VIEWPOINT

Postdoctoral Patterns, Career Advancement, and Problems

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Postdoctoral appointments can have different functions and meanings, depending on the field and whether the postdoc is a man or a woman. The *Ph.D.'s—Ten Years Later* study confirmed that in biochemistry, the postdoc, not the Ph.D., has become the general proving ground for excellence both in academia and industry. Because they spent a longer time in these "mandatory" postdocs, biochemists had the largest proportion of untenured faculty 10 to 13 years after the Ph.D. In mathematics, where substantially fewer postdoctoral positions are available, Ph.D.'s taking postdocs are more likely to obtain faculty positions, but this is true only for men. University administrators should be accountable for monitoring the total time spent in these positions and should provide administrative assistance for skills training, career growth, and the job search. In addition, creative solutions concerning the dual-career couple phenomenon are necessary.

Recent reports in the United States have claimed that increasing numbers of Ph.D. scientists are holding postdoctoral appointments for longer periods than ever. Concern about the implications for careers in the life sciences even prompted a warning from a National Research Council committee about a possible overproduction of Ph.D.'s in this area (*1*). However, recent comprehensive data on postdoc appointees and their experiences have not been available, given that the last national postdoc survey was published 15 years ago (*2*). Rectifying this situation was one of the goals of the *Ph.D.'s—Ten Years Later* study (*3*), which collected data on the career paths of scientists and engineers in biochemistry, computer science, electrical engineering, and mathematics, including the role of postdoc appointments (Table 1). Here we highlight some results from this study and discuss some of the implications for policies regarding postdoc positions.

Addressing matters related to the educational and training environment of postdocs in the United States is complicated, because few universities have a central authority overseeing the conditions of postdoc appointments, such as duration, salary structure, benefits, and placement services. Few universities can provide a truly accurate count of the number of postdoc fellows on campus. These deficiencies exist because of the lack of a consistent definition among hiring units in universities and other laboratories of what constitutes a postdoc, and because postdocs are compensated and recorded in several different ways—some are paid as university employees, some are paid through an entirely separate stipend account, and others are paid directly by foundations and foreign governments.

We analyzed the career paths of the 86% of Ph.D. biochemists and 31% of Ph.D. mathematicians responding to the *Ph.D.'s—Ten Years Later* survey who had held postdoc appointments. In computer science and electrical engineering, less than 10% of respondents had a postdoc appointment along their career path.

In biochemistry, for the cohorts who graduated from July 1982 to June 1985, the postdoc was the norm. In this field, a postdoc appointment is regarded as a necessary step after doctoral completion, whether the individual plans a career in academia or in the business, government, or nonprofit (BGN) sectors. Consequently, the postdoc, not the Ph.D., has become the general proving ground for academic excellence, scientific entrepreneurship, and ultimate intellectual independence.

By 1995, about half of all Ph.D. biochemists who had held postdocs (49%) were employed in the BGN sectors, and the other half (51%) worked in various jobs within academia; 34% held a tenured or tenure-track faculty position (Table 2). Not surprisingly, biochemists outside of academia earned almost $22,000 more in median annual total salary (including consulting, overtime, summer research or teaching,

Table 1. Size of the surveyed population and response rates. The data cover Ph.D. recipients in six fields at 61 universities from 1 July 1982 to 30 June 1985.

Major field	Men	Women	International (out of total)	Total	Total responses (*n*)	Response rate (%) Domestic	Response rate (%) International
Biochemistry	694	268	97	962	654	70	50
Computer science	583	69	209	652	388	65	51
Electrical engineering	966	36	417	1002	534	57	48
English	567	650	72	1217	814	67	65
Mathematics	1005	187	395	1192	752	67	57
Political science	630	199	144	829	525	68	47
Total	4445	1409	1334	5854*	3667	66	52

*This number excludes 63 people who were deceased.

Table 2. Employment in 1995 by postdoc history and gender. Data are in percent except where raw numbers are given in parentheses. M, men; F, women.

	Biochemistry				Mathematics			
	Postdoc		No Postdoc		Postdoc		No Postdoc	
	M (376)	F (143)	M (63)	F (20)	M (180)	F (37)	M (395)	F (85)
Tenured faculty	20	18	21	(2)	75	46	56	54
Tenure-track faculty	15	16	16	(5)	9	(2)	6	5
Academic researcher	3	8	(2)	–	1	–	2	4
Academic other	9	17	(4)	(5)	3	(5)	5	3
BGN researcher	35	23	32	(2)	5	30	21	18
BGN manager/executive	12	13	13	(2)	4	(1)	5	8
BGN other	6	4	(4)	(3)	2	(1)	3	8
Both academic and BGN	(1)	1	(2)	(1)	1	–	2	–

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and other income sources) than those employed in the academic sector (where the median salary was $57,000) (*4*).

On average, the biochemists employed in academia in 1995 had spent 7 months longer in postdoc appointments than the 3.5 years of those employed in the BGN sectors. The length of time spent in postdoc training did not appear to be a factor in the decision to appoint a postdoc to a faculty position. However, if the postdoc period was 5 years or less, those who were hired into the faculty had a better chance of being appointed to a position at one of the top quarter (*5*) of doctoral programs. Individuals who received one of the prestigious, portable postdoctoral fellowships from the National Institutes of Health or the National Science Foundation (NSF), as did 12% of the first-time biochemistry postdocs, had an advantage when competing for faculty positions in the top-quarter–ranked doctoral programs.

The results of the study revealed that university administrators and professional societies in the sciences need to be concerned both about the long time it takes to earn a doctoral degree and about long intervals between Ph.D. degree completion and the first non-postdoc position. Biochemists spent 3.8 years in postdoc appointments, whereas mathematicians spent 2.5 years and computer scientists and electrical engineers only 1.6 years. As a result biochemists, who had the shortest time to Ph.D. among these disciplines but essentially faced a mandatory postdoc, had the largest proportion (46%) of untenured faculty 10 to 13 years after completion of the Ph.D. (Table 3).

Fewer postdoc appointments are available in mathematics than in biochemistry. These seemed to be highly sought after by those whose career goal was a faculty position. Just under one-third of the Ph.D.'s in mathematics spent time in postdoc training, and of these, 78% held a tenured or tenure-track faculty position in 1995. However, a large proportion (61%) of mathematicians who did not take postdoc appointments also held a tenured or tenure-track position in 1995, and almost one-third (31%) found employment in the BGN sectors (Table 2). Unlike biochemistry doctorates, 21% of mathematics Ph.D.'s spent a portion of their postdoc appointment abroad (domestic, 14%; international, 36%).

The survey results also revealed two particular positive outcomes for mathematics postdocs. First, the time invested in a postdoc significantly improved the odds of gaining a faculty position in the top quarter (*5*) of research doctorate programs—particularly if the applicant was among the 12% of first-time postdocs (*6*) who received a portable fellowship, such as an NSF fellowship, or had spent a year or more at one of the internationally renowned mathematics institutes. However, this was true only for men, 84% of whom were tenured or tenure-track faculty in 1995, and not for women (Table 2). Second, the experience gained in a postdoc position in mathematics, often called a visiting assistant professorship, seemed to be reflected to a modest extent in a shorter tenure clock. The

Table 3. Age at tenure and percent in tenured and tenure-track (TT) positions in 1995 in the United States, by field.

	Age at grad school entry	Time to Ph.D.	Years between Ph.D. and TT	Years to tenure	Age at tenure	Tenured (%)	TT (%)
Biochemistry	22.8	5.9	4.1	6.1	38.9	18	16
Computer science	23.1	7.6	0.5	6.1	37.3	32	4
Electrical engineering	23.5	6.4	1.3	5.7	36.9	24	3
English	23.7	8.9	1.1	5.9	39.6	57	6
Mathematics	22.6	6.9	1.4	5.6	36.5	59	6
Political science	23.7	8.7	0.5	6.2	39.1	54	8

Table 4. Family, postdoc appointments, and career. Data are in percent except where raw numbers are given in parentheses. M, men; F, women.

Did postdocs	Biochemistry				Mathematics			
	Married at Ph.D.		Not married		Married at Ph.D.		Not married	
	M	F	M	F	M	F	M	F
Goal at end of Ph.D.	(182)	(77)	(192)	(73)	(66)	(20)	(119)	(15)
Wanted to become a professor	37	26	35	32	70	55	58	40
First employment after postdoc*	(184)	(79)	(201)	(76)	(69)	(21)	(113)	(18)
Tenure-track faculty	25	23	27	18	71	29	62	72
Academic researcher/other	24	32	20	38	16	28	19	(2)
BGN researcher/other	45	41	47	39	(2)	43	12	(1)
Spouses' 1995 education	(177)	(73)	(159)	(48)	(64)	(19)	(85)	(10)
Spouse had a Ph.D., J.D., or M.D.	24	75	43	56	25	84	22	80
Employment 1995	(179)	(77)	(197)	(66)	(69)	(20)	(111)	(17)
Tenure-track faculty	15	20	15	12	(4)	(1)	11	(1)
Tenured faculty	21	17	19	18	84	35	69	59
Academic research/other	12	23	13	29	(1)	(1)	6	(4)
BGN researcher/other	39	26	42	29	(5)	50	9	(2)
BGN manager/executive	13	14	11	12	(1)	(1)	5	–

*First employment after postdoc may not total 100% because the small numbers of tenured faculty and BGN managers and executives are not given.

Table 5. Major reasons for choosing postdoc appointments. Data are in percent except where raw numbers are given in parentheses. M, men; F, women.

	Biochemistry				Mathematics			
	First postdoc		Last postdoc		First postdoc		Last postdoc	
	M	F	M	F	M	F	M	F
Necessary employment step	76	76	59	49	57	35	56	(2)
Additional training	38	38	22	11	46	53	25	(2)
Training in another field	42	45	42	44	7	–	6	–
Specific organization	10	6	14	11	16	(3)	29	(3)
Specific person	32	33	36	36	23	(5)	38	(3)
Only acceptable employment	11	9	24	22	31	(5)	22	(2)
Specific geographical area	17	29	30	52	16	35	20	(5)
Location worked for both spouse and self	21	38	38	66	15	50	17	67

same is not true in biochemistry. Like the biochemists, however, mathematicians working in the academic sector in 1995 earned less annually than did their counterparts in the BGN sectors (an average of $53,000 versus $80,300).

A substantial percentage of women in mathematics who did postdoc training in the hope of becoming a professor did not realize this aspiration. Women who were married at the time of Ph.D. completion and who held postdoc positions were more likely to end up in research positions in the BGN sectors than in academia (Table 4). Women postdocs in biochemistry, whether married or not, held tenured or tenure-track positions in 1995 at about the same proportion as men, although women stayed slightly longer in postdoc positions and thus advanced even more slowly to tenured faculty positions than men did. Furthermore, for women in both biochemistry and mathematics, the motivation to enter postdoc positions often seemed to be related to the desire to live in the same location as their partners and to combine family and career (Table 5).

Less has been known, in either discipline, about the careers of international students who studied in the United States. The 1983–1985 Ph.D. cohorts comprised 10% international students in biochemistry (*7*) but 33% in mathematics. International and domestic Ph.D.'s in both disciplines assumed postdoc positions in about the same proportions. Half of the U.S.-trained international mathematicians remained in the United States. For them, postdoc training did not affect the odds of their holding a faculty position—in 1995, with or without postdoc training, 75% of these U.S.-trained international mathematics Ph.D.'s were in tenured or tenure-track positions. Although few of the prestigious U.S. postdoc fellowships are available to non-U.S. citizens, the postdoc gave them a hiring advantage for faculty positions at the top quarter (*5*) of research universities.

In their search for more permanent employment, postdocs used many sources of assistance with varying degrees of utility. The postdoc mentor was certainly important for biochemists in the job search, but less so for mathematicians, who returned to their Ph.D. advisors for this significant support. The second most commonly used source was job notices in relevant journals. Universities should certainly extend the placement services that they offer to doctoral students to postdocs.

In light of the *Ph.D.'s—Ten Years Later* findings (not all of which we could cover here), and from our experience as doctoral and postdoctoral administrators, we recommend that universities designate a central authority for postdoc affairs—either the senior research administrator or the graduate dean. This office should monitor the total length of time graduates spend in postdoc appointments, allowing a maximum of 5 years in these training positions, including time spent at other institutions (*8*). Any subsequent appointments, even if they are by fiscal necessity temporary, should be staff appointments and should reflect career growth and advancement. Adequate salaries and employment benefits should be ensured for postdoc appointees. Administrative assistance should be provided to create a campus-wide postdoc community to combat the frequent experience of isolation, to provide the skills training necessary for becoming a professional in academia or the BGN sectors (including grant writing and presentation and communication skills), and to support career planning and job search activities. Finally, we recommend that a high-level National Research Council (NRC) committee be established to develop creative solutions, especially in the universities, to the widespread phenomenon of dual careers for couples. More spousal accommodation would enable our country to take greater advantage of the proven talent of its men and women scientists.

References and Notes

1. NRC, *Trends in the Early Careers of Life Scientists* (National Academy Press, Washington, DC, 1998).
2. W. Zumeta, *Extending the Educational Ladder. The Changing Quality and Value of Postdoctoral Study* (Lexington Books, Heath, Lexington, MA, 1984). See also these earlier studies: NRC, *Postdoctoral Appointments and Disappointments* (National Academy Press, Washington, DC, 1981); NRC, *The Invisible University: Postdoctoral Education in the U.S.* (National Academy Press, Washington, DC, 1969).
3. *Ph.D.'s—Ten Years Later* is a national study, conducted by us, of the career paths of doctorates, involving almost 6000 Ph.D.'s from six disciplines (biochemistry, computer science, electrical engineering, English, mathematics, and political science) from 61 doctoral-granting institutions across the United States. The Mellon Foundation funded this study, and selected analysis was funded by NSF. The survey population accounted for 57% of Ph.D.'s awarded at all U.S. institutions in the six selected disciplines between 1 July 1982 and 30 June 1985. The study had a total response rate of 66% from domestic Ph.D.'s (U.S. citizens and permanent residents) and a 52% response rate from international Ph.D.'s (temporary visa holders at the time of their doctorate completion). The number of minority respondents was too small for a meaningful analysis.
4. These salaries are those of biochemists employed within the United States.
5. "Top quarter" refers to a 1982 NRC evaluation of doctoral programs [*An Assessment of Research—Doctoral Programs in the United States: Biological Sciences and Mathematical and Physical Sciences* (National Academy Press, Washington, DC, 1982)].
6. Counting all postdocs, 14% of the biochemists and 19% of the mathematicians held portable fellowships.
7. Before 1985, relatively few international students (temporary visa holders) studied biochemistry in the United States.
8. It is difficult to understand why, after a well-organized doctoral program and a 2- or 3-year postdoc position under a thoughtful mentor, a Ph.D. would not have acquired the necessary skills for more permanent employment.

9. We thank the research team of the *Ph.D's—Ten Years Later* study (E. Armstrong, M. Goulden, D. Gupta, R. Sadrozinski, L. Sells, O. Shakked, and E. C. Rudd) and D. S. Miller for editorial suggestions.