Why Are There Still Too Many Graduate Students?

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As the economy tanks the number of new graduate students is going up. In Sept 2009 the Council of Graduate Schools reported a 4.7% rise in the number of US national students, beating out the increase in foreign students for the first time in several years (1). Its not surprising that more young Americans are choosing graduate school as a refuge in times of economic uncertainly, what is surprising is that our universities and our federal funding agencies are allowing this to happen in the face of extensive evidence that we are training far too many PhD students. Despite shrinking opportunities in the academic world and massive layoffs of PhD scientists by the pharmaceutical, biotechnology, and other high-tech industries, our universities continue to pump out new PhDs at an ever-increasing rate.

This situation is not new; overproduction of PhDs has a long history in this country. I am going to confine myself to a discussion of the biomedical sciences, since I know this area best. However, I would imagine that similar issues prevail in other area of science PhD training. In 1998 the American Society of Cell Biology undertook a study of career prospects and patterns for biomedical scientists (2). This report delineated increasing levels of frustration and disappointment among young biomedical scientists. Some of the causative factors mentioned were (a) the need to spend many years in postdoctoral positions before finding a 'real job' in academia or industry (b) the difficulty in obtaining independent funding (c) the uncertainty associated with this career path. Going forward, an analysis by the National Institutes of Health in 2000 (3) stated "There should be no growth in the aggregate number of Ph.D.s awarded in the basic biomedical sciences ". This was based on an estimate that while about 1,500 to 3,000 new biomedical PhDs would be needed each year to meet employment demands, the annual biomedical PhD output (in 2000) was close to 5,400. Despite these concerns, the pace of PhD production continues to increase. In 2007-08 the Council of Graduate Schools indicated that 5,040 PhDs were awarded in the health sciences as well as 6,749 in the biological and agricultural sciences (some of which are likely biomedical-related)(4). The consequence of this failure of policy and planning was poignantly illustrated in a recent article in *Nature* that described the complete loss of funding by two previously successful PhDs (5). In an accompanying editorial (6) *Nature* comments "too many scientists chase an all-too-finite supply of jobs and money " and the result is "The process ceases to select for only the very best young scientists, and instead starts to drive many of the smartest students out of research entirely. They realize that the risks outweigh the benefits in science and choose alternative careers."

What drives this heedless increase in PhD production? Most likely it is the very nature of current ultra-competitive biomedical research combined with an outmoded approach to faculty advancement prevalent in universities. In an insightful analysis Freeman et al (7) suggest that scientific research fits a 'tournament' economic model where small differences in productivity translate into large differences in recognition and reward (e.g. think of getting 'scooped' just as you are about to publish a major finding). This leads senior investigators (PIs) to build up their labs with as many students and

postdocs as possible irrespective of whether this is really beneficial to the trainees. As Freeman et al state " If encouraging graduate students and postdocs to specialize narrowly helps PIs win the research tournament, this will occur even if alternative forms of training, or leaving the lab sooner, might better serve the students and postdocs." Almost every senior scientist (including me) has 'burned' students or postdocs in seeking to solve a particularly demanding research problem.

What are the consequences of our current faculty-driven approach to graduate training? First of all, because of the mismatch of supply and demand, there is the well-known 'holding pattern' for postdoctorals. After attaining a PhD it has become commonplace for young scientists to spend up to six or seven years as a postdoctoral (or research associate or research assistant professor, all temporary, grant funded, 'soft money' positions) prior to attaining a 'real job' in academia or industry. A particularly worrisome trend is an increase in the number of PhDs who are unemployed or employed part time (8). Being a postdoc for an extended period has very negative economic consequences. For example, after spending years getting a PhD, the average salary for a postdoctoral fellow is substantially less than the average for individuals with only a bachelor's degree (9). A second issue concerns the types of jobs young PhDs eventually find. In many cases these are middle management jobs in the pharmaceutical or biotech industry or in a government organization, jobs that require some knowledge of biomedical science but do not require the intensive research training associated with award of the PhD. Finally, the insecurity and low compensation of associated with careers in biomedical science are driving the best and brightest young people into other pathways. Scientists are supposed to be smart and creative. However, the dirty little secret of most university graduate programs is that the intellectual caliber of US national students in PhD programs is substantially inferior to those in other areas such as law or medicine when any reasonably objective measure is used (for example, verbal GRE scores, which in my experience are one of the best predictors of success in graduate school in the biomedical sciences). This has led ambitious PIs to depend more and more on talented foreign students. For example, in recent years over 50% of the doctorates awarded in the science and engineering have gone to foreigners (10). While it is appropriate that America's outstanding universities help train outstanding students from other nations, one wonders if it is really a good idea to have so much of our nation's science and technology workforce be comprised of individuals who inevitably will have divided loyalties.

What is to be done? First of all graduate training needs to be uncoupled from the tournament economics of PI ambition. The goal of training should be training- not PI advancement. A good way to do this would be to end support for graduate research assistants on federal research grants. Graduate students could be supported on individual competitive fellowships or as part of university wide training grants (T32s in NIH parlance). Work in the labs would then become more dependent on postdocs and technicians rather than students. This would also give granting agencies a way to better align the number of PhD candidates to the expected demand in various fields by controlling the number of training slots. Since federal training funds are largely targeted to US nationals, this policy would also tend to reduce the proportion of foreign students, although other fellowship sources would still be available to support a healthy cohort of international students. Finally, this would boost the status and prestige of graduate

students, especially those who have won competitive fellowships.

A second thrust would be to reconstitute the Master's degree as an essential element of graduate training. Increasing the pool of individuals with Master's degrees in biomedical sciences would help industry and government to fill those numerous middle management positions that require an element of scientific sophistication, but not a PhD. Students receiving the Masters could track into those positions without going through the lengthy and demanding PhD process. The existence of a solid career pathway based on the Master's would also allow graduate faculty to redirect students who seem unsuited for the PhD to the Master's, thus raising the caliber of the PhD trained pool.

Finally, as alluded to in several publications and reports, universities need to develop stable, non-replicating research career pathways. Current biomedical science depends on a large cohort of postdoctorals, research associates, and research track faculty who perform the day to day work in the laboratories in a highly skilled manner. However, these types of positions almost uniformly depend on the success on an individual PI in obtaining grant funding; thus they have no stability and no status in the university aside from the connection to the PI. This needs to change. Universities need to recognize the vital importance of these individuals who do the science, but do not bring in grant funds, but who also do not 'replicate' (train more and more students). It will be key to find ways to assure continuity of employment of these researchers; perhaps 'taxing' grant funds to provide a university-wide rainy day fund might be an approach.

(1) (http://www.cgsnet.org/Default.aspx?tabid=240&newsid440=95&mid=440&&).

(2) E Marincola & F Solomon. *Molecular Biology of the Cell* 9:3003-06, 1998

(3) (http://grants.nih.gov/training/nas_report/NIHResponse.htm)

(4) (http://www.cgsnet.org/Default.aspx?tabid=168).

(5) Closing Arguments Nature **457,** 364–365; 2009

(6) A Crisis of Confidence (editorial) *Nature* 457: 635, 2009

(7) R Freeman et al *Science* 294: 2293-94, 2001

(8) (Survey of Doctorate Recipients, NSF)

(9) (http://postdoc.sigmaxi.org/results/)

(10) (http://www.nber.org/papers/w14792)