Molecular Biology of the Cell
Vol. 9, 3003–3006, November 1998

Essay

The Career Structure in Biomedical Research: Implications for Training and Trainees

The American Society for Cell Biology Survey on the State of the Profession

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INTRODUCTION

The scope of biomedical research in the United States has increased significantly over the last 20 years. At the same time that the number of trainees has proportionately increased, the number of traditional, tenured academic positions has declined.[1] This appears to have profoundly changed the profession, at least in the view of the majority of established scientists who took their degrees before 1980. Today's principal investigators may not be able to provide their trainees with the same clear sense of the future as did their own mentors for them. Throughout the community, there is anxiety and insecurity about the number and nature of the jobs today's young scientists are likely to find.

To address these issues, the American Society for Cell Biology (ASCB) determined to examine concerns raised by an increasing number of its members.[2] The Society initiated a survey of its membership with the purpose of obtaining data that would reveal the extent of real and perceived opportunities in the profession of biomedical science, as well as the perceptions of those at different stages and representing different generations.[3] The data set includes both raw data and statistical analysis, which reveals valid correlations for cohort and gender.[4] A summary of the survey results was published as an editorial in *Science* (Marincola and Solomon, 1998). It is available in its entirety at www.ascb.org/ascb.

The survey instrument was a printed four-page questionnaire, which was distributed in mid-1997 to a random 45% of the ASCB membership, including students, postdoctoral fellows, and "regular" (i.e., investigator) members in the United States. The questionnaire asked for information that was both objective, (e.g., date and institution of training and professional history) and subjective (e.g., satisfaction with one's career and view of future prospects). The response rate was 65% (n = 2406). Twenty-five percent of the respondents are under age 40; 36% are between 40 and 49, and 28% are between 50 and 59. Twenty percent of respondents identify themselves as still in training, and these are nearly equally divided between men and women. In contrast, 36% of all respondents are women. Eighty-four percent of respondents identify themselves as white, and 9% identify themselves as Asian-American or Asian; very few respondents identify themselves as either Hispanic (2%) or black (1%).

The Society acknowledged that by choosing its own membership as the study population, the results would be biased to reflect more favorable conditions than would a true cross-section of biomedical scientists and scientists-in-training. Membership in a scientific society by definition selects for those likely to attend the society's meetings and to read and publish in its journals. Nonetheless, the ASCB leadership chose its own ranks for its accessibility and because it anticipated that if the survey results were cause for concern, that that concern would be if anything understated, not overstated, by the group selected.

[1] In 1985, 3791 PhDs were awarded in the biomedical sciences, and there were 20,377 tenured biomedical faculty in the United States; in 1995, the number of PhDs awarded increased to 5878, whereas the number of existing tenured biomedical faculty dropped to 16,306 (National Research Council Survey of Doctorate Recipients 1996).

[2] J. Michael Bishop, now Chancellor of the University of California, San Francisco, as President of the Society at that time, requested that the Society's Education Committee analyze this issue.

[3] A subcommittee of the ASCB Education Committee designed and commissioned the study; Frank Solomon of the Massachusetts Institute of Technology served as chair of the committee and subcommittee. The other members were Joan Brugge, Gerald Fischbach, Elizabeth Gavis, Arthur Lander, and J. Richard McIntosh.

[4] The statistical survey firm of Belden, Russonello & Stewart (Washington, DC), was competitively commissioned to administer the questionnaire and analyze the data.

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RESULTS

Unsurprisingly, the survey reveals that, by many measures, developing a satisfactory biomedical research career is more difficult than it used to be. The average time to obtain a doctoral degree has risen from 4.4 years for those receiving their degrees in the 1970s to 5.6 years for those in the 1990s. Seventy percent of scientists receiving their degrees before 1970 report having obtained their first full-time position in less than 6 months; the number of 1980s graduates who report the same success was half of that (36%). Only 14% of pre-1970 graduate respondents who held more than one postdoctoral position did so because they were unable to find a desirable independent position as the primary reason for seeking a subsequent fellowship; that reason applied to 39% among those graduating in the 1980s. Those graduating before 1970 report that after their postdoc they applied for a mean of four to five permanent positions; this number jumped to a mean of more than 30 for 1980s graduates. More than two-thirds of established scientists claim that it has become harder to obtain funding since they started out: of those who have applied for grant funding from the National Institutes of Health, National Science Foundation, or American Cancer Society, 71% of those graduating before 1970 report having won funding on their first attempt; that success drops to 43% of those graduating in the 1980s. Indeed, the only transition that has not become significantly more difficult is the ability to obtain a postdoctoral position.

Dissatisfaction also emerges from responses to qualitative evaluations. Twice as many respondents would "probably" or "definitely" not do it all over again—pursue their doctoral degrees—among those who received their degrees in the 1990s (31%) compared with the 1970s (16%). Respondents who received their doctorates before 1970 indicate overwhelmingly (81%) that their jobs are highly satisfying (6–7 on a 7-point scale), whereas fewer than half (49%) of those receiving their degrees in the 1980s do; conversely, 13% of the younger group indicate that their careers are unsatisfying (1–3 on the 7-point scale), whereas an insignificant number (<2%) of the older cohort rank their satisfaction that low. Nine in 10 of all respondents who advise or oversee the work of trainees indicate that obtaining a desirable full-time position in biology is more difficult than when they were first seeking one. And of these supervising investigators, an insignificant proportion (1%) of those receiving their doctoral degrees before 1980 report that a year or more had elapsed between initiating their first search for a permanent job and starting that job, whereas >21% of those obtaining their degrees since 1980 report the lapse of a year or more in that interval.

THE INTERESTS OF SCIENCE AND THE INTERESTS OF SCIENTISTS

These results and perceptions appear to be the natural consequence of a professional structure whereby each grant-holding principal investigator trains many times more than the single scientist required to replace that investigator. The current generation of researchers may be the real-life manifestation of the notion that biomedical science is experiencing a "Malthusian Crisis" (McIntosh, 1995): a pyramidal growth in trainees, which is generating demand for jobs and funding that outpaces even the impressive growth in federal funding of biomedical research of recent decades. This view holds that the situation is not stable and, allowed to persist, is a threat to the structure and future of the profession.

Balancing these factors is great and understandable hesitation to fix something that by many counts is decidedly not broken. US biomedical research has produced spectacular progress, measurable not only in basic knowledge but in the fight against virtually every type of disease. National Institutes of Health peer review is the model for funding allocation for other US research agencies and for biomedical science worldwide. And over the last generation, researchers in US labs have won more than two-thirds of all Nobel Prizes in Physiology or Medicine.

But there is a deep disconnect between these accomplishments and the state of mind of most scientists, especially young people and those who are responsible for training them. Among many researchers who are not yet independent, there is a cynical perception that although science itself may be thriving, it is because the scientific establishment is all too willing to compromise the careers of its students and postdocs.[5] For these individuals and for the future of American science, it remains important to consider whether the present structure of advanced training in biology, fashioned from a long tradition that has enriched academic research, is adequate and appropriate for the future of the profession. More important, are there genuine reasons for concern?

A structural feature of biomedicine may have significantly contributed to creating this paradox and seems to reinforce the consequent tensions: the practice of biomedicine even more than the practice of

[5] When the ASCB solicited comments from its members to convey to the Trends in Early Research Careers Committee of the National Research Council in 1996, more than 100 responses were received. An illustrative comment from one young researcher was, "I honestly believe that many institutions and individuals are abandoning their responsibilities and are sacrificing their students to survive and succeed. It is traditional among senior administrators and investigators to accept the necessity of dog-eat-dog, but scientific education today is becoming dog-eat-puppy, and if that goes on long enough there will be no dogs left."

clinical medicine or any other profession is largely implemented by trainees. This system has resulted in both unprecedented scientific accomplishment and in researchers who are highly trained. But the cost is great: people are investing more time in training to become independent yet may be able to choose among fewer jobs once they are trained. In strictly economic terms, it is in the interest of investigators not to reduce the number of trainees in the system; in fact, in these economic terms, it is in their interest to keep the number as high as possible to ensure an abundance of relatively inexpensive workers. Trainees from the United States and abroad meet demand for scientific output by working extraordinarily hard primarily in exchange for a crack at someday attaining the independence enjoyed by their principal investigators. This labor supply also undermines the leverage that workers (in this case students and trainees) may enjoy in other fields of work.

POSSIBLE SOLUTIONS

Take No Action

Some urge that nothing be done to limit the number of scientists being trained in the United States, pointing to the uncertainties of future demand and the failure of economists in the past to accurately plan for future manpower needs (Garrison and Gerbi, 1998). But not planning is tantamount to de facto planning, and the current "nonplan" is at minimum causing serious uncertainty in the short run and may prove harmful to science in the long run. That is because an extremely uncertain future may undermine the determination of the best, brightest, and most motivated students to make the sacrifices necessitated by scientific training. They have other alternatives to satisfy their desire for intellectual reward, independence, mentoring young people, and challenge without facing the difficult odds of successfully meeting their professional goals in biomedical research.

Careers away from Bench Science

Almost three-quarters of survey respondents favor the encouragement of mixed curricula in doctoral programs that train students in finance, marketing, law, and pedagogy alongside the traditional disciplines of biology programs. One barrier to this notion as a comprehensive solution, although it merits careful consideration, is the lack of a reliable calculation of the number of satisfying jobs that exist outside of bench science. A deeper examination of this option must also consider what drives people to pursue a career in science in the first place. To biomedical researchers, financial security is usually not the major motivating factor (a minority of 39% of survey respondents indicate satisfaction with their financial compensation). Instead, the ASCB survey reveals that job satisfaction is measured by the opportunity to teach, by the prospect of independence, and by a sense of having made an important contribution to scientific understanding. Even if such jobs for scientists are obtainable (and it is not evident that they will be on a scale to absorb a significant proportion of trainees), they may not always meet this special set of expectations. And finally, it is not clear that the traditional PhD—with its emphasis on completed, publishable research projects—is a necessary or even an appropriate entrée into these professions.

Redistribution of Funding

One way to deal with limiting resources is to redistribute them: two-thirds of survey respondents favor addressing this challenge by restricting the total funds that a single laboratory may receive. Although this may seem "fair" from the point of view of a scientist unable to attain funds or from a student or trainee fearful of being in such a position, inviting resource allocation by criteria other than peer review threatens the premise on which our successful biomedical enterprise is built.

Capping Trainee Numbers

Another alternative, endorsed by more than half of the respondents, is to restrict the number of trainees. This supply-side approach raises several questions: how and at what level will such control be exercised? Which labs will remain training labs, and by what criteria will that determination be made? Shutting down programs raises the specter of choking off research at institutions that may fall below some threshold, however determined—another consequence of the tight coupling of biomedical training and biomedical research.

Creating Professional Positions That Do Not Self-Replicate

A possible approach may be in modifying the paradigm that has resulted in the dependence of principal investigators on trainees to produce work. Survey respondents in significant numbers (61%) endorse the notion of creating permanent research positions held by scientists who would neither apply for competitive grants nor be responsible for training students. Instead, they would be supported through investigators who hold traditional academic appointments. Some of the support for these researchers could be derived from the institution, in return for technical or even teaching contributions. This different class of researcher has in a sense already emerged, embodied in the longer duration of postdoctoral training documented in the survey. This career track could be rec-

ognized explicitly, legitimized, encouraged, and nourished. Although such researchers may not enjoy the "prestige" of a tenured academic appointment, they would be spared the constraints of faculty obligations and laboratory management, as well as prolonged uncertainty and unrealistic expectations in their careers. The majority of survey respondents who write grants cite as a major source of job dissatisfaction the proportion of time required to prepare grant proposals at the cost of time at the bench, suggesting that such a solution may be welcome by many.

Realistically, the establishment of such positions will require changes in fundamental policies at both granting agencies and recipient institutions, agreed to and acted on in a concerted manner. Perhaps the major issue is how to pay for a significant permanent research work force of relatively senior scientists, who will be more expensive to support than are trainees. Part of their expense may reasonably be provided by their institutions, which have a stake in a stable and well-trained staff because it brings in grant money through research, participates in the teaching program, and runs joint facilities.

CONCLUSIONS

The ASCB survey reveals that young scientists, compared with their predecessors a generation earlier, are experiencing greater challenge and frustration in establishing their careers, as measured by objective indicators as well as by the perception of scientists at all career stages. Attitudes vary with generation, but all cohorts register deep concern about the profession, especially by and for those who are not independent researchers. Quantitative measures confirm that for most scientists, most aspects of the profession are getting harder.

If the goals of the scientific enterprise are research that contributes to the public welfare and the effective training of researchers to perform that work, it may be important for today's scientific leaders to take the results of the ASCB survey as evidence of significant dissatisfaction and act accordingly to protect the future of biomedical research. The first step may be to acknowledge explicitly the quantitative and qualitative evidence revealed by the ASCB survey that young people are facing serious obstacles to establishing a satisfying career in biomedical science. A next step may be to make training more appropriate to the career intentions of trainees: for example, the requirements of a scientific career in industry seem likely to emphasize collaborative skills rather than the individual decision making which is characteristic of academia; a career in law or business may require rigorous scientific training but not demonstrated productivity in research. Rigid adherence to traditional training modes threatens efficiency and may even be counterproductive when not attuned to the environment for which the scientist is being trained.

Perhaps the most compelling solution to this problem may be the creation of respectable, reasonably paid professional scientist positions, to be held by fully trained researchers who neither write grants nor train others. Embodied in these positions is the uncoupling of training from research that may be the long-term alternative to a difficult future for biomedicine and its practitioners.

ACKNOWLEDGMENTS

We thank J. Michael Bishop, Mina Bissell, Elizabeth Blackburn, and Lydia Villa-Komaroff for support of this project and Elizabeth Blackburn and Marc Kirschner for their critical comments on the manuscript. Financial support of the survey was provided by the American Society for Cell Biology and Northwestern University.

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