Stuck in the Middle: Doctoral Education Ranking and Career Outcomes for Life Scientists

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Why do some Ph.D.'s languish in positions with little authority, and what does educational background have to do with it? Hypotheses predicted that life scientists with Ph.D.'s from elite programs would be the most likely, those from middle-ranked programs the next most likely, and those from lower ranked programs the least likely to achieve supervisory positions. A sample of 2,062 life scientists with doctorates from U.S. universities was collected from records archived from 1983 to 1995. In contrast to hypotheses, Ph.D.'s from elite and lower ranked schools did not have a significantly different chance of supervising. Within prestigious organizations, however, Ph.D.'s from top 10 programs did have a greater likelihood of leading. Ph.D.'s from middle-ranked programs were less likely to advance into supervisory positions. Qualitative interviews explored how, in a knowledge-expanding field such as the life sciences, being stuck on the bottom rung early on can adversely affect a scientist's career.

Keywords: *science careers; educational stratification; life scientists; postdoctoral scientists; university prestige; sociology of science*

The number of Ph.D. recipients from American universities has been increasing over the past three decades. From 1970 to 1999, there was a 30% increase in the number of new Ph.D.'s with science and engineering degrees (including the social sciences). Not all specialties are equally popular, however. Doctoral degrees in the physical sciences granted in 1999 were down 8% from the number in 1970. During the same time period, Ph.D. recipients in the biological sciences increased by 37% (National Science Foundation, 2002, Appendix Table 2-24). The trend in degrees reflects the prominence of fields: Scientific advances in physics were heralded in the 20th century, but 21st-century headlines feature developments in the life sciences.

Where do all these new Ph.D.'s go? As academics are well aware, the number of new tenure-track jobs has not kept pace with the number of new Ph.D.'s. Often, recent Ph.D.'s are "stuck" in low-paying jobs with little or no stability or autonomy, such as postdoctoral positions. The percentages of new science and engineering Ph.D.'s planning on academic positions or on postdoctoral study reversed from 1975 to 1990. In 1975, 26% of doctoral graduates would become postdocs, and 39% counted on academic jobs; in 1990, 37% would be postdocs after graduation and 26% academics (Smith & Tang, 1994). Hackett's (2001, pp. 135-136) interpretation of the National Research Council's (1998) study of life scientists notes that postdoctoral fellows experience a "crisis of expectations" in attempting to become full-fledged scientists, a crisis that sociologists might call alienation or anomie. Professionals, like postdocs, who live in indefinite transition periods may feel a separation of self from the work they are doing, until they can begin their "own" work.

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To be sure, there is variation in postdoctoral positions in terms of an individual's criticality to the lab, autonomy, and publication record (Owen-Smith, 2001). Every postdoc, however, is still in a (supposedly) temporary transition period. In Owen-Smith's (2001) study of a university laboratory, some postdocs were called "professor level" to distinguish them from the "hired hands." Scientists invented this informal title to explain the mismatch between the publishing productivity of some life science Ph.D.'s and their lower status as postdoctoral fellows. Regardless of accomplishments, all postdocs are "in-betweeners." Understanding which Ph.D.'s must linger in this kind of position can tell us how stratification operates in the sciences.

Educational Prestige and Career Outcomes

In the analysis of occupational stratification, education is one of the most significant explanatory variables, often measured by years of education. The relationship is fairly linear: The more years of education, the greater pay-off in the labor market. When "years of education" is constant rather than variable among an occupational group, education remains, as Spring (1976) termed, an important "sorting machine." Rather than stratification by years of schooling attained, however, in a population with the same degree level (i.e., Ph.D.), the prestige of degree-granting programs becomes the sorting device.

Much less research on the effects of educational "quality" ranking, or prestige, on careers has been conducted, in comparison with numerous studies of the effects of the quantity of years of schooling (e.g., Blau & Duncan, 1967; Coleman, 1984; Featherman & Hauser, 1978; Grusky, 1983; Hout, 1988). The available research on prestige effects does show a clear relationship between educational ranking and career success (e.g., Astin, 1968; Kingston & Smart, 1990; Trusheim & Crouse, 1981). Morgan and Duncan (1979) found that graduates with bachelor's degrees from U.S. colleges with higher American College Test scores (rather than expenditures per student) were likely to earn more in the labor market. Likewise, James, Alsalam, Conaty, and To (1989) found that college grads from prestigious, but not necessarily high-spending, schools were more likely to have greater future earnings. Useem and Karabel (1986) asserted that the individuals who enter the business elite accomplish it through "scholastic capital" (prestigious university degrees), as well as through their upper-class origins. As found in the American population, college prestige also plays an important role in the career achievement of Japanese (Ishida, 1993) and South Korean (Lee & Brinton, 1996) graduates. Solmon (1975) and Solmon and Wachtel (1975) looked not only at undergraduate college prestige but also at graduate education ranking. They observed that the prestige of education is even more important for the status attainment of students completing graduate work.

Education Ranking and Scientists

Among Ph.D. scientists, educational prestige is key. Studies of the stratification of scientists have found that the ranking of Ph.D. education is a major predictor of success in academe (e.g., Bowen & Schuster, 1986; Clark, 1987; Cole & Cole, 1973; Long, Allison, & McGinnis, 1993; Zuckerman, 1977).[1] Having a more prestigious Ph.D. education is related to attaining a good first job in a tenure-track position (Hurlbert & Rosenfeld, 1992). In fact, studies by Long, Allison, and McGinnis (e.g., Allison & Long, 1987; Long & McGinnis, 1981) have shown that the prestige of a bioscientist's Ph.D. is a better predictor of obtaining a prestigious academic job than research productivity.

This body of work on the effects of doctoral prestige, however, assumes that scientists work in academia, when more than one third of Ph.D. scientists work in industry (National Science Foundation, Survey of Doctoral Recipients **PLS. PROVIDE REF.**). For example, in a recent review of the literature on scientific careers, Long and Fox (1995) noted that half of Ph.D. scientists work in education and one third in industry. They went on to argue that because the university is so central to the training of scientists, "the research and focus of this paper is on academic scientists" (p. 50). The dearth of research on industrial scientists may have been another reason for the focus of their review. Yet examining the effects of graduate education on the large group of scientists outside the academy allows a broader view of the effects of education rank. In contrast to the trend in the literature, this article investigates scientific careers across the university and industrial sectors to gauge the importance of educational prestige ranking for stratification of all life scientists.

The Biotechnology Industry and the Life Sciences

The field of the life sciences presents a particularly interesting case for studying the effects of graduate education because of the emergence of the biotechnology industry. Biotech is a knowledge-intensive industry, one in which the most successful firms collaborate closely with university labs and research institutes (Powell, Koput, & Smith-Doerr, 1996; Shan, Walker, & Kogut, 1994; Stuart, Hoang, & Hybels, 1999). In the biotechnology industry, basic science and publication are much more important to scientists' careers than was traditionally found in the industrial sector (Eaton, 1999; Smith-Doerr, 2004). These science-based organizations concern themselves with functions that are traditionally thought to be the sole domain of academe.

Biotechnology firms, in fact, have postdoctoral fellowship positions. These positions provide another instance of the overlap between biotechnology firms and university programs in the life sciences. The idea that a postdoc would go to an industrial firm for training in basic science developed along with the emergence of science-based biotech firms. This perception of the biotech industry contrasts with more traditional industrial employment in chemical or pharmaceutical corporations. For example, Genentech is a prominent biotechnology firm that many other firms in the industry have emulated. Since its founding in 1980, Genentech has had a postdoctoral program and now retains 60 postdocs on average. Like academic postdocs, for a time, those in biotech firms are stuck in supporting roles. As Sarah Hymowitz, a former postdoctoral fellow at Genentech admitted, "As a postdoc, I was more of a team member than a team builder" (http://www.genentech.com, May 2002 **PLS. PROVIDE REF.**).

As industrial life science firms come to look more academic, by publishing and training postdocs, so have university labs come to seem more commercial. Social scientists see cause for concern in university commercialization (e.g., Croissant & Restivo, 2001 **PLS. DELETE CITE OR ADD REF.**; Slaughter & Leslie, 1997 **PLS. DELETE CITE OR ADD REF.**). One concern is the effect research collaboration between universities and for-profit firms will have on graduate education. Slaughter, Campbell, Holleman, and Morgan (2002) went so far as to argue that "when professors entered into partnerships with industry, students became products, purchased by corporations" (p. 289). Some life scientists, especially members of the old guard, also express doubts about the effects of commercialization and patents on academic work. In the words of one of these professors,

> I'm left with a kind of a sad, sinking feeling because I still have an old fashioned idealism about the academy. I think this ought to be an arena where all ideas are up for open debate. . . . There's a certain greedy, "have it now" mentality that may motivate people. (Owen-Smith & Powell, 2001, pp. **PLS. PROVIDE PAGE(S) OF QUOTE**)

This life scientist expressed the viewpoint that academic freedom will be compromised by commercial interests, particularly the secrecy that may arise from more patenting in universities. An analysis of the effects of the increasing overlap between the university and science-based firms is beyond the scope of this article. What is clear is that activities that were once treated as the domain of either the academy or industry are being pursued in both. Another outcome of this changing scientific and organizational landscape that must be considered is what happens to the "haves" and "have-nots" in science. Because of the close connections between universities and biotech firms, the ranking of a scientists' Ph.D. programs should be important in the early careers of scientists working in biotech firms as well as in the academy.

Educational Prestige and Promotion

Although general public opinion polls show that all scientists are considered members of a prestigious educational and occupational group, scientists, like members of other occupational groups, compare themselves with one another rather than with the general population (Cole & Cole, 1973). Sociologists of science note that for Ph.D.'s, years of education is simply not as salient as the prestige of where and with whom one studied. Educational prestige does indeed matter for Ph.D.'s. Four of five American Nobel laureates, members of the National Academy of Science, and those in top 10 university professorial positions received Ph.D.'s from university departments ranked among the top 15 (Zuckerman, 1977). Among all academic scientists, the reputation of the department in which one received one's Ph.D. is positively related to the prestige of one's first university position (Crane, 1969; Long & McGinnis, 1981).

The theoretical bedrock of studies of stratification among scientists is Robert Merton's (1968) "Matthew effect." Inequality among research scientists can be summed up by a biblical passage from the gospel according to Matthew: "To those who have, more shall be given." Early access to important career resources, such as graduate training in a prestigious department, gives scientists head starts over their peers by making it more likely that they will work with well-known scientists, perhaps publishing together. Scientific rewards can be transformed into further resources (i.e., widely read publications into prestigious career options). Initially small disparities can lead to larger differences over the long run of careers. One key outcome of an advantaged background is an early position supervising other scientists' work, directing laboratory projects rather than having one's work directed. A hypothesis regarding the advantageous career outcomes for having a highly ranked Ph.D. education follows this logic:

Hypothesis 1: Having an elite Ph.D. education will be positively related to obtaining a supervisory position for young life scientists.

Not only does the Matthew effect state that those who have will be given more, but also "to those who have little, what little they have will be taken away" (Merton, 1968, p. 60). The process of cumulative advantage in science careers can be a vicious as well as virtuous cycle, often depending on where one starts, namely, in a Ph.D. program. Thus, the relationship between nonelite Ph.D. education and career outcomes must also be considered. If one envisions Ph.D. programs on a continuum from elite to lesser ranked, then education prestige should be more than a dichotomy of elite versus other. The problem of measuring rank as a quasi-interval level variable (i.e., using each school's ranking score from 1 to 200), however, is that the differences between closely ranked programs are not meaningful. One would not expect any real difference between Stanford University (ranked fourth) and Harvard University (ranked fifth). The scientists I interviewed about the meaning of graduate education for life science careers regularly spoke of "top programs," "B-level [or pretty good] schools," and "the rest." Thus, hypotheses about the effects of Ph.D. education were made using these three commonly understood, ordered categories. The following hypotheses cover the middle- and lower ranked Ph.D. education effects:

Hypothesis 2: Life scientists with middle-ranked Ph.D. educations will be less likely than elite-educated scientists, but more likely than those with lower ranked Ph.D. educations, to attain supervisory positions early in their careers.

Hypothesis 3: Life scientists with lower ranked Ph.D. educations will be the least likely to attain supervisory positions early in their careers.

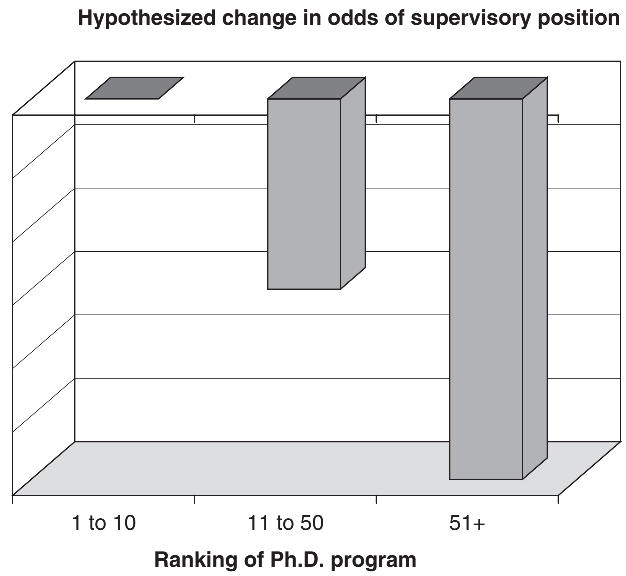

Figure 1. Hypothesized Relationship Between Ranking of a Scientist's Ph.D. Program and the Odds of Obtaining a Supervisory Position

Note: The baseline comparison is having a Ph.D. from a top 10 program. Other bars show the relative decrease in the odds of obtaining a leadership role, hypothetically (controlling for the effects of gender and experience).

The above hypotheses assume that there will be controls for variables that might affect a scientist's probability of attaining a supervisory position other than education rank. Gender is a significant predictor of mobility in scientific careers (e.g., Fox, 1995 **PLS. DELETE CITE OR ADD REF.**) and was included as a control. Also, the number of years since one's Ph.D. was obtained were controlled for, because more time and experience would obviously provide a greater chance of moving into a lab-directing role.

Figure 1 presents a visual summary of the hypotheses. In this figure, Ph.D.'s from top-ranked programs are the baseline; this assumes that they will be the most likely to supervise. Compared to having an elite education, the lower the prestige of a Ph.D.'s education, the greater the decrease in the likelihood of taking on a leadership role.

Data and Methods

The quantitative data consisted of a sample collected from the National Institutes of Health archives, specifically from the National Institute of General Medical Sciences (NIGMS) training grant programs. Information filed at the Bethesda, Maryland, NIGMS

Table 1. Statistical Description of Sample Data on Life Scientists

Variable	Values	*M* (*SD*)
Gender	0 = male, 1 = female	0.28 (0.45)
Rank of Ph.D. education prestige	1 = 50 to 200 (low), 2 = 11 to 50 (middle), 3 = 1 to 10 (high)	1.90 (0.74)
Years since Ph.D.	0 to 34	4.50 (5.30)
Prestige of employing organization	0 = elite university, dedicated biotech firm, 1 = nonelite	0.78 (0.41)
Supervisory position	0 = nonleader, 1 = leader	0.29 (0.45)

office had not been systematically entered into a computer database until this study. The NIGMS is the institute that provides the majority of funding to graduate programs to support predoctoral students' training. I randomly selected universities from the list of cellular and molecular biology grants. I chose grants in this area after consulting with several National Institutes of Health program directors, who indicated that cellular and molecular biology grants were among the most encompassing as far as areas of study and would include a more diverse sample of students. Application dates ranged from 1983 to 1995. The median year for individuals' receipt of their Ph.D.'s was 1985. The sample of Ph.D. recipients is described in Table 1.

Independent Variables

The prestige of education classification was derived from a ranking published by the National Research Council (1995) on Ph.D. programs. Specifically, rankings of biochemistry and molecular biology departments were used as the disciplinary division most closely aligned with the NIGMS grant categories analyzed here: cellular and molecular biology and biotechnology. Universities are ranked from 1 ("most effective") to 200. Ties in ranking do occur. The 1993 scores were attributed to university programs at all time points in the analysis because the 1984 National Research Council ranking did not include molecular biology programs, an indication of how relatively new this scientific area is. Related department rankings (i.e., genetics) were stable over time, with 80% and above reliability, so using the available year's ranking seemed a judicious measure. Prestige of education was collapsed into three categories for logistic regression analyses. A score of 3 was given to the most "elite" category, schools ranked 1 through 10, so that a higher score was interpreted as more elite. Other categories were as follows: A school ranked 11 through 50 was given a score of 2, and a school ranked 51 or lower was given a score of 1. These categories matched scientists' discussion of "top" schools, "B-level" schools, and "other" schools. The reversal of categories (i.e., schools ranked 1 through 10 were given the highest score) was performed so that a more elite education would produce a positive rather than a negative effect. The percentages of life scientists who fell into these educational prestige categories were 29.4% from lower ranked programs, 38.2% from middle-ranked programs, and 32.4% from elite programs.

This sample of Ph.D.'s was relatively young in career terms. On average, these scientists were only about 5 years out of graduate school when the data were collected, and the majority held nonleadership positions (i.e., postdoctoral training). Experience, or years since receiving one's Ph.D., was used as a control variable, as was gender. Gender was coded from given names. Comparable with other national figures for this time period (National Research Council, 1994), 28.3% of the Ph.D.'s were female. The basic model examined the effects of educational prestige, controlling for experience and gender.[2]

Another factor that might have a significant impact on a scientist's ability to secure a leading role in a laboratory is the prestige of his or her employing organization. The most competition occurs in academe over a tenure-track job at an elite university and in industry over heading a lab at a well-regarded science-based firm such as Genentech. Subsequent models incorporated this dichotomous control variable of employment at an elite scientific organization. An elite employment setting was measured across sectors: working at a top 10 university or at a biotechnology firm dedicated to research on human therapeutics. Of the sample, 31.6% worked at elite life science organizations.

Dependent Variable

The supervisory-level position variable was measured by having a career position at or above assistant professor or research team leader level. For this

Table 2. Ph.D.'s' Job Titles and Supervisory Levels

Academic Position	Industry Position	Supervisory Level
Student, research assistant		0
	Assistant, technician	0
Postdoctoral fellow		0
	Scientist	0
	Team director, senior scientist	1
Assistant professor		1
Associate professor		1
	Department/section head	1
	Upper research administration	1
Full professor		1
Dean/administration		1
	Board of directors, CEO	1

analysis, only the most recent career point was evaluated. The ordering of position codes and the dichotomy into leadership and nonleadership positions is summarized in Table 2.

Level of position integrated academic, industry, and government settings into one ordered scale. This scale was developed in consultation with bioscientists in the public and private sectors. Position level was dichotomized as leadership or nonleadership position, measured at a natural bottleneck in the sciences that crosses the industrial and academic sectors. Nonleadership positions included Ph.D.'s in assisting roles (e.g., postdocs).

Comparable with postdoctoral positions in universities, I found in biotech firms that similar differences were made between Ph.D.'s working under direction at the bench and those with more experience (i.e., who had completed prestigious postdocs before coming to the firm) and authority. One technician in a biotech firm, Richard,[3] explained to me that he and his fellow technicians referred to some of the Ph.D.-level scientists as "super Ph.D.'s" to distinguish them from others (also see Smith-Doerr, 2004). Richard went on to list all the scientists at the startup firm who fit the super Ph.D. category, as opposed to "regular Ph.D.'s." The super Ph.D.'s were those who led research teams, as opposed to other newly minted Ph.D.'s working under their direction. Those whom Richard called regular Ph.D.'s were in a comparable position with that of the postdocs I had observed in a university lab. Richard's categorization of Ph.D.'s paralleled my own dichotomous leadership variable.

Leaders have relatively more autonomy over their work—supervising others in projects—such as professors and senior scientists in industry. Hence, supervisory position was measured by having a career position at or above assistant professor in academia or research team leader in industry. In the sample, 24% of the Ph.D.'s had supervisory roles. Logistic regression models[4] were used to analyze effects on this dichotomous dependent variable, holding a supervisory position or not.

Qualitative Data

Supplementary qualitative data amplified explanations of the statistical findings in the discussion. These data came from ethnographic observations and semistructured interviews I conducted with 44 scientists in multiple academic and industrial life science settings. The qualitative data were collected as a snowball and convenience (multiple interviews at the same locations) sample, with intentional variation in organizational settings and scientists' gender built into the sampling process. See Smith-Doerr (2004) for further details on data collection and analysis.

Results

How does the prestige ranking of education affect the job positions of life science Ph.D.'s? The results of logistic regression models that analyzed the effects of Ph.D. educational ranking on position are presented in Table 3. The log odds results were mathematically transformed into percentage change in odds (see the third column in each model in Table 3). The first, most basic, model looked at the effects of the prestige of a scientist's doctoral program on attaining a leading role in the laboratory, while controlling for gender and experience.

Gender was related to leadership position, so that men were more likely to become leaders. Being female resulted in a 32% decrease in one's odds of holding a leadership position. This is consistent with other studies of gender stratification in academic science (e.g., see Long & Fox, 1995; Zuckerman, Cole, & Bruer, 1991). Men were generally more likely to have leadership positions than women.[5] Experience (years since Ph.D.) was, not surprisingly, positively related to attaining a leadership position. Controlling for the number of years since one's Ph.D. was granted and for gender, who is more likely to

Table 3. Effects of Ph.D. Education Ranking on Supervisory Position for Life Scientists: Results of Logistic Regression Analyses (n = 2,062)

	Model 1			Model 2			Model 3		
Variable	**Logistic Coefficient (*SE*)**	**Significance Level**	**% Change in Odds**	**Logistic Coefficient (*SE*)**	**Significance Level**	**% Change in Odds**	**Logistic Coefficient (*SE*)**	**Significance Level**	**% Change in Odds**
Education rank: low[a]	–.106 (.137)	.438	*ns*	–.219 (.142)	.122	*ns*	–.774 (.318)	.015	54% decrease
Education rank: middle[a]	–.299 (.130)	.021	26% decrease	–.437 (.133)	.001	35% decrease	–.762 (.288)	.008	53% decrease
Gender (female)	–.384 (.123)	.002	32% decrease	–.377 (.124)	.002	31% decrease	–.367 (.124)	.003	31% decrease
Years since Ph.D.	.234 (.016)	.0001	26% increase	.215 (.016)	.0001	24% increase	.212 (.016)	.0001	24% increase
Nonelite employer				1.070 (.137)	.0001	191% increase	.757 (.202)	.0001	113% increase
Education Rank Low[a] Nonelite Employer							.718 (.355)	.043	Significant increase[b]
Education Rank Middle[a] Nonelite Employer							.444 (.322)	.168	*ns*
Constant	–1.755 (0.115)			–2.385 (0.149)			–2.159 (0.178)		
χ^2	299.864	.0001		368.551	.0001		373.221	.0001	
df	4			5			7		

a. The relevant comparison category is doctoral degree from a Ph.D. program ranked in the top 10.

b. Further analysis of this interaction effect showed that the supervisory odds for Ph.D.'s from lower ranked programs were 4 times greater at nonelite organizations than at elite organizations (see Figure 3).

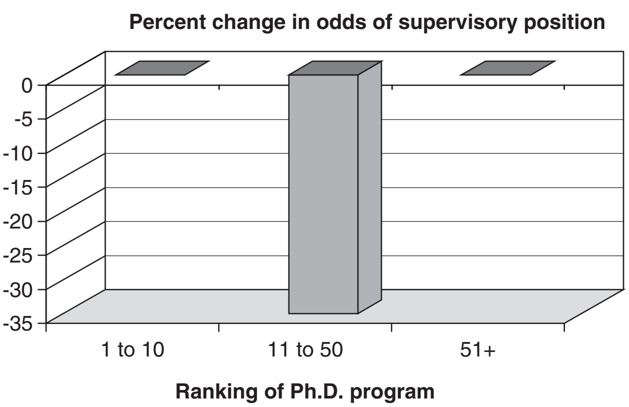

Figure 2. Percentage Change in the Odds of Obtaining a Supervisory Position by Ranking of Ph.D. Program
Note: The comparison category is receiving a Ph.D. from a top 10 program. Other bars show the relative decrease in the odds of holding a leadership role (controlling for the effects of gender, experience, and the prestige of the employing organization).

achieve leadership positions in science-intensive organizations? Those from the lowest ranked departments did not significantly differ from those from the highest ranked departments, but the those from middle-ranked departments appeared less likely to become leaders.

This finding of disadvantage for Ph.D.'s from middle-ranked programs might be affected by the prestige of the organizations are which scientists are employed. The second model controlled for employment at elite universities and biotech firms to see whether this unexpected effect of educational prestige still held. Gender and experience had similar effects in this model. Employment at a nonelite organization did significantly improve one's odds of taking a leading role. Yet Table 3 shows that controlling for employing organization, Ph.D.'s from middle-ranked universities were still significantly less likely to hold leading roles in laboratories than Ph.D.'s from elite and lower ranked programs. In comparison with the elite-educated Ph.D.'s, the midprestige Ph.D.'s had a 35% decrease in the odds of gaining a supervisory position. Figure 2 illustrates this finding from Model 2 in Table 3. In contrast to the hypothesized odds of supervisory positions depicted in Figure 1, Figure 2 shows the actual relationship between educational prestige and holding a position of authority.

Thus, in results from the first two models, there was mixed support for the hypotheses. Hypothesis 1 found support in that those from the most elite departments were more likely to gain leadership positions than those from the middle ranked departments. But given that the most elite educated Ph.D.'s did not significantly differ from the least elite educated Ph.D.'s in their chances for leadership, the first hypothesis did not have complete support from the data. Hypothesis 2 likewise found only partial support: Ph.D.'s from middle-ranked departments were less likely than elite-educated Ph.D.'s to supervise science, but they were not more likely than those from the lowest ranked doctoral programs. Hypothesis 3 was falsified in that Ph.D.'s from the lowest ranked schools were actually more likely than those from the middle-ranked schools to attain early supervisory roles.

To further analyze the puzzling finding that doctoral-level scientists from the lesser ranked schools had about the same chances of landing good jobs as those from top 10 departments, the third model included an interaction term. The interaction between educational prestige and employment prestige showed whether the effect of working in a nonelite organization differed for Ph.D.'s by their educational ranking. In this model, gender and experience had the same effects on leadership: lower odds for women, greater odds for more years of experience. Because the interaction effect was included in the third model in Table 3, the coefficients for low- and middle-ranked schools show their effects, compared with high educational prestige, only for Ph.D.'s working in prestigious university or biotech settings. Figure 3 demonstrates the relative odds of attaining a good position in an elite organization. Compared with elite-educated Ph.D.'s, scientists from lesser ranked universities had a 54% decrease in the odds of supervising, and middle-prestige Ph.D.'s had a 53% lower likelihood of leading scientific projects. The coefficient for a nonelite employing organization in this model gave the effect for elite-educated Ph.D.'s. Even those from top programs had over 100% greater odds of leading at nonelite organizations than at top universities or biotech firms. Compared with the elite-educated Ph.D.'s, those from the middle-ranked schools did not have any greater odds of leading at less prestigious organizations. But for those from lesser ranked doctoral programs, there was a significant difference. The odds for doctoral life scientists from less prestigious universities having stable positions of authority were 4 times greater when working at a nonelite academic or industrial organizations.

The third model in Table 3 suggests how scientists from less prestigious programs attained good jobs

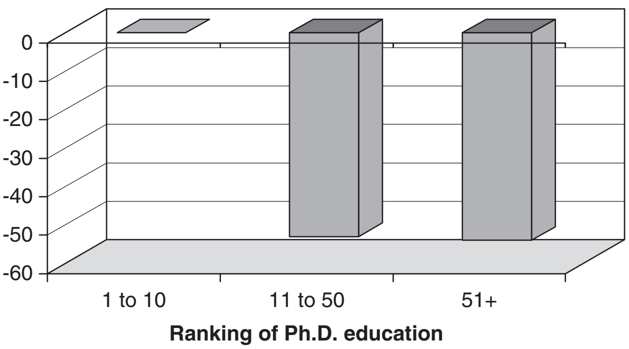

Figure 3. Among Scientists Employed at Prestigious Organizations, Percentage Change in the Odds of Obtaining a Supervisory Position, by Ranking of Ph.D. Education

Note: The comparison category is having a Ph.D. from a top 10 program. Other bars show the decrease in the odds of having a leadership role (but only for scientists at top universities or dedicated biotech firms), controlling for gender and experience.

(e.g., by working outside of elite universities) but still leaves the puzzle of the Ph.D.'s from middle-ranked schools. Those from what scientists called "pretty good" schools had a worse likelihood of good jobs than Ph.D.'s from less prestigious programs in most life science organizations and had no better odds of being principal investigators in elite university and industry settings.[6] For the most part, scientists who languish in low-paying, less autonomous positions after investing so much in their human capital are not from the least prestigious universities; they are from the middle-ranked schools.

Discussion

To summarize the rather unexpected findings of this project, one might consider variations on Merton's (1968) Matthew effect. It is true for Ph.D.'s educated at elite programs that to those who have, more is given. Those from top-ranked programs have the advantage for supervising, especially at elite organizations. For doctoral life scientists from lesser ranked programs, however, instead of "to those who have not, what little they have is taken away," one might say "to those who have not, what little they have they get to keep." At less prestigious laboratories, those from low-ranked schools have no less chance of leading than elite educated Ph.D.'s. To describe Ph.D.'s from middle-prestige programs, in a spin on the Matthew effect, we could state that "for those in the middle, there is extended servitude." Across the models (including some not presented here that disaggregated academic positions from others), Ph.D.'s with middle-ranked educational prestige were stuck longer in lower level jobs.

Why do we see these scientists "stuck in the middle?" In conversations with life scientists, when I tell them about these statistical findings, I receive surprised but not shocked reactions. The trend of Ph.D.'s from middle-ranked schools ending up in lower level positions seems to go unobserved by scientists themselves, but when confronted with the finding, they see it as logical and are able to relate stories of friends or themselves that fit the data. I turn now to exploratory qualitative data to understand why this unexpected finding for the effects of educational ranking occurs.

Jeanne, a life science Ph.D. educated at a "good but not elite" school, was a Harvard postdoc and instructor for 9 years before leaving natural science for another profession. Her perspective on the difference between a graduate education at a middle-ranked school and an elite university (on the basis of her many years working at one) was that an elite education allows many students to specialize, which is rewarded in science. She explained to me,

> One difference between top tier and the next level of schools is your teaching experience. As a grad student, someone at a top school would not have to teach. When I was a grad student at [a middle-ranked state university], I had to teach for three quarters, because there's not oodles of money like at Harvard.

Many of those earning Ph.D.'s at middle-level schools spend time as generalists in their activity, doing both teaching and research. Jeanne also argued that scientists with her kind of graduate training were educated more generally in the content of science taught: "I was in the Biology Department and we had to know everything from systematics to molecular biology. There were not enough people to spread around in the different specialties. So we learned different skills." Perhaps those stuck in the middle are simply spread too thin during training to move into early supervisory roles. If trained more generally in research and spending more time away from research to teach, those from middle-ranked schools are less connected to the reward systems of science than elites. As Jeanne described the outcome of her early career years in teaching roles, "it counts against you. You don't have enough time and connection to things that bring money in, when you're teaching." Elites can concentrate on research, and those from lower ranked schools perhaps specialize in other activities. Jeanne's comments signal that those from middle-ranked places are "jacks-of-all-trades but masters of none" and end up spending more time in postdoctoral training as a result.

The middle ranks may fall through the cracks. Elite educated Ph.D.'s likely have the recognized aspects of the Matthew effect (Merton, 1968) working for them (i.e., prestigious publications). Perhaps Ph.D.'s from lower ranked programs are likely to have other forms of social capital very different from elites (e.g., more administrative experience or teacher training) that result in leadership positions. Meanwhile, the middle ranks may be less likely to attain leadership roles because of not having the best access to specialize in either elite or nonelite social resources.

Another explanation may be that in addition to a lack of specialization, middle-ranked programs provide less consistency than both more and less prestigious departments in the match between aspirations and opportunities. In other words, Ph.D.'s from middle-ranked universities are less likely to attain leadership positions because of a mismatch between their professional socialization and the available jobs. Those from top places gain leadership roles at highly visible organizations, and those from less prestigious places take leadership roles at organizations that Ph.D.'s from middle-ranked universities do not consider for employment. Stuart's position provides an example of an ambitious young scientist from a middle-ranked educational background. At the time I spoke with him, Stuart was in a nonleadership academic position at a top university. He lamented, "The head of our program basically told me that there are no openings for tenure track in-house right now." My field notes reveal his struggle to gain a leadership role in a prestigious organization, and concurrent reluctance to take any job in a lower ranked setting:

> Stuart spoke in a somewhat envious tone of a friend with "lots of scientific resources" who helped to start up a biotech firm and also had a position at Stanford as an assistant professor. "Some people have all the luck," he said. When I asked if he would consider a job in industry, he replied, "only in an established biotech firm, like Genentech." In asking about academia, I noticed that his aspirations for a tenure track job were at prestigious places just below the top ten, including Baylor and University of Washington. He wasn't sure where he would be able to get a job next, but was only willing to "go where good research programs are." For universities he would not consider moving outside of cities where he considered the geographical research centers to be, or to lower ranked institutions. "There's no way I'd do that," was his reaction.

Stuart's opinion that nonleadership work at an elite organization is preferable to leading at one with low standing may be held by other scientists with middle-ranked educational backgrounds, leading to the results found in Table 3. After he left that lab, Stuart took another nonsupervisory role at a laboratory at a top university in another state, in the hope of jumping to the tenure track eventually. Stuart was in his late 30s, his curly black hair glinting with silver-gray highlights. He would not marry his girlfriend until he "knew where he would end up." Stuart seemed to view a lower level job at a top place as a stepping-stone to a higher level position. But are these positions stepping-stones or places from which one is more likely to slip off? Jeanne and others like her have left science from such unstable positions.

The qualitative data illuminate aspects of the process and meaning of graduate education in the life sciences. Variation in the career goals of young Ph.D.'s and achievement can be traced in part to the ranking of their schools. The resistance of scientists trained at middle-ranked schools to entering less prestigious organizations in favor of lower level positions at more visible life science organizations perhaps creates vacancies for those from less highly ranked programs. This high-low split by educational background may result from midlevel institutions employing elite scientists as leaders at the same time that lower level organizations, unable to attract more prestigious employees, have a different set of candidates: those from lesser ranked schools. Some Ph.D.'s are stuck in the middle because the scientists from middle-ranked schools are more likely to take lower level positions at prestigious organizations than supervisory roles in other settings. The ways that education shapes career norms and preferences may have important implications for the career mobility of a large number of professionals. Placement in a stratified educational system can affect not only structural opportunities but individuals' perceptions of available positions as well.

We need more research on how employers of scientists perceive educational prestige as well. Perhaps those hiring life scientists believe that Ph.D.'s from lower ranked programs will be more stable, long-term employees than those with more prestigious degrees, who will leave. In this case, there would be more demand for those with lower ranked, perhaps more local university degrees, than for Ph.D.'s from the middle prestige ranks. At the same time, it may also be the case that the uncertainty inherent in the rapidly changing science in biology makes it especially difficult to judge who is best prepared to lead project teams. Thus, Ph.D.'s with highly prestigious degrees are especially sought after because objective measures (such as a programming test for computer scientists) are not feasible. These combined employer perceptions about lower and higher prestige education would place those from middle-ranked schools at the end of the queue. Further research on employers' understanding of the meaning of doctoral program prestige could test these ideas.

In a knowledge-expanding field such as the life sciences, being stuck on the bottom rung early on can adversely affect a Ph.D.'s career. Suppose a female scientist working for someone else has a paradigm-shifting new scientific idea but cannot pursue a large project that requires a laboratory staff of one's own (or does not want credit for the idea to go to her current boss). By the time she becomes a principal investigator, science may have moved on past her once innovative idea. This outcome would only increase her sense of alienation at being stuck in a supporting role.

Moreover, there are implications of this study's findings for the ability of scientists to feed their families. Especially in the most expensive metropolitan areas in the United States, where many scientists work (e.g., the San Francisco Bay area, Boston), those who are stuck in nonsecure employment earn only enough to get by, in stark comparison with those who are able to move up into supervisory positions. A survey of life scientists reported in *Science* (Holden, 2001) demonstrated the dramatic difference in livelihood. Postdoctoral fellows at universities and science-based firms earned median annual salaries from $32,000 to $36,000 (in 2001 dollars). In contrast, assistant professors and investigators leading research in industry have median salaries ranging from $60,000 to $80,000 annually. If Ph.D.'s from middle-ranked programs are waiting longer to move into more comfortable income brackets, and perhaps delaying having children as a result, there are possible implications for lifetime earnings and fertility.

More scholarly study of postdoctoral positions, informed by sociological theory, is needed. What will be the effects of the increasing the number of years scientists spend in low-autonomy positions? The number of science and engineering doctoral recipients with postdocs has doubled in the past two decades. Although two thirds of all postdocs are located in the life sciences, the rate of spending time in postdoctoral positions has grown in engineering, social and behavioral sciences, and physical sciences as well (National Science Foundation, 2006, Figure 2-28). Government statistics can show us trends, but more qualitative analysis would reveal what the experience means to the morale of scientists. Twenty-five years ago, Hartnett and Katz (1977) called for a revamping of graduate training to bring students' aspirations more in line with the reality of a tight academic labor market. The stopgap measure to deal with even more Ph.D.'s matriculated since then seems to have been to create more postdoctoral fellowships, and for longer periods. It is past time to revisit policies for graduate and postdoctoral training, especially for Ph.D.'s who are more likely to get stuck waiting for the "right" job.

Notes

1. This finding may be limited to the developed world. Shrum and Campion (2000) found that for academic scientists in less developed countries, there are fewer returns to having had prestigious doctoral education abroad.

2. Other factors may also affect a scientist's ability to obtain a leadership role, including race, productivity, and social capital. Unfortunately, data on these variables were not available. The reader should keep in mind that the analyses presented did not control for these other variables.

3. Names used in this article are pseudonyms to protect the confidentiality of my informants.

4. Strictly speaking, general log linear models would be most appropriate because the quantitative sample was drawn by university rather than by the random selection of individuals. Thus, some underlying bias, for example, the gender distribution of individuals by university, might violate the logistic regression assumption of fixed values of x (i.e., gender). The distribution of gender for each university was explicitly examined and not found to significantly differ in the proportion of men to women; a bias that would violate the logistic regression assumption was not found. Because of the ease of interpretation and wide familiarity of logistic regression models, these models were used instead. General log linear regression analyses of the same variables (not presented here) produced essentially the same results. The general form of Model 2, incorporating the three hypotheses, can be described by the following equation for the logistic regression: Prob(Position = Supervisor) = $1/(1 + e^{-z})$, where z = Constant + Education Rank + Gender + Years Since Ph.D. + Prestige of Employing Organization.

5. However, this gendered result did vary by the type of organization in which scientists worked. Smith-Doerr (2004) found that women employed in science-based biotechnology firms relying on interorganizational networks were nearly 8 times more likely to achieve positions of authority than women in the more hierarchical settings of academe and traditional pharmaceutical companies.

6. This finding was robust across other models not presented here. For example, I divided the middle group in half at the mean university ranking score, but the results were similar for both of these middle-ranked categories.

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