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Biomedical science postdocs: an end to the era of expansion

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ABSTRACT **After >3 decades of steady growth, the number of biological and medical science postdoctorates at doctoral degree-granting institutions recently began to decline. From 2010 through 2013, the most recent survey years, the postdoctoral population decreased from 40,970 to 38,719, a loss of 5.5%. This decline represents a notable departure from the previous long-standing increases in the number of postdoctorates in the biomedical workforce. The rate of contraction appears to be accelerating in the most recent survey years, and this has important implications for the biomedical workforce.—Garrison, H. H., Justement, L. B., Gerbi, S. A. Biomedical science postdocs: an end to the era of expansion. *FASEB J.* 30, 000–000 (2016). www.fasebj.org**

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From 1979 through 2010, the number of biological and medical science postdoctorates (hereafter postdocs) rose annually (**Fig. 1*A***) (1). This growth in the postdoctoral population reflected both an increased number of U.S. citizens and permanent residents (referred to as U.S. hereafter) and foreign scientists on temporary visas (Fig. 1*B* and Supplemental Table S1). Only 3 times during this 4-decade span (1982, 1995, and 1999) did the number of postdoctorates tallied in the National Science Foundation (NSF) Survey of Graduate Students and Postdoctorates (GSS) fail to exceed the number reported in the previous year. (The GSS only collects information from degree-granting institutions and does not cover freestanding research institutes, government agencies, and commercial firms. Therefore, postdocs outside of academia are undercounted. The tabulations used in this study are for doctorate-granting institutions only.) At times, one population grew faster than the other. In 1979, foreign citizens on temporary visas comprised just over one-quarter of the biomedical science postdocs. During the 1980s and 1990s, the growth rate for foreign postdocs was far greater than for U.S. postdocs, and by 1999, there were more foreign than U.S. postdocs in the biomedical sciences (1). More recently, the number of U.S. postdocs in the biomedical sciences increased faster than foreign postdocs, rising from 13,583 in 2003 to 18,030 in 2009 (an increase of 32.7%), whereas the corresponding number of foreign postdocs rose from 17,677 to 19,113 (8.1%). The number of women in biomedical postdoc positions also grew steadily over the past 3 decades, rising from 22% in 1979 to 45% in 2013. Before 2000, most of the increase was from foreign women, but more recently, the increase has been driven by greater participation of U.S. women.

Beginning in 2010, the decades-long pattern of growth came to an end. The postdoctoral population decreased in 2011, 2012, and 2013. The losses are larger in each succeeding year, reaching >1100 in 2013. Over the course of the 3 yr period, the number of postdocs declined from 40,970 to 38,719, a loss of 5.5%. Although losses were found among males and females and among U.S. citizens and foreign postdocs, the largest losses were among U.S. males. Over the 3-yr period, the number of U.S. male postdocs fell by 1066 or 10.4%. This was the largest decline (in both absolute and relative terms) of any demographic group.

Change in the aggregate size of the postdoctoral population could be the result of fewer people entering the pool or a consequence of more rapid departures from the postdoctoral workforce (*i.e.*, individuals spending shorter periods of time as a postdoc). Evidence suggests that both factors are at work. Fewer people are reporting plans to become postdocs. According to the NSF Survey of Earned Doctorates (2), the number of new biological and medical sciences' Ph.D. students with definite plans for postdoctoral study after graduation has decreased in the most recent survey years (from 4397 in 2010 to 4061 in 2011, 3943 in 2012, and 3667 in 2013) even as the number of new Ph.D. students in these fields rose. Although declining numbers of Ph.D. students entering postdoctoral positions account for most of the loss of, data from another NSF survey are consistent with the hypothesis that the length of postdoctoral training is also becoming shorter. For those in the biological, agricultural, and environmental life sciences, the fraction in postdoctoral positions ≥6 yr after their Ph.D. declined from 14.9 to 14.4% (3, 4) between 2008 and 2010.

Abbreviations: ARRA, American Recovery and Reinvestment Act; GSS, Survey of Graduate Students and Postdoctorates; IDP, Individual Development Plan; NSF, National Science Foundation

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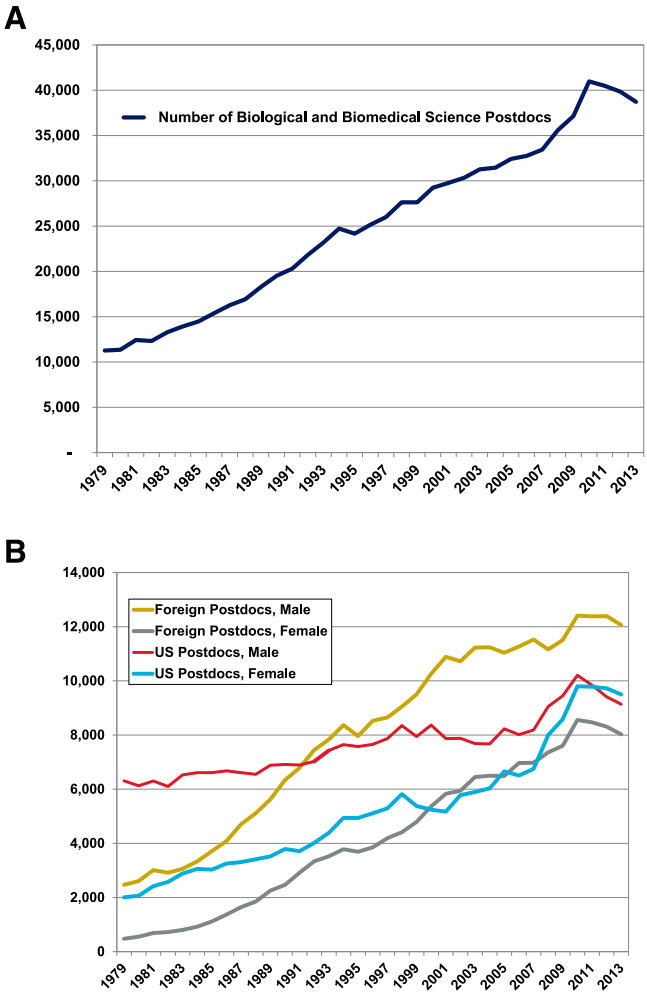

Figure 1. *A*) Biological and medical sciences postdocs. *B*) Biological and medical sciences postdocs by sex and citizenship or visa status. (Source: National Science Foundation, Survey of Graduate Students and Postdocs, *http://www.nsf.gov/statistics/srvygradpostdoc/#sd*)

What is behind the sudden decrease in the postdoc population? There are 4 possible causes for the declining number of postdocs: 1) a decrease in qualified applicants, 2) a technical change in employment titles, 3) a diminished demand for postdocs, or 4) shifting patterns in the number of doctorates willing to take these positions.

The contraction of the postdoctoral population cannot be explained by a shortfall in qualified candidates with biomedical science Ph.D. degrees. Graduation from doctorate-granting departments at U.S. institutions continued to grow at the same time that the postdoctoral population was shrinking (**Fig. 2** and Supplemental Table S2). Likewise, it does not appear that the decline in foreign postdocs is related to trends in immigration. The number of H1B visas has risen steadily since 2009, and J1 visas have remained at their 2009 level after a slight increase in 2010 and 2011 (5).

Does the decline in the number of postdocs reflect a change in nomenclature of the job title? The National Postdoctoral Association (6), the National Research Council (7, 8), and others have called for shorter periods of postdoctoral training. With funding agencies such as the NIH supporting this proposal (9), it is possible that some position titles have been changed without substantially modifying the terms of employment. Such changes in postdoc nomenclature could affect the classification of individuals with >4 yr of postdoc experience and might also contribute in part to the decreased number of postdocs reported. However, it is unlikely that this would affect the number of new postdocs and those with <4 yr of postdoc experience.

Research funding levels affect the demand for postdoctoral labor, but the relationship is complex, and fluctuations in funding levels do not have an immediate impact on the number of postdocs. The postdoc population grew when the NIH budget remained essentially flat from 2003 through 2008. In 2009, NIH received a dramatic, short-term infusion of funds through the American Recovery and Reinvestment Act (ARRA), and multiyear research grants with ARRA funds were awarded in the final 2 mo of fiscal year 2009 and in fiscal year 2010. The number of new biomedical science Ph.D. students reporting "definite plans for postdoctoral study" at the time of graduation increased by 500 between 2008 and 2009, and the actual number of postdoctoral positions reported in the GSS rose by 10% between 2009 and 2010. However, ARRA funds were still being used when the postdoc populations began to decline in 2011, and an analysis of ARRA grant budgets by fiscal year demonstrated that the largest fraction of ARRA grant funds was slated to be spent in fiscal year 2011 (10).

It may be the case that the number of research grants and the number of independent laboratories have a greater direct effect on postdoctoral hiring than the absolute size of the NIH budget. The inflation-adjusted budget of the NIH has been falling since fiscal year 2003 and lost 19% of its purchasing power between 2003 and 2012, and the total number of new and competing R01-equivalent grants, including R01, R23, R29, and R37 activity codes) declined from 29,626 in fiscal year 2003 to 26,285 in fiscal year 2012 (11). Losses of R01 grants were particularly severe in 2011 and 2012 when the number of R01-equivalent grants fell by 1274. The loss of grants and the closing of laboratories could have resulted in a loss of postdoctoral positions.

Alternatively, it may be that the declining purchasing power of grants and the rising cost of postdoctoral stipends and benefits reached a critical threshold after 2010. Postdocs are the most vulnerable part of the workforce, hired for short-duration, temporary positions. Therefore, as research budgets come under increased pressure, it would be expected that this group would be affected the most.

The decrease in number of postdocs is reflective of a broader contraction in the biomedical research workforce. Unemployment for biomedical science Ph.D. students has been increasing since the late 1990s, even though research funding was rapidly increasing. Although the unemployment rate for doctoral-level biomedical scientists in 2012 (2.3%) was well below that of the general population, it was significantly higher than it was during the peak years of NIH budget growth, 1999 and 2001 (Supplemental Table S3). The unemployment rate for "early-career" biological and medical scientists (those individuals who earned their Ph.D. within the past 4 yr) rose to 3.2%, significantly above the rate for this group in 1999 and 2001 (1.4 and 1.0%, respectively). These data suggest that it is harder now for new biomedical Ph.D. recipients to find employment than it was before 2010. Between 2007 and 2011, the

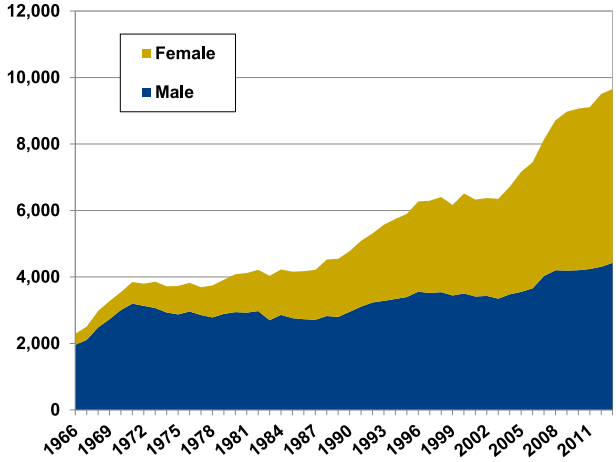

Figure 2. Doctorate degrees awarded in the biological and medical sciences by sex. (Source: National Science Foundation, Survey of Earned Doctorates, *http://www.nsf.gov/statistics/srvydoctorates/*)

number of postdoc positions advertised in *Science* declined by more than two-thirds, and competition for the remaining postdoc positions has increased (12). Opportunities in related fields are also constrained. Starting salaries for new chemistry Ph.D. students have declined substantially in every year since 2011, indicating a weakening labor market (13).

Whereas their mentors encountered an expanding job market when they completed their training, today's biomedical science Ph.D. recipients face different prospects for an academic career and may be making decisions to pursue other career options immediately after earning their doctorates. Data from the Survey of Doctorate Recipients indicate that tenured and tenure-track academic positions in the biomedical sciences rose by only 1000 between 2010 and 2012 (14). Full-time medical school faculty in basic science departments declined during this period (15). Growing awareness of the heightened competition for research grants and academic positions may have led many early-career scientists to alter their career plans. Increased competition for research funding in an era of limited budget growth has brought renewed attention to the changing nature of academic employment and may have encouraged more of the early-career scientists to reconsider their career goals and to use their Ph.D. training in a sector outside of academia. (These developments are not new, and reports have documented the challenges faced by early-career biomedical scientists since the 1990s. The decrease in the number of new biomedical science Ph.D.s planning to become postdocs, however, did not begin until 2010. It is possible that dramatic funding increases for biomedical research that included the doubling of the NIH budget between fiscal year 1998 and 2003 and the stimulus funding from the American Recovery and Reinvestment Act of 2009 initially muted the impact of the discouraging news in the employment reports.)

In response to limited prospects for academic employment, individuals and organizations have begun collecting data, as well as developing tools, programs, and policies, to help early-career scientists identify a wider range of career options. More data on temporary, nonfaculty appointments will be collected on future NSF postdoc surveys. The Federation of American Societies for Experimental Biology promoted the use of Individual Development Plans (IDPs) to assist career choice and in collaboration with other organizations made this concept available to the entire community through *myIDP* (16). NIH and many other organizations are now encouraging trainees and their mentors to use IDPs (17). Training programs are being encouraged to broaden their definition of successful career outcomes to include careers outside of academia (18), and NIH has stimulated this effort by funding programs to broaden experiences of trainees (19, 20). Early-career scientists are becoming more aware of employment options outside of academia and may choose not to pursue a postdoc or to limit their time in such positions before they pursue nonacademic careers.

Historically, the postdoctoral position has been a crucial step in the career of an independent scholar. With the growing recognition that the number of faculty positions is no longer increasing, this is a good time to reexamine the structure of the scientific workforce and the various incentives for pursuit of a research career. Rather than staffing laboratories with trainees who are being prepared for faculty positions that may not materialize, we should consider ways to create more attractive career opportunities for new generations of scientists. Staff scientist positions (21–23) that provide stability and adequate compensation are one approach. A recent report from the National Research Council, for example, recommends raising the salaries of postdocs to "appropriately reflect their value and contribution to research" (24). These options may be difficult during a time of scarce research funding. However, unless we find some way to improve career prospects for early-career scientists, we risk losing the talent that will be essential for our future progress in the biologic and medical sciences.

Is the decline in the number of biomedical postdocs good or bad? From the perspective of the newly minted Ph.D. students, eschewing a postdoc reflects a rational response to a tight academic labor market with low compensation and uncertain prospects for success. Moving into other employment settings without pursuing a postdoctoral position may be the right decision for many recent Ph.D. graduates. From society's perspective, however, a continued decline in the number of postdocs could have negative consequences for the quality and quantity of our biomedical research. Postdocs along with graduate students comprise a majority of the research workforce in the biomedical sciences. A continued loss of postdocs without an alternative source of talented research personnel will slow our rate of progress. We need to develop a steady-state model for the biomedical research workforce while maintaining the vitality and excellence of the enterprise. FJ

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