, but geographic location does not have consequences for academic rank (Coggeshall 1981, Marwell et al 1979, Rosenfeld 1981; see also Hurlburt and Rosenfeld 1992). The research of Long and his colleagues (1993) on biochemists shows a positive effect of marriage upon women's odds of being promoted from assistant to associate professor; for promotion to full professor, marriage had no effect. Other data (Ahern & Scott 1981) indicate that while marriage negatively affects the rank of academic women, the effects are not significant (but note that they did not have any measures of research productivity).

The preponderance of data indicate that being married has a small positive effect while the effects of having children are weak or non-existent. Several studies have found a positive effect of marriage on productivity (Cole 1979, Long 1990, Fox 1994, Reskin 1978a), while Helmreich et al (1980) found no effect. The presence of children has been found to have no effect on women's publication productivity (Cole & Zuckerman 1987, Hamovitch & Morganstern 1977, Fox 1994), a nonsignificant negative effect (Long 1990, Reskin 1978a), a significant negative effect (Hargens et al 1978), or a positive effect (Astin & Davis 1985, Fox & Faver 1985, Fox 1994).

Education and Training

Conceptions of the scientific role, styles of work, and standards of performance are developed during graduate school (Zuckerman 1977), and thus it is reasonable to look to graduate school background as an explanation of differential attainments by sex and race. According to key indicators of graduate background, however, male and female scientists are remarkably similar. They are equally likely to receive their doctorate from top ranking universities (National Research Council 1983) and are similar in indicators of financial support for graduate training (National Research Council 1979, 1983). However, these data do not specify the quality or character of assistantships (Hornig 1987), which may indicate different opportunities to join research groups, collaborate, and gain access to the culture of science (Fox 1995).

Minorities do differ from whites in their doctoral origins. Blacks are more likely to receive their doctorate from lower ranking departments, are more likely to interrupt graduate studies and to study part-time, and take longer to complete their degrees (Pearson 1985). Native Americans, blacks, and Hispanics are less likely than whites and Asians to report that the university is their main source of financial support (Pearson 1987:137). However, funding disadvantages of earlier cohorts of blacks have diminished in later cohorts (Pearson 1985:167).

These aggregate data do not address the dynamics of graduate education such as student-faculty interactions, advising, and mentoring that may affect the career attainments of women and minorities (Fox 1995, Reskin 1978b).

Collaboration with a mentor is a particularly important factor since it affects predoctoral productivity, job placement, and later productivity (Long & McGinnis 1985). In his study of biochemists, Long (1990) finds that having young children decreases a woman's odds of collaborating with the mentor, while this effect does not exist for men. Having a female mentor increases the odds of women collaborating, but in biochemistry as in most other scientific fields, the number of female mentors is limited. Grant and her colleagues (1993) report that women and minorities in chemistry experience problems with mentors, including difficulty gaining access to eminent mentors. In one of the few studies of minority experiences in graduate education (Duncan 1976 cited in Pearson 1987:144–145), three quarters of the minority students reported that they were "on the fringes" of their departments and that they were less likely to report that a professor had helped them to "become a professional." Minority group experiences may be changing, and experiences may differ among groups. Much needs to be determined in these areas.

Researchers have examined the effect of doctoral origins upon 1) the initial job obtained, 2) academic rank, and 3) research productivity. Doctoral origins have strong effects on the initial job obtained, but it is less clear how the effect varies by sex. Hurlbert & Rosenfeld (1992) reported that the effect of the prestige of the doctoral department was the most important variable affecting the prestige of the first job, and that its effect did not differ significantly by sex. The effect of productivity was statistically insignificant. Cole (1979:141), on the other hand, found a slightly stronger effect for men of doctoral origins on the prestige of employing departments. Looking at type of academic appointment, Reskin & Hargens (1979) found an insignificant effect of doctoral origins on whether the first job was tenure track, and this effect did not differ by sex. Little is known about sex differences in the effect of doctoral origins on the organizational context of employment (e.g. academic, government, industry).

Studies of academic rank have generally shown that the effects of doctoral origins are insignificant and do not differ by sex (Cole 1979:1411, Hurlbert & Rosenfeld 1992, Long et al 1993), although Long and his colleagues found that the effect of doctoral origins on promotion to full professor was significant but similar for male and female biochemists. The effect of doctoral origins on research productivity appears to be greater for men than for women among chemists (Reskin 1978a), biochemists (Long 1990), and scientists in six fields (Cole 1979:141).

Overall, minorities appear to be disadvantaged in the prestige of their doctoral origins, but little is known about the process by which they are admitted to graduate departments and their experiences once admitted. Men and women have similar doctoral origins. The biggest differences in the effects of origins may be in relationships with the mentor. In considering the effects of origins on later outcomes, the effects appear to be slightly stronger for men, perhaps indicating that they are given a greater return than women for their doctoral training.

Location and Context

Organizational context is especially important in science because scientific work relies upon facilities, funds, apparatus, and teamwork. Through largely informal interactions within the workplace, scientists continually shape, test, and update their research. In this way, performance is tied to the environment of work (Fox 1991, Crane 1965, Hagstrom 1967). A series of studies have established that organizational context affects research productivity. Across broad types of employers (e.g. academia, industry), a scientist's level of productivity changes to conform to the organizational context of employment (Long & McGinnis 1981, Reskin 1977). Within academia, longitudinal data from five fields show that departmental prestige affects productivity, and that changes in departmental location result in changes in productivity (Allison & Long 1990, Long 1978).

Unfortunately, no studies are available that trace the effects of organizational context on productivity for comparable samples of men, women, and minorities. Future research needs to assess whether the effects of context differ for women and minorities. Research on specific organizational processes suggests that resources and opportunities may operate differently for different groups. In a national sample of social scientists in four fields, Fox (1995) finds that in both baccalaureate and doctoral granting departments, women report significantly less interaction with and recognition from faculty in their departments. In masters and doctoral granting departments, women gave significantly lower rankings to the resources available to them, and in PhD departments they report significantly higher undergraduate teaching loads. The factors of interaction, reported resources, and teaching loads correlate with productivity levels (Fox 1995). Pearson (1985:168) reports race differences in perceptions of communication and exchange. Black scientists feel that whites do not regard them as intellectual peers and are reluctant to confer with them. Blacks feel excluded from communication about and access to important scientific knowledge, especially to information about pathbreaking research and funding opportunities.

Because science involves teamwork and shared resources, collaboration has been sought as an explanation of women's lower attainments in science. However, the data on collaboration are mixed. Studies of sociologists report that women are both less likely (Chubin 1974) and more likely (Mackie 1977) to collaborate. Other studies involving seven fields report that women were as likely as men to coauthor papers (Cole & Zuckerman 1984, Long 1992). The issue may be more subtle than simply rates of coauthorship. Women may have more difficulty establishing collaboration and may have fewer coauthors available to them (Fox 1991). The perceived significance of a coauthor's individual contribution to the work may also be less for women coauthors. These issues remain to be determined.

Role Performance

Under the norm of universalism, the allocation of resources and rewards should be most closely associated with contributions to science, which are most clearly indicated by measures of research productivity. The evidence suggests that this is not always the case. In the allocation of the first job after the PhD, research productivity is not an important factor (Hurlbert & Rosenfeld 1992, Long et al 1979), and there are no indications of sex differences. Evidence on rank advancement is mixed (Long et al 1993, Cole 1979:246); details are discussed below. Reskin & Hargens (Reskin 1978a, Reskin & Hargens 1979) found that early productivity has less effect on later productivity for women than for men, and they suggested that women may be more dependent on context, resources, and recognition.

Cumulative Advantage

Research initiated by Merton's ([1968] 1973) essay on the Matthew effect has established the importance of cumulative advantage in science. Cumulative advantage involves processes by which initial advantages, however obtained, are used to gain further advantage. Conversely, cumulative disadvantage reinforces and magnifies initial disadvantages. These processes may be especially important for understanding sex and race differences. First, women and minorities are less likely to be in jobs that support research and are more likely to be in less prestigious jobs. Such jobs restrict resources, making future productivity less likely. Second, the lower productivity of women and minorities may make it more difficult for these groups to obtain the resources to facilitate further productivity. As a consequence, sex and race differences in productivity may increase over time. This is consistent with sex differences in productivity over the first decade of the career (Cole & Zuckerman 1984, Long 1992). Long, however, reports decreasing differences after the first ten years which suggests that processes other than cumulative advantage may become important later in the career. Third, more subtle forms of discrimination such as exclusion from informal collegial networks may erode motivation and inhibit an individual's investments in research.

While these processes are plausible, there is little empirical research that addresses whether processes of reinforcement operate differently for women, minorities, and white men. The most detailed analysis is that of Reskin & Hargens (1979), who found that processes of cumulative advantage are weaker for women and concluded that there was evidence of discrimination.

The Case of Rank Advancement

Since it is in processes of rank advancement that the evidence for particularism is strongest, we discuss this topic separately. Not only are there large differences in the proportions of men compared with women at higher ranks, but those differences persist with controls for time since degree, fields, and publication productivity. For scientists at each level of productivity, Cole (1979) found that women were less likely than men to receive promotions, and this held with controls for departmental prestige. Among women and men matched on year and institution of PhD, field, and race, Ahern & Scott (1981) found large and pervasive sex differences in academic rank among natural, physical, and biological scientists. Unfortunately, they did not have controls for research productivity. In a sample of biochemists, Long and his colleagues (1993) report sex differences in advancement in rank after controlling for articles, citations, doctoral origins, and variables related to marriage and family. Sonnert's (1990) study of recipients of prestigious postdoctoral fellowships reports that the predicted rank of women is one third lower than that of men within the physical sciences, mathematics, and engineering (but not in biology) after controlling for years since the doctorate, fields, and fellowship. Outside of academia, in industrial science, some, but more limited, evidence exists of discrimination by sex in rank. In a study of scientists in a nonacademic firm, which included controls for human capital and demographic variables, women had fewer opportunities for promotion to management (Shenhav & Haberfeld 1988).

Summary

The operation of particularism has been evident, especially with respect to rank advancement and the granting of tenure. Because of the centrality of rank and institutional location to stratification in science, these findings are important. Resources, rewards, and productivity are connected, making the assessment of particularism complex. Although a universalistic norm may help to create pressure for resources and rewards to be allocated on the basis of performance, it does not guarantee equal opportunity for women and minorities to acquire the resources that enable performance in science. As we have seen, performance is not a simple function of motivation or ability. It is the result also of background and environmental context over the career—mentorship, advising, collaboration, teamwork, institutional facilities and apparatus. Although not the focus of our paper, qualitative studies, narratives, and widely publicized discrimination cases also point to the operation and complexity of particularism. Discrimination in science is a reality experienced by women and minorities, recorded in numbers of accounts across fields (Ainley 1990, Gornick 1990, Kass-Simon & Farnes 1990, Pearson & Bechtel 1989, Zuckerman et al 1991). Clearly much remains to be done to expand our understanding of stratification by sex and race in science. To this end, we conclude with two sections that offer suggestions on how research in this area might proceed. In the first section, we consider conditions for particularism (see also Cole 1992: 184). By considering conditions under which particularistic factors are most likely to operate, we point to areas where research might most effectively be conducted. In the final section, we consider methodological problems that restrict our ability to assess universalism and particularism. Attention to these problems, and solutions to them, may help to refine future research.

CONDITIONS FOR PARTICULARISM

On the basis of previous research and our inferences from it, we consider four conditions that support particularistic allocations on the basis of sex and race, particularly in academic science.

The Absence of Information

When little information on the qualifications of a scientist exists, particularistic factors are more likely to be brought to bear. This is consistent with Festinger's (1954) theory of social comparison, maintaining that in the absence of objective bases for judgment, people use social bases of comparison.

For example, Cole (1979:75–76) tested the relationship between the absence of information, the sex of a scientist, and the allocation of prestigious jobs and academic rank. Since the scientists in this sample had no publications, those making decisions on the allocation of position had no means of assessing research quality. Nonproductive men were more likely than nonproductive women to be located in prestigious departments and to obtain high academic ranks. In a sample of prolific scientists, women were not pushed out of prestigious departments, but they were deprived of high rank. Although the results are based upon small samples, they support the proposition that "functionally irrelevant characteristics, such as sex, will be more quickly activated when there are few functionally relevant criteria on which to judge individual performance" (Cole 1979:75).

The operation of particularism in the absence of information suggests that the initial allocation of positions may be extremely important for understanding sex and race stratification in science. Upon the completion of the doctorate or a postdoctoral fellowship, productivity is limited, and for those publications that are available it may be difficult to disentangle the work of the student and the mentor. If particularistic factors operate in the allocation of the initial job, processes of cumulative advantage may increase sex and race differences later in the career.

Ambiguity of Standards

When criteria for evaluation are ambiguous, particularistic outcomes are more likely to occur (Blalock 1967:99). Studies indicate that the more loosely defined and subjective the criteria, the more likely that white men will be perceived as the superior candidates and that bias will operate (Deaux & Emsmiller 1974, Nieva & Gutek 1980, Pheterson et al 1971, Rosen & Jerdee 1974). When the criteria for evaluation are standardized, particularistic considerations are reduced. Without such standards, functionally irrelevant attributes can govern in strong degree. As one example, in a survey of deans of liberal arts colleges, Seldin (1984) found that "personal attributes" such as dress, politics, and friends were a major factor in overall evaluation of faculty among 38% of the deans in 1978 and 28% in 1983. The relationship between organizational practices, criteria for evaluation, and particularistic outcomes is an important area for continuing research.

Some argue that ambiguity is inherent in science, that no pre-established impersonal criteria exist for matching research to nature, and that all evaluation is therefore subjective, based upon particular perspectives and interests (Mulkay 1979). In this case, according to Mulkay, it becomes "possible to conceive that women and the members of other social categories in science are systematically prevented from (or favored in) establishing that their work is of high quality" (Mulkay 1979:26). More specifically, the feminist critique of science has maintained that science is imbued with male cognitive authority, such that men's understandings and interpretations are more often taken as scientific truth, while women's may be taken as peculiar or false (Keller 1985, Harding 1986). Under conditions of cognitive authority, criteria for evaluation can be used flexibly depending upon the interests of the powerful parties involved (Mulkay 1976:245). In this way, cognitive authority may interact with and even permeate the organizational causes of attainments discussed earlier. These issues have been the subject of considerable interest, but little systematic empirical inquiry.

Less Developed Scientific Paradigms

Fields with less developed scientific paradigms have less consensus about research issues, methods, and course curricula. In fields with low consensus on criteria for decision-making, particularistic variables may account for more of the variance in outcomes. Hargens & Hagstrom (1982) found a positive association between consensus levels of fields and career outcomes based upon performance. Studies of editorial processes show that particularistic factors play a greater role in editorial policies and practices within social compared with physical and natural sciences (Beyer 1978, Yoels 1974). Further, in a study of outcomes of grant applications in the National Science Foundation, a stronger relationship between institutional membership on NSF advisory panels and institutional receipt of grants was found in sciences with less developed scientific paradigms (Pfeffer et al 1976).

These studies have not investigated the relationship between paradigm development and outcomes based upon sex and race. Future research should consider the degree to which levels of consensus may be related to particularistic effects of race and sex.

Secrecy

Open processes in hiring, promotion, and allocation of rewards increase universalistic decision-making, as does the exercise of due-process procedures. Secret and nonsystematic processes tend to activate particularistic considerations (Konrad & Pfeffer 1990). Under experimental conditions, subjects were more likely to base their decisions about whom to hire on criteria of social similarity to themselves when information used to make decisions and the identity of the decision-maker were secret (Salancik & Pfeffer 1978). Since scientists are predominantly male and white, decisions based on social similarity will reproduce their personal characteristics. Openness and due-process procedures entail an accountability in decision-making that reduces the use of social similarity in hiring choices. This is consistent with conformity studies which show that when behaviors are public, compliance with normative standards increases (Kiesler & Kiesler 1969).

The issues can be assessed with investigations that examine allocations of positions and rewards under variable organizational and group conditions of openness and due process. As one example, Cole (1992: 185–88) considers the use of particularistic network ties under conditions of secrecy.

METHODOLOGICAL PROBLEMS[8]

Research on factors that account for sex and minority differences in career outcomes is fragmented and sometimes contradictory. To advance research in this area, future research should consider a set of common methodological problems. We hasten to add that while this section is necessarily critical, its purpose is not to dismiss prior research. We hope to positively influence research on women and minorities in science by considering five problems: 1) incomplete specifications; 2) aggregation over time; 3) assumptions of uniform effects and overgeneralization; 4) sampling on the dependent variable; and 5) problems in measurement.

[8]The discussion of methodological problems draws from Long (1987).

Incomplete or Atheoretical Specifications

Research designs that leave out variables that are known to be causally relevant and theoretically central can only describe distributions, but cannot explain how those distributions are generated. A trade-off exists between the size of a sample and the richness of information collected. Large samples allow one to precisely estimate the distribution of outcomes, but unless critical independent variables are included in the study, satisfactory explanations of what generates those distributions are unlikely. As noted earlier, the method of residuals depends critically on controlling for relevant variables.

Consider research on academic rank. While the underrepresentation of women in higher ranks is undisputed, explanations are unclear. Examining rank without knowing the type of institution or the prestige of the department in which the rank is held provides an incomplete picture of a scientist's location in the stratification system. Even if women were equally represented in higher ranks, if they were predominantly in lower prestige institutions, our understanding would be incomplete. Further, without controlling for time since the doctorate, it is impossible to determine if their absence from higher ranks is proportional to their lesser seniority. Similarly, given that rank advancement in graduate programs should be strongly influenced by research productivity and given that women and minorities are known to be less productive as groups, assessments of particularism in rank advancement must control for productivity.

Aggregation Over Time

The scientific career should be viewed as a sequence of events occurring at unique times for each individual. Here we can benefit from the insights of "life course analysis" as discussed above. In the life course both the timing and the occurrence of events are important. The greatest insights are likely to be obtained from panel designs in which a sample of scientists are followed through time, from entrance into graduate school, through graduate school, and through employment for the rest of their careers.

For example, consider the relationship between recognition and performance. Because of processes of cumulative advantage and the reciprocal relationships between performance and recognition, understanding requires longitudinal evidence. While women as a group are less productive and generally hold less prestigious positions, we cannot conclude that they hold less prestigious positions due to their lower productivity. Research has shown that position affects productivity. If less productive women are in less prestigious positions, it is unclear whether the lower productivity resulted from being forced into a position less conducive to research (perhaps as a result of discrimination) or whether the less prestigious position resulted from poor performance. Assessments of discrimination and of universalism in science can best be made with longitudinal data that allow assessment at each step of the career.

Assumptions of Uniform Effects and Overgeneralization

Misleading conclusions can result from the implicit assumption that effects are uniform across disciplines, cohort, sector of employment, sex, or race. Care must be taken in citing a result based on scientists in a particular field at a particular time and not presenting the result as though it characterizes all fields, times, races, and sexes. For example, data on one minority group should not be generalized across all minority groups, since minority groups differ in their experience, and generalizations obscure our understanding of this variation. When studies include multiple disciplines, cohorts, sectors, sexes, or races, care must be taken in how these groupings are specified in the models used.

For example, consider an analysis of the prestige of academic appointment as the outcome with sex and productivity as the independent variables. If the model is specified as $PRESTIGE = \beta + \beta_{SEX}SEX + \beta_{PROD}PROD + \varepsilon$, it is misleading to assess the effect of sex on prestige based on the coefficient β_{SEX} since the model assumes that the way in which productivity affects prestige is identical for men and women. It is possible that men receive a greater return for productivity (e.g. for each additional paper, they get a greater increment in prestige) than do women. Failing to allow effects to differ by sex or race can mask important sex- or race-specific effects. Models should allow the effects of key variables to differ across groups, unless there are compelling reasons to suggest that the effects are uniform. Support for particularism can be found from differences in the intercepts, as with the traditional method of residuals, as well as from differences in the coefficients relating performance to recognition.

Sampling on the Dependent Variable

Many studies of stratification in science are based on nonrepresentative samples, and often on samples of elite scientists. This may be appropriate when we want to study the factors affecting those who have been the most successful (e.g. studies of Nobel Laureates). However, problems occur when results based on a nonrepresentative sample are generalized to all scientists. Within the statistics literature, the analysis of nonrepresentative samples is referred to as sample selection bias (Winship & Mare 1992). The statistical consequences of sampling on the dependent variable are that inferences from the nonrepresentative samples do not generally apply to the population as a whole.

For example, consider the effects of having children on achievement in science. It is possible that having young children affects the career differently at different stages. Having young children may affect a woman's decision or opportunities to pursue a tenure-track academic position. Women with young children may choose not to pursue such positions, and those hiring may particularistically decide that women with young children should not be considered for employment. Even so, some women with young children may for exceptional reasons obtain prestigious appointments. Analyses based on successful women might find that the presence of young children has no effect on their productivity. However, if the entire sample of women were analyzed, an effect of children might be found.

The analysis of nonrepresentative samples may occur in subtle ways even when the attempt is to obtain a representative sample. Consider a sample defined in terms of those obtaining degrees in a particular field over a particular period of time. Those women who change their name after receipt of the degree because of marriage, divorce, or changing norms may "disappear" later in the career since their name is unknown. If those lost are disproportionately those who changed names, the sample will not be representative.

Problems in Measurement

The use of measures that have differential validity or reliability by sex or race can generate spurious findings. To take one example, consider the measurement of productivity based on counts of first-authored papers. Such measures are common when using *SCI* since papers are not indexed for junior authors. To the extent that coauthorship patterns differ by sex or race, artificial sex or race differences in productivity may be found.

A very difficult measurement problem in assessing particularism and universalism involves the ambiguous meaning of common indicators of achievement and ascription. Particularism is said to operate when factors other than achievement affect recognition. If we want to study initial job placement, we would want to consider the effects of doctoral origins. If those with more eminent mentors and those from more prestigious graduate programs receive more prestigious jobs does this suggest universalism or particularism? To the extent that more eminent mentors and more prestigious programs train students better, the allocation is universalistic, rewarding the students for their greater potential. However, if the allocation is simply based on an "old boys" network, the allocation is particularistic. Many common measures used in studies of the scientific career are inherently ambiguous. Subtle designs and analyses are necessary to tease out the processes that are at work.

SUMMARY AND CONCLUSIONS

It is clearly established that women and most minorities are less likely to participate in science, have less prestigious positions, have lower productivity, and have less recognition. While understanding of the processes leading to these differential outcomes is incomplete, our review indicates that universalism falters in science. In some processes, such as rank advancement, being a woman or a minority may have negative effects. In other processes, women (the evidence for minorities is lacking) are less able to translate their productivity into resources and recognition. Qualitative studies point to many examples, both subtle and blatant, in which members of underrepresented groups did not receive due recognition or rewards. It is not enough to ask whether particularism or universalism operates in science, for few would maintain that science is wholly the one or the other. Rather, given the patterns observed, it is important to understand more fully the processes leading to the lower participation and performance of women and minorities in science. We hope that our review will contribute to future research in this area.

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