The American Physiological Society

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The following comments are submitted on behalf of the American Physiological Society (APS). The APS appreciates the opportunity to provide feedback to the NIGMS and recognizes the institute's leadership on training the next generation of researchers.

The APS is a scholarly association founded in 1887 to advance understanding of how living systems function. Today more than 10,000 APS members are involved in research and education in colleges, universities, medical and veterinary schools, in industry, and in government throughout the U.S. As a member of the Federation of Societies for Experimental Biology (FASEB) we also endorse their comments, submitted separately.

Current strengths, weaknesses and challenges in graduate biomedical education.

Strengths:

- The current system – which is essentially an apprenticeship model - is very good at training people to be academic researchers.
- Students are major contributors to academic research and by and large go on to successful careers.
- NIGMS training grants are essential to continue to encourage the best and the brightest students to enter the field of biomedical research. These programs also provide the best potential to increase diversity and address the current disparities in the biomedical workforce, which is an ongoing goal for the NIH and the research community as a whole.

Weaknesses:

- Many students pursue careers outside of the traditional academic laboratory setting, either because they choose to do so, or because the changing job market has reduced the number of available tenure track academic positions. Since most of those who now serve as mentors were trained in academic settings under the apprenticeship model, few are equipped to help train their students for jobs outside of academia. Consequently, their students may not be acquiring the skills that they will need to be successful.

Challenges:

- Scientific fields change quickly, and it is a significant challenge for graduate programs to adapt and provide access to training for the broad range of skills that students will need to succeed in the workforce, whether they pursue positions within or outside of academia.
- NIH's training programs have not fully adapted to the reality that only a minority of PhDs remain in academic research. As a result, when training grants are reviewed, there continues to be a heavy emphasis on the proportion of a program's trainees who go on to academic research careers. To remedy this, when training grants are reviewed, emphasis should be placed on the training environment that the program provides, and success in terms of career outcomes should be broadly defined to include a diversity of employment sectors. NIH should also consider modifying language in requests for applications for training grants to indicate that the overall goal of the program is to train the next generation of scientists for a broad range of scientific careers.

Changes that could enhance graduate education to ensure that scientists of tomorrow have the skills, abilities and knowledge they need to advance biomedical research as efficiently and effectively as possible.

- Graduate training should move towards a model of formal education for foundational scientific skills, especially scientific method and design. Not only would this type of training improve the rigor of scientific discovery, it would also allow greater flexibility in the next stage of a student's career since a sound understanding of scientific method or statistics can be applied in multiple fields.
- Students should be encouraged to make use of Individual Development Plans (IDPs) to help them focus their career plans and acquire the skills they will need to be successful on their chosen path.

The major barriers to achieving these changes and potential strategies to overcome those barriers.

- Most graduate programs lack general, standardized training for laboratory techniques. In order for students to be able to identify the best experimental approaches or come up with a good testing paradigm, it is essential that they know and consider interaction between systems and methods. Most graduate programs also lack training in teaching, budgeting and many of the other skills listed below. While some aspects are taught through the mentor/mentee relationship, it is not formalized or standardized in many cases.
- As we see in a discipline such as physiology, scientific research can be highly specialized within and between fields. This presents a significant challenge in providing any kind of standardized training. For example, trying to provide standardized training in laboratory techniques, experimental design or statistical analysis would be a huge challenge in many graduate programs, especially the large "umbrella" type of programs that are now quite common at large research institutions.
- In general, there should be more of an investment in developing courses in graduate training programs that would offer the opportunity to develop some of the skills described below. Instead of having each institution develop its own courses for each of the skills, it makes more sense for NIH to sponsor the development of online courses that can be shared.

The key skills that graduate students should develop in order to become outstanding biomedical scientists, and the best approaches for developing those skills. These could include but not be limited to: a) essential skills applicable to all fields that ensure ability to design meaningful experiments and critically analyze data, b) ability to adapt new and emerging technologies or approaches and c) other skills such as team science

- Among the skills that students need are:
    - Scientific method and process
    - Training related to rigorous experimental design
    - Statistical analysis
    - Data management
    - Journal article writing and review
    - Grant writing and review
    - Budgeting
    - Teaching
    - Mentoring and leadership
    - Educational outreach
    - Laboratory and project management
    - Time management
    - Team science
    - Communications
    - Tech transfer
    - Business/finance for scientific lab management
- These skills are necessary not only for success as an academic researcher, but they are also essential for anyone who is looking to pursue a career outside of a laboratory setting.
- Many of these skills could be offered in foundational coursework early in Ph.D. programs. The teaching of some skills may be well-suited to presentations offered via online courses that could be made available to multiple grantee institutions.
- The NIGMS supports a diverse set of institutional training grant programs, each with their own particular strengths. NIGMS should encourage programs to develop training modules or workshops based on their existing areas of strength. These modules or workshops could then be shared with other NIGMS-supported trainees.

Potential approaches to modernizing graduate education through the existing NIGMS institutional predoctoral training grants program to ensure that trainees have the skills and knowledge they need to be prepared to enter the biomedical research workforce.

- NIGMS should encourage grantees to include foundational training that includes the skills listed above into their training programs.
- Institutional training grant review should focus less on any particular career outcome of students and more on the research environment being provided by the institution. Institutional training grant programs should clearly demonstrate how they will provide students with the skills they will need to pursue various career pathways.
- Reviewers of training grants should not equate success with a high proportion of graduates going into academic research settings. Instead, the definition of career success should be broadened to include non-bench research related academic and non-academic career choices.

Anything else you feel is important for us to consider.