the WINNOWER

SCIENCE AND SOCIETY

Future of Research Response to NIGMS Request for Information (RFI): Strategies for Modernizing Biomedical Graduate Education (NOT-GM-16-109)

FUTURE OF RESEARCH BOARD OF DIRECTORS GARY S. MCDOWELL

The National Institute of General Medical Sciences (NIGMS) issued a Request for Information (RFI) seeking input on how to catalyze the modernization of biomedical graduate education through NIGMS's institutional predoctoral training grants program. This is the response submitted by the Board of Directors of the Future of Research nonprofit.

CORRESPONDENCE:
garymcdow@gmail.com

DATE RECEIVED:
August 09, 2016

DOI:
10.15200/winn.147071.15403

ARCHIVED:
August 09, 2016

KEYWORDS:
policy, funding, biomedical research, graduate education, training

CITATION:
Future of Research Board of Directors , Gary S. McDowell, Future of Research Response to NIGMS Request for Information (RFI): Strategies for Modernizing Biomedical Graduate Education (NOT-GM-16-109), *The Winnower* 3:e147071.15403 , 2016 , DOI: 10.15200/winn.147071.15403

INTRODUCTION

The Future of Research (FoR, http://futureofresearch.org/) is a nonprofit that is working to represent junior scientists, through grassroots advocacy, to promote systemic change to the way we do science. We are seeking to help junior scientists discuss solutions to problems they perceive with the scientific enterprise, primarily through junior scientist-organized meetings, and make their voices heard (Dolan, Pierre, and Heckler 2016; G. S. McDowell et al. 2014; Mazzilli et al. 2014).

The National Institute of General Medical Sciences (NIGMS) issued a Request for Information (RFI) seeking input on how to catalyze the modernization of biomedical graduate education through NIGMS's institutional predoctoral training grants program, with submissions accepted through August 5th 2016 (National Institutes of Health 2016). FoR has taken an active role in discussing reforms of graduate training (Dolan, Pierre, and Heckler 2016; G. S. McDowell et al. 2014; J. K. Polka, Krukenberg,\n and McDowell 2015; Goodwin et al. 2015), and FoR members have previously posted their responses to RFIs as part of our aim to advocate transparently (J. Polka 2015; V. Pai 2015; G. S. McDowell 2015a, b). Here we record our submission to RFI NOT-GM-16-109 (National Institutes of Health 2016) in full.

RELEVANT TEXT TAKEN FROM NOT-GM-16-019

The full notice can be found at https://grants.nih.gov/grants/guide/notice-files/NOT-GM-16-109.html (National Institutes of Health 2016). The following text is taken from the notice:

PURPOSE

The National Institute of General Medical Sciences (NIGMS) seeks input on how to catalyze the modernization of biomedical graduate education through NIGMS's institutional predoctoral training grants program. This Request for Information (RFI) will assist NIGMS in identifying, developing and potentially implementing strategies that will catalyze the modernization of graduate education at the national level to ensure that trainees gain the skills, abilities and knowledge required to be successful in the biomedical research workforce.

BACKGROUND

NIGMS supports basic research that increases understanding of biological processes and lays the foundation for advances in disease diagnosis, treatment and prevention. The Institute also has a longstanding commitment to and provides leadership in training the next generation of biomedical scientists through support of a wide array of programs including Ruth L. Kirschstein NRSA Institutional Predoctoral Research Training Grants (T32) in multiple scientific areas and the Medical Scientist (M.D.-Ph.D.) Training Program (MSTP). The overall goal of these programs is to promote fundamental, interdisciplinary and innovative research training relevant to the NIGMS mission.

NIGMS has taken steps in its continuing efforts to catalyze the modernization of graduate education including offering administrative supplements to support innovative approaches in the areas of rigor and reproducibility, career outcomes and graduate education. Additionally, NIGMS held a meeting covering these topics in the spring of 2016. This Request for Information (RFI) is designed to obtain feedback, comments, novel ideas and strategies to inform NIGMS on how best to catalyze the modernization of graduate education through its institutional predoctoral training grants program.

INFORMATION REQUESTED

NIGMS invites all interested parties, including the general public, to provide input on the modernization of biomedical graduate education. Topics that could be addressed include, but are not limited to, the following:

- Current strengths, weaknesses and challenges in graduate biomedical education.
- 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.
- The major barriers to achieving these changes and potential strategies to overcome those barriers.
- 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
- 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.
- Anything else you feel is important for us to consider.

FOR SUBMISSION IN RESPONSE TO RFI

Here is the text in response to the survey from the Board of Directors at FoR:

1. CURRENT STRENGTHS, WEAKNESSES AND CHALLENGES IN GRADUATE BIOMEDICAL EDUCATION.

Graduate biomedical education is currently geared primarily toward the production of academically-oriented researchers, but such a career path has become increasingly competitive as the pool of trainees expands while the academic jobs do not. While the U.S. currently produces many talented researchers with a high level of technical expertise in specialized fields, graduate education generally does not focus on non-technical skills required for academic and non-academic careers alike, including financial and personnel management, and mentoring.

The academic career track is often referred to as a “pipeline” which implies a conservative and constricted view of what effective and efficient science look like, rather than valuing the varied approaches and contributions that can be made to science and development. This has created an academic culture that prioritizes aspiration towards academia as the only acceptable career goal, despite the reality that this goal will not be realised by the majority of trainees. It relies on a particular

values system and measurement of scientific contribution (i.e. publications in high impact factor journals), and as personal values and incentives in biomedical careers vary with social identity (Gibbs and Griffin 2013) this may act to reduce diversity of and inclusion within the biomedical enterprise, which is key to its ability to develop and support efficient and effective science.

Academic success and research productivity in the form of data for publications and grant applications are highly valued and incentivized. However, there is little assessment of training or transparent reporting of training and career outcomes (J. K. Polka, Krukenberg, and McDowell 2015). This has led to a climate in which training is not a priority. To decrease reliance on the use of trainees as cheap labor, training outcomes should inform funding decisions via research and training grant mechanisms. These outcomes should be measured, transparently reported, and assessed by pedagogical experts.

In summary:

STRENGTHS:

- Production of highly technically-skilled specialized research scientists.

WEAKNESSES:

- Lack of career development for a variety of skills required in both academic and non-academic career progression, beyond technical skills.
- Prioritization of academic career goals and incentive structure geared towards publications and grants resulting in a system that does not utilize unique contributions from a diverse population, creating a less inclusive environment.

CHALLENGES:

- Creating a culture that prioritizes training of trainees as a means to fostering scientific creativity and innovation.
- Fostering an environment that supports training scientists for a scientific enterprise, not supporting an academic enterprise alone.

2. 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.

NIH-supported courses early in graduate training which focus on career development and transferable skills training, applicable for both academic and non-academic careers, could be combined with allowing students the opportunity to do a more intensive internship. Length and timing could vary depending on the career path of interest, and for academia could facilitate time learning a new technique in another lab. Funding to cover travel and health insurance is necessary to allow full participation of all students. The placement of training at the beginning and again later in graduate training provides early decision-points in graduate training, early development of skills, and a useful experience in application of those developed skills.

The length of graduate training is currently highly variable. This in itself can disrupt the search for employment if the trainee has no clear point of departure. Graduate students are most productive in bench science by the end of training and this can be a disincentive to graduating. Graduate programs should clearly define the structure of training, in terms of decision points, milestones, and length of the program, for the benefit of all parties. This system can be compared with other fixed-term training systems internationally.

One-third of admitted graduate students in the U.S. biomedical enterprise currently leave without completing their graduate degree (J. Polka 2014). The diversity of the biomedical enterprise, which is essential to create an effective and efficient research enterprise, also suffers throughout the course of graduate and postdoctoral training, often referred to as a “leaky pipeline” analogy.

Improvements in and incentives to reward outstanding mentoring of graduate students, to properly cultivate and support their abilities in contributing towards scientific research, will make graduate training more effective and efficient by stemming the flow of diverse talent out of graduate biomedical training. Training the trainers is as important as training the trainees.

Training outcomes assessment and collaboration with experts in pedagogy, rather than simply relying on biomedical scientists to assess their own success in training, is also highly desirable and likely actionable in the review and assessment of T32 training grants. The merits of the biomedical science can and should be judged by biomedical experts; likewise the merits of the training and teaching should be judged by experts in pedagogy. Negative research results, as well as successes, should be expected and the results published and documented to prevent the repetition of similar research undertakings at other institutions. These negative results should be welcomed and not viewed negatively or negatively affect grant renewal. Rather, applicants should be able to demonstrate what information the findings have provided and articulate plans to disseminate this information and state how they plan to revise their proposal as a result. In this way the ability of training programs to improve the efficiency and efficacy of biomedical training and resulting scientific research can be thoroughly evaluated.

3. THE MAJOR BARRIERS TO ACHIEVING THESE CHANGES AND POTENTIAL STRATEGIES TO OVERCOME THOSE BARRIERS.

Major cultural barriers exist to allowing scientific trainees to develop their passion for science in non-academic venues, or indeed to consider non-academic career tracks as a possible direction. There is a perception that bench research is inherently good training for a variety of jobs, yet it does not provide many of the skills valued in non-academic settings or the experience necessary for the non-academic career paths that the majority of predoctoral trainees will eventually take. The assumption that “learning by doing” is inherently the best system is prohibitive to trainee efforts to spend time training away from the bench, and is reinforced by the perception that productivity is directly proportional to time spent at the bench.

Predoctoral biomedical researchers have a recognised dual role as both trainees and employees (National Institutes of Health 2014) and in particular the National Institutes of Health have clarified the requirement to “support the development of skills critical to pursue careers as independent investigators or other related careers”. In practice, training is a secondary priority to bench science: bench science productivity is incentivized by rewarding data generation with publications and grants, essential currencies in the research enterprise. Training outcomes, however, are not highly valued in graduate biomedical research except in the production of a dissertation (itself possibly a collection of publications). Therefore rewarding training according to a particular set of criteria (including accountability for and reporting of training outcomes; better training for PIs in mentoring; and defining and rewarding "good training”) could overcome the activation energy in training. Mentoring and management skills of the professoriate in these realms may be limited, understandable as they themselves have been trained almost exclusively in bench science. Career development is lacking for both academic and non-academic careers in graduate biomedical research, and yet for all career tracks the development of relevant skills is essential to improve efficiency and effectiveness. Adoption of a clear policy about what is an acceptable amount of time to spend pursuing training outside the lab, and what types of activities are acceptable, is desirable.

Students are worried they will be penalized by their PIs for declaring their intention not to stay in academia. Even if their PI doesn't actively discourage them, cultural norms mean that unless the PI explicitly states their support regardless of career path, students frequently express concern that the PI will de-prioritize mentoring them as soon as that intention is declared. There is a common perception (G. S. McDowell et al. 2014; Goodwin et al. 2015) that there is a need for students to draw a veil of secrecy around their efforts to advance their careers outside of academia. Cultural attitudes are hard to change, but novel approaches to training could be rewarded in training grant applications. Cultural change could also be facilitated by requiring increased transparency in training outcomes data

and making improvements in the ways applicants are able to judge a PhD program before entering.

In assessment of teaching and training outcomes by experts in pedagogy, negative attitudes will be encountered towards the social sciences and research in pedagogy. It is however only through the inclusion of the relevant expertise that grants can be claimed to be properly assessed and this is a matter of implementation of policy.

4. THE KEY SKILLS THAT GRADUATE STUDENTS SHOULD DEVELOP IN ORDER TO BECOME OUTSTANDING BIOMEDICAL SCIENTISTS, AND THE BEST APPROACHES FOR DEVELOPING THOSE SKILLS.

Scientific training can provide necessary skills for many career paths. While critical thinking and problem solving skills are readily transferable to other domains, leadership and managerial skills are not part of the training environment for most PhDs. Success in academia can result from the development of effective communication skills, such as written, oral and interpersonal communication, and while these are often practised in academia, their explicit development is not currently explicitly required to be part of the training of all biomedical graduate students but is instead thought to be developed (at levels of efficacy as yet undetermined) by “learning on the job”. Junior faculty reflecting on the challenges of personnel management within a lab report how little their training prepared them for what is required rarely in pre- and postdoctoral training, but is a primary function of the PI and again relies on their ability to “learn on the job”. Employers list interpersonal communication skills, including developing collaborative relationships, integrating diverse viewpoints and other leadership skills, as being critical skills which are underdeveloped in PhD-level scientists they look to hire. For example, consulting firms have reported the need to train PhD-level candidates on interview skills before interviewing them, to prevent this from being a selection bias in their hiring of the candidates they need. These skills are essential for the academic career track as well as non-academic jobs related to research such as science outreach, policy, law and education.

Likewise, there are a variety of non-academic career tracks, which the majority of biomedical graduate students will end up taking, that may require other skills besides those described here. Therefore it is worth exploring whatever skills graduate students may themselves desire; what skills potential employers may desire; and whether development of these skills, while perhaps not obviously applicable to biomedical research, may still result in affecting the efficiency and productivity of graduate students by providing an overall rewarding experience of training at graduate school and improving mental health and well-being. Development of all these skills is rarely explored in training grant opportunities for graduate students. Therefore it is vital to openly evaluate projects which are providing these skill sets and communicating the results to facilitate successful implementation in other training programs.

5. 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 currently operates programs such as the Biotechnology Predoctoral Training Program, which includes internship opportunities and could be further modified to incorporate some of the approaches suggested above, and institutional T32 grants to incentivize effective predoctoral training at institutions. There is room for improvement of the T32 program to make investment of federal funding more effective and efficient by creating an academic culture and nurturing a scientific community studying training itself, and the modernization of training of graduate students for the present day demands of the scientific community.

In a similar manner to that currently being explored by the NIH BEST awards, the T32 structure could incorporate scientific analyses of individual training programs and initiatives, and a way to

communicate experimental successes, failures and best practices for implementation of various training programs. This will necessitate the identification of potential collaborators, and the creation of partnerships and a collaborative community, with educational, demographic and pedagogical researchers with biomedical investigators to evaluate whether T32-funded training programs are meeting the aims of both the institution and the NIH. The aims of the T32 program to improve training for graduate students can be further realised by incentivizing scholarly discussion of best practices for modernizing training. To address the cost of including more researchers in evaluation, NIGMS should update the T32 Funding Opportunity Announcement encouraging collaborative assessment of training outcomes and suggest inclusion of program evaluation costs in applications. There should also be a recommendation that proposals include evaluation plans with priority given to proposals that compare alternatives and particularly those that collaborate to compare and contrast programs across institutions. This could also perhaps be achieved by consideration of T32 applications to study T32 programs at a given institution to further promote evaluation. This will help to reduce the workload of biomedical PIs on grants who also run labs and instead spread the work amongst researchers who also have expertise in different areas of education and demography. Publication of this work should be encouraged in open-access journals and which can be submitted to a repository which NIGMS should maintain and encourage future applicants to utilise for evidence-based training approaches. Communication of results should be a stated expectation of awarded T32 programs. Funding should be awarded to assist expenses such as publication and conference attendance to promote the dissemination of training program outcomes.

As with all experiments on training, particular attention must be paid to diversity and inclusion and indeed these should be standard and primary concerns during assessment and evaluations rather than an afterthought. Many graduate students from underrepresented groups report a sense of not belonging in their academic environment (Gibbs, McGready, and Griffin 2015). Therefore T32 mechanisms have the potential to explore experimental environments aimed at improving diversity of the workforce and promoting inclusion of researchers from a variety of backgrounds, and with a variety of values and incentives, within academia.

6. ANYTHING ELSE YOU FEEL IS IMPORTANT FOR US TO CONSIDER.

Supporting students directly on training grants or fellowships would grant students greater autonomy to pursue training outside of the expertise of their own lab. Furthermore, this would reduce incentives to use them as an inexpensive labor source. In addition, doing so would provide a funding body with the ability to more directly track trainee outcomes, demographics, and numbers. This information could be used to exert feedback (from labor market and outcome data) on the optimal number of trainees in the research enterprise. If such a course of action is considered, training grants and fellowships must also provide more opportunities to trainees who are not US nationals.

NIGMS should consider smaller grant supplements for PIs to innovate in the areas of graduate and postdoctoral education, covering personnel, program costs, evaluation and dissemination to incentivize and support further innovation, and perhaps itself act as an experiment in how larger training mechanisms could function.

There is a very clear concern from the junior scientific community that the role of “trainee” is being used to justify long periods of employment as cheap labor, with no measurable outcomes of actual training except the successful defense of a PhD thesis. This is combined with a culture that prioritizes academic success and generation of data for publications and grants over other scientific contributions, and a climate that promotes the concepts that to leave academia is to leave science, or to leave is to fail, despite their awareness of the poor prospects of securing an academic position. In summary, morale within the junior scientific population is declining. Furthermore, the lack of training for academics themselves in the increasingly managerial role that a PI position entails, is creating an inefficient and ineffective system in which trainees begin to take matters into their own hands.

Junior scientists have begun to organize in unions, advocacy groups, and peer-mentoring groups in

search of the protection and career development support that the enterprise should provide to its trainee population. By incentivizing and promoting an academic study of training around biomedicine, and making efforts to ensure trainees feel they are able to carry out science but also have access to training, NIGMS has a real opportunity to change this environment.

REFERENCES

Dolan, Kyle T., Joseph F. Pierre, and Erin J. Heckler. 2016. “Revitalizing Biomedical Research: Recommendations from the Future of Research Chicago Symposium” [version 1; Referees: 2 Approved with Reservations].” F1000Res 5. doi:10.12688/f1000research.9080.1.

Gibbs, Kenneth D, and Kimberly A Griffin. 2013. “What Do I Want to Be with My PhD? The Roles of Personal Values and Structural Dynamics in Shaping the Career Interests of Recent Biomedical Science PhD Graduates.” CBE Life Sci Educ 12 (4): 711–23. doi:10.1187/cbe.13-02-0021.

Gibbs, Kenneth D, John McGready, and Kimberly Griffin. 2015. “Career Development Among American Biomedical Postdocs.” CBE Life Sci Educ 14 (4): ar44. doi:10.1187/cbe.15-03-0075.

Goodwin, Patricia R., Kearney T. W. Gunsalus, Erica M. Walsh, and Gary S. McDowell. 2015. “Future of Research - How Can We Improve Career Awareness and Preparedness? A Workshop at the NatureJobs Career Expo Boston 2015.” The Winnower 2: e143664.41987.

Mazzilli, Sarah A., Kearney T. W. Gunsalus, Gary S. McDowell, Kristin A. Krukenberg, and Jessica K. Polka. 2014. “Logistics of Organizing the FOR Symposium.” The Winnower, January. doi:10.15200/winn.141697.77958.

McDowell, Gary S. 2015a. “A Response to the NIH RFI ‘ Sustaining the Biomedical Workforce and a Potential Emeritus Award for Senior Researchers’.” The Winnower. doi:10.15200/winn.143189.95895.

McDowell, Gary S, Kearney T W Gunsalus, Drew C MacKellar, Sarah A Mazzilli, Vaibhav P Pai, Patricia R Goodwin, Erica M Walsh, et al. 2014. “Shaping the Future of Research: a Perspective from Junior Scientists. [version 2; Referees: 2 Approved].” F1000Res 3: 291. doi:10.12688/f1000research.5878.2.

McDowell, Gary S. 2015b. “A Response to the NIH RFI ‘Optimizing Funding Policies and Other Strategies’.” The Winnower 2: e143136.63273. doi:10.15200/winn.143136.63273.

National Institutes of Health. 2014. NOT-OD-15-008: OMB Clarifies Guidance on the Dual Role of Student and Postdoctoral Researchers. October 10. http://grants.nih.gov/grants/guide/notice-files/NOT-OD-15-008.html.

National Institutes of Health. 2016. NOT-GM-16-109: Request for Information (RFI): Strategies for Modernizing Graduate Education. 2016. Accessed August 9. https://grants.nih.gov/grants/guide/notice-files/NOT-GM-16-109.html.

Pai, Vaibhav P. 2015. “A Response to NIH Request for Information on Optimizing Funding Policies and Other Strategies to Improve the Impact and Sustainability of Biomedical Research.” The Winnower. doi:10.15200/winn.143135.51381.

Polka, Jessica. 2014. American Society for Cell Biology COMPASS Blog. Where Will A Biology PhD Take You? April 11. http://www.ascb.org/where-will-a-biology-phd-take-you/.

Polka, Jessica. 2015. “Response to NIH RFI ‘Optimizing Funding Policies and Other Strategies’.” The Winnower, May. https://thewinnower.com/papers/942-response-to-nih-rfi-optimizing-funding-policies-and-other-strategies.

Polka, Jessica K, Kristin A Krukenberg, and Gary S McDowell. 2015. “A Call for Transparency in Tracking Student and Postdoc Career Outcomes.” Mol Biol Cell 26 (8): 1413–15.

doi:10.1091/mbc.E14-10-1432.

APPENDIX

The members of the Board of Directors of Future of Research are: Jessica Polka; Sarah Mazzilli; Rebeccah Lijek; Kristin Krukenberg; Carrie Niziolek; Cara Weismann; Kearney Gunsalus; David Riglar; Kyle Dolan; Rodoniki Athanasiadou; Erica Walsh-Michel; Patricia Goodwin; Yelena Bernadskaya (http://futureofresearch.org/board-of-directors/).