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Postdoctoral Appointments and Employment Patterns of Science and Engineering Doctoral Recipients Ten-plus Years after Ph.D. Completion: Selected Results from the "Ph.D.s - Ten Years Later" Study[1]

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In an episode of the highly acclaimed television show, *Law & Order*, a physicist, unable to find an academic position after years of education and postdoctoral appointments, is working as a doorman at a New York hotel. When he discovers that his proton decay theory has been stolen by a celebrated physicist, he snaps. A letter bomb intended for the unscrupulous scientist instead kills his estranged wife. The story includes a few more twists of plot: an affair, a prosecutor sympathetic to the misguided physicist/doorman, and plenty of commentary on the underemployment of highly educated scientists. Luckily, although the television series is often based on actual events, most scientists do not end up spending their post-Ph.D. years behind bars serving 25 to life. What are the career outcomes for science and engineering Ph.D. recipients?

Ph.D.s - Ten Years Later, a national study of the career paths of doctoral recipients and the feasibility of assessing doctoral programs in terms of the career outcomes of graduates, addresses this question. The study involved almost 6,000 Ph.D.s from 61 doctorate-granting institutions across the United States[2] and focused on six disciplines selected from major fields of study: life science (biochemistry), engineering (computer science, electrical engineering)[3], humanities (English), physical science (mathematics), and social science (political science). We selected the 61 universities based on their participation in the 1982 National Research Council doctoral program assessment, the availability of doctoral programs in the selected fields, level of Ph.D. production (minimum of six Ph.D. degrees in the three years sampled), geographical distribution, and a representative mix of private and public institutions. Once an institution was selected, all doctoral recipients of the relevant programs were included in the survey population. No sub-sampling occurred. This survey population accounted for 57% of Ph.D. degrees awarded at all U.S. institutions in the six selected disciplines between July 1, 1982, and June 30, 1985.[4]

We obtained addresses for Ph.D. recipients from participating institutions, commercial locator agencies, professional association membership directories, the national faculty directory, the national telephone directory and on-line search engines as well as library author searches. Surveys were mailed out between October 1996 and October 1997. The overall response rate was 63% (66% from U.S. citizen and permanent resident Ph.D.s and 52% from foreign doctorate recipients who were temporary visa holders at the time of their doctorate completion).[5] Biochemists responded at the highest rate of 68% (70% of domestic Ph.D.s), English Ph.D.s and political scientists followed with response rates of 67% (also 67% of domestic English Ph.D.s) and 64% (68% of domestic political scientists), respectively; we achieved response rates of 63% of mathematicians (67% of domestic Ph.D.s), 60% of computer scientists (65% of domestic Ph.D.s), and 53% of electrical engineers (57% of domestic Ph.D.s).

The survey questionnaire focused on the employment history of the doctorate recipients and probed about the job search process and factors important in the decision to accept the first and current positions; it also asked for retrospective evaluations of their doctoral program and the usefulness of the doctoral degree. In addition to the survey, we conducted in-depth interviews with 64 people to provide information about the context within which people make career decisions. We chose those interviewees according to regional density by discipline, and by willingness and time to be interviewed. The *Ph.D.s - Ten Years Later* data set has been integrated with the *Survey of Earned Doctorates* data of the same group, allowing analysis by type of institution, time-to-degree, program size, parental education, and fellowship support.

A comprehensive analysis of the findings from the Ph.D.s - Ten Years Later study will appear in the forthcoming book *The Ph.D.- Passport to Multiple Destinations*. Here we present major findings regarding postdoctoral appointments and employment outcomes ten to thirteen years later for the five science and engineering fields.[6] The numbers reported have been weighted to be representative for the population of 170 Ph.D.-granting institutions

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rated in the 1982 NRC doctoral program assessment.[7] Where appropriate, we compare the findings from *Ph.D.s - Ten Years Later* to results of the *Survey of Doctorate Recipients* (SDR).[8] Differences between the groups[9] have been cited only if they are statistically different at the 95% confidence level.

Postdoctoral Appointments

Postdoctoral appointments are a standard component of careers in the life sciences and common in the physical sciences. Eighty-five percent of biochemists reported having held an average of 1.5 postdoctoral appointments for an average of 3.8 years. Close to a third[10] (28%) of mathematicians reported holding an average of 1.5 postdoctoral appointments for an average of 2.4 years (table 1). Among biochemists and mathematicians who had worked as postdocs, a substantial minority (40%) reported having had two or more postdoctoral appointments.

Postdoctoral appointments are much less common in the other fields surveyed, with only 9% of electrical engineers, 8% of computer scientists, and 8% of political scientists reporting ever having held a postdoctoral appointment (table 1).

Employment by Sector and Ph.D. Employment Type in 1995

Ten to 13 years after completing graduate school, more than half of the Ph.D.s in biochemistry, computer science, and electrical engineering were employed outside the academic sector in the business, government, and non-profit sectors (BGN).[11] In contrast, more than two-thirds of the mathematicians and political scientists worked in the academic sector[12] (figure 1 - see page 7).

Although only small percentages of each group worked simultaneously in both sectors, this work pattern might be an interesting future trend, given the increasing interactions between academic institutions and industry, and should therefore be monitored.[13]

Ten years after earning the doctorate, 53% held academic appointments. 39% of Ph.D. recipients in the five science and engineering fields worked for doctorate-granting universities[14] while 14% worked for non-Ph.D.-granting universities. About one-third of the Ph.D. recipients worked for business and industry employers. The remaining 14% were spread across several different kinds of employers, with 4% working for local, state, and federal government agencies, 2% for non-profit organizations, 2% for national laboratories, and 6% working for military, university hospital, community colleges, and "other" employers.

Academic Employment

Although most Ph.D. recipients employed in the academic sector were tenured faculty by 1995, there were important disciplinary differences (figure 2 - see page 7). Due to lengthier postdocs, only one-third of biochemists in academe had tenure[15] and another 34% of them were in tenure-track positions in 1995. Biochemists also had the largest group (33%) in other academic positions; these were primarily research or lecturer appointments.

Total Annual Median Salary[16]

For Ph.D. scientists in each of the five fields, total annual median salaries were higher by about $17-28,000 in the BGN sectors than in the academic sector.[17] The total annual salary reflects pretax income, including bonuses, overtime, summer teaching or research and pay for other extra activities. Computer scientists and electrical engineers reported the highest annual salaries in the academic sector, while the political scientists in the business sector reported the highest median business salaries (figure 3).

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***TABLE 1:* Postdoctoral Appointments by Field**

Field	*Percent Having a Postdoc*	*Mean Number of Appointments*	*Mean Years*	*Median Years*
Biochemistry	85%	1.5	3.8	3.5
Computer Science	8%	1.2	1.5	1.1
Electrical Eng.	9%	1.3	1.7	1.1
Mathematics	28%	1.5	2.4	2
Political Science	8%	1.3	1.3	1

Note: Excluded from these calculations are any postdocs that began immediately after the Ph.D. in the Ph.D- granting institution and lasted for less than 9 months.

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Reasons for Not Working

Only 2.5% of Ph.D. scientists and engineers were not in the paid work force in 1995. Reasons for this included unemployment and fringe employment[18] (0.3% of the population), being between jobs, having a medical disability, being retired and being a caretaker. Women biochemists who were not in the work force were especially likely to be home with children. Some of these female scientists explained that the organization of work in biochemistry labs had forced them to choose, at least while their children were young, between being mothers and working in biochemistry fulltime.

Summary

The findings of *Ph.D.s Ten Years Later* show very positive career outcomes and very low unemployment rates for science and engineering Ph.D.s. But, they also point to problem areas such as the long period of time biochemists spend in mandatory postdoctoral appointments, the need to prepare doctoral students for work in various employment sectors, and the difficulty of combining a family with a science career.

Taking a postdoctoral position after completion of the doctorate and before moving into more permanent employment has become the norm in biochemistry whether subsequent employment is in the academic or business, government, or non-profit sectors.

Biochemists not only had the largest proportions in postdoctoral appointments as compared to the other four science fields, they also spent the longest average time in such positions. The educational and training value of such long postdocs will need to be carefully examined in order to prevent postdoctoral positions from becoming a holding pattern.

About 70% of the science and engineering Ph.D. recipients who entered the academic sector were tenured faculty in 1995, except in biochemistry. The effect of the extended stay in postdoctoral training in biochemistry resulted in just 30% tenured faculty in 1995 and another 34% being still tenure-track assistant professors ten to thirteen years after degree completion.

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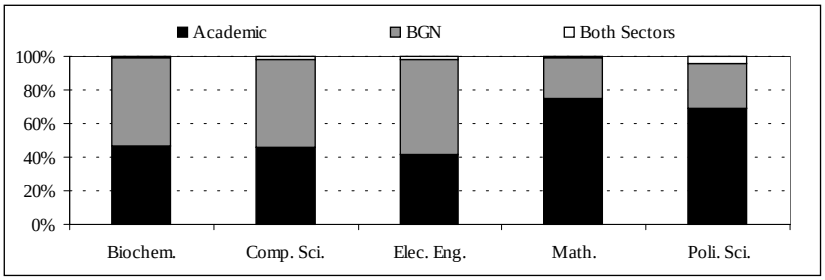
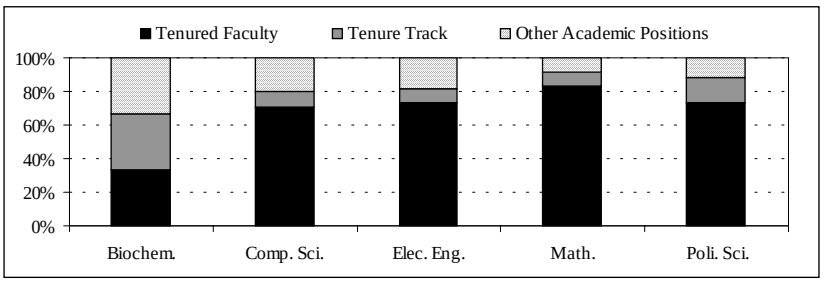
FIGURE 1*: Employment Sector by Field, Dec. 1995*



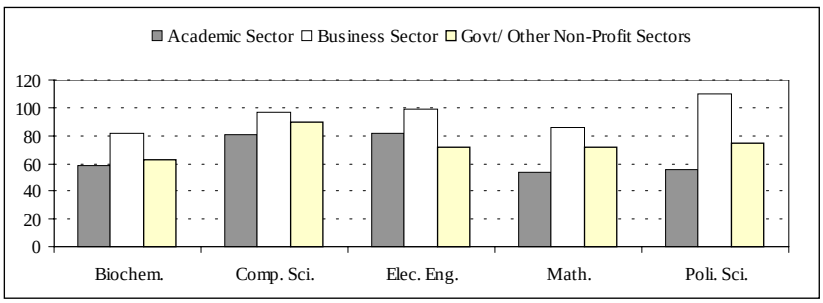
Note: Excludes those not in the workforce (2.5%) and those indicating no sector (5.5%) – Total (8%)

***FIGURE 2*: Academic Employment by Field, Dec. 1995**



Source: "Ph.D.s– 10 Years Later" Study, UCB Graduate Division

***FIGURE 3*: Total Annual Median Salary by Field and Sector: (Dec 1995)**



Note: Total annual salary reflects pre-tax income, including bonuses, overtime, summer-time teaching or research and pay for other extra activities

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[4] Golde, Chris M. and Dore, Timothy M, *At Cross Purposes: What the experience of today's doctoral students reveal about doctoral education*, January 2001, p. 34.

[5] *Ibid.* , p.33.

[6] *Ibid.* , p. 29.

[7] Lovitts, Barbara, and Cary Nelson, " A Hidden Crisis in Graduate Education: Attrition from Ph.D. Programs," *Academe*, November-December 2000, p. 49

[8] *Ibid.*, p. 30.

[9] Barbara E. Lovitts, *Leaving the Ivory Tower*, Rowman & Littlefield Publishers, Inc., Boston and London, 2001, p. 51.

[10] *Ibid.* p. 37

[11] John L. Snell, "The Master's Degree, " in *Graduate Education Today*, Everett Walters ed., American Council on Education, Washington, D.C., 1965, pp. 81-2.

[12] Syverson, Peter, "Data Sources: The New American Graduate Student, Part II," *Communicator*, June 2002.

[13] Lovitts, *op. cit.*, p. 177.

[14] Golde and Dore, *op. cit.*, p. 30.

[15] Lovitts and Nelson, *op. cit.*, p. 45.

[16] Golde and Dore, *op. cit.* , p. 32.

[17] John L. Snell, *op. cit.*, p. 82.

[18] Clifton Conrad, Jennifer Grant Haworth, and Susan Bolyard Miller, *A Silent Success: Master's Education in the United States*, The Johns Hopkins University Press, Baltimore and London, 1993, p. 11.

[19] Actually, this should have been the title of the talk. However, Return of the Masters sounds more interesting!

[20] Stephen H. Spurr, *Academic Degree Structures: Innovative Approaches*, The Carnegie Commission on Higher Education, McGraw-Hill Book Company, New York, 1970, p. 80.

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The fact that more than half of the Ph.D.s in biochemistry, computer science, and electrical engineering were employed outside academia needs to be reflected in doctoral curricula in these fields. Doctoral programs should recognize the fact that their graduates become professionals in a variety of employment sectors.

The percentage of Ph.D. scientists and engineers who were not in the paid workforce in 1995 was extremely small. Hardly anyone was involuntarily out of work and seeking employment. However, many women commented on the difficulty of combining the raising of children with being a lab-based scientist. As one woman interviewed for the study succinctly put it:

"If academia wants more women in science, engineering, and mathematics, they need to be more supportive of women with children. Academia cannot say, 'It's okay to have children as long as it doesn't inconvenience us.' For many women a doctoral education doesn't help or is not of value if they cannot get a job that will allow them time out for kids or to arrange teaching schedules so they can take kids to school in the morning."

Thus, while many federal agencies have focused on increasing the number of women Ph.D.s, it is clear that support for men and women with child care responsibilities needs to be extended throughout the doctoral and postdoctoral years--and beyond to make sure that scientists are not forced to leave their chosen professional path because of the difficulty of combining a family with a career in science. ❖

Notes

[1] Many thanks to Elizabeth Rudd for her excellent work on this article.

[2] This survey was funded by the Mellon Foundation and selected analysis by the National Science Foundation.

[3] At some universities these two programs exist in one department; in others, they are two separate entities.

[4] In order to capture long-term career outcomes, we surveyed doctorate recipients at least 10 years after they earned the Ph.D. The book on the complete finding of the *Ph.D.s - Ten Years Later* survey will examine multiple relationships between graduate school education and career outcomes, such as the relationship between evaluation of the usefulness of the Ph.D. and respondents' employment sector, "current" job satisfaction, and the impact of family and marital status on objective and subjective measures of career outcomes among Ph.D. recipients in this study. Existing publications include an article examining postdoctoral appointments, *Science* 285 (1999) pp. 1533-1535; and an article about career outcomes of English Ph.D.s, referred to later.

[5] This response rate is calculated by taking all awarded Ph.D.s not just the ones we were able to locate. The response rate when calculated only by those we located was 70% for domestic and 63% for international PhDs.

[6] Results for English Ph.D.s are reported in "From Rumors to Facts: Career Outcomes of English Ph.D.s" *Communicator* 32(7) Special Issue Fall, 1999, reprinted in Association of the Department of English, *Bulletin* 124 (2000): 43-55.

[7] These cover around 95% of the Ph.D.s awarded in our six fields in the U.S. for academic years 1983-1985. The weighting takes into account both the sampling weights (representativeness of our sample of 61 institutions) and the weighting adjustment for survey non-response (regression model based on demographic characteristics). A full description of the methodology will appear in the forthcoming book of on the study.

[8] The SDR comparison group differs from the *Ph.D.s - Ten Years Later* sample in two important ways. First, the SDR definitions of fields do not exactly match the definition used for the *Ph.D.s - Ten Years Later* study. The correspondence between the *Ph.D.s - Ten Years* Later fields (and the SDR fields) was as follows: biochemistry (biological sciences: biochemists and biophysicists), computer science (computer science and information sciences, and computer and systems engineering), electrical engineering (electrical and related engineering fields), mathematics (mathematical sciences) and political science (political science and related fields, excluding public policy studies). Second, the SDR provides data on only those who were working within the United States at the time of the survey, while the *Ph.D.s - Ten Years Later* study also includes data on Ph.D.s working outside the United States.

[9] For more meaningful comparison with the SDR data, a special subset of the *Ph.D.s - Ten Years* Later sample, containing only those who were working in the United States at the end of 1995, was used for the purpose of significance testing only.

[10] Comparing those who were employed in the United States in 1995, the mathematicians in the SDR data reported a significantly lower percentage (p=.05) of postdoctoral appointments after their Ph.D., as well as a significantly shorter overall postdoctoral time (p=.05), than the mathematicians in the *Ph.D.s-Ten Years Later* sample. The bioscientists in the SDR data reported a significantly smaller number of postdoctoral appointments (p=.05) than the biochemists in the *Ph.D.'s - Ten Years Later* sample.

[11] Academic institutions are: Ph.D. granting university, non-Ph.D. granting college or university, two-year college or community college, university hospital, national laboratory. BGN organizations are: business or industry, state or local government agency, federal government agency, international agency, military organization, non-university hospital or clinic, foundation or other non-profit.

[12] The distribution of the SDR comparison group across sectors in 1995 was similar: most respondents in mathematical sciences and political science and related fields worked in the academic sector and more than half of those in biological sciences, computer and information sciences and electrical and related engineering fields worked in business, government, or non-profit organizations. The respondents from political science and related fields in the SDR data were significantly more likely (p=.05) to be working in the academic sector than the political scientists in the *Ph.D.s-Ten Years Later* sample.

[13] Those reporting that they were *simultaneously* holding at least one job in the academic sector and one job in the BGN sector constitute the category "Both Sectors." Tenured or tenure-track faculty who work in both sectors are included in the academic sector and excluded from the category "both."

[14] If we focus on only those employed in "Carnegie classified" academic institutions the overall percentage of Ph.D.s working in doctorate-granting institutions (Carnegie classified 11-14) was comparable to the Ph.D.s in the SDR data and those in the *Ph.D.s-Ten Years Later* sample, at around two-thirds. However, the biological scientists in the SDR data were significantly less likely to be at doctorate-granting institutions (p=.05) than the biochemists in the *Ph.D.-Ten Years Later* sample. Conversely, the computer scientists in the SDR data were significantly more likely to be in a doctorate-granting institution (p=.05) than the computer scientists in the *Ph.D.s-Ten Years Later* sample.

[15] Comparing those employed in the academic sector in the United States in 1995, the biological scientists in the SDR data were significantly more likely to be in tenure-track positions (p=.05) and less likely to be in tenured positions (p=.05), than the biochemists in the Ph.D.s - Ten Years Later sample.

[16] No direct comparison with the SDR data for the total annual salary in 1995 was made since the SDR data provide only the basic (pre-tax income, excluding bonuses, overtime, summer teaching or research and pay for other extra activities) annual salary for 1995.

[17] Because the basic salary in the academic sector in most cases is for nine months only, as opposed to 12 months in the BGN sector, we asked respondents to include all income.

[18] Fringe employment refers to those earning $5,000 a year or less.