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Subject: Request for Information: Building A 21st Century Bioeconomy

Creating a 21st century bioeconomy depends on training excellent bench scientists and scientist/entrepreneurs. Biomedical research is a complex enterprise that requires scientists to engage in a variety of fields outside of bench research including economic, political, legal, and social arenas. However, the training graduate students and postdoctoral researchers (postdocs) receive is not sufficient to ensure success in the variety of careers available to them. This is a potential hindrance to creating a 21st century bioeconomy. Therefore, reorganization of the training programs for graduate students and postdocs is the most important topic for the Office of Science and Technology Policy to focus on because the type and quality of training of new scientists will shape the national scientific endeavor for decades.

Collaboration between academic scientists and biotechnology companies is essential to efficiently translate discoveries from the bench to the marketplace. The establishment of the National Center for Advancing Translational Sciences and the Cures Acceleration Network shows the commitment of the NIH to finding treatments and cures for disease. These programs will discover important new compounds, materials, and techniques. In order to bring these products to the market in the quickest, most efficient, and safest manner possible, graduate student and postdoctoral training should educate scientist/entrepreneurs in technology transfer and the process of commercializing important biomedical products.

To support the pipeline that brings new treatments and technologies to market, we must expand the breath of careers available to graduate students and postdocs. For example, training scientists as political advocates will allow them to make the case to legislators regarding predictable increases in NIH funding. NIH funding creates jobs, increases economic output, and is an essential aspect of the 21st century bioeconomy. Additionally, arming graduate students and postdocs with the most effective educational techniques will improve K-12 and college curricula. Training scientists as communicators will let them effectively convey the facts, goals, and impacts of biomedical research to non-scientists and the media. Finally, scientist/lawyers who understand the significance of biomedical innovation will ensure this work is safeguarded from a legal standpoint.

I have two recommendations to improve the career training of graduate students and postdocs.

A. **Diversify graduate student training through establishment of programs that facilitate collaboration between biomedical and non-biomedical departments.**

Colleges and universities contain a large number of highly educated people who are generally interested in disseminating knowledge. Collaboration between individuals in different departments has led to groundbreaking discoveries and technologies. For example, the recent expansion of the bioinformatics and biophysics fields is due, in part, to improved collaboration between biomedical research departments and computer science and physics departments. The success of graduate students in these fields can also be partially attributed to acquiring a broad skill set encompassing multiple areas.

The OSTP should encourage expanded collaboration between biomedical research departments and non-science departments in order to broaden the skill set of graduate students. This could be achieved through a college- or university-wide, graduate student exchange program. This program would serve two goals: First, biomedical graduate students could intern in the business or communications departments, for example, to learn skills that will help them run a successful lab, start a biotech company, or advocate on behalf of biomedical research to the government, media, or public. Second, graduate students from non-science departments could gain lab experience, gain a better understanding of scientific research, and become ambassadors for biomedical research.

While internships for biomedical graduate students in non-science departments are rare, the structure for such a program is already present in nearly every Ph.D. granting program in the United States. Almost all graduate students are required to be a teaching assistant as part of the requirement for attaining their degree. Teaching assistantships are designed to give graduate students classroom experience, and graduate students are expected to spend 10-15 hours each week to prepare for their classes. The graduate student exchange internship could be set up with similar parameters.

Entry into the internship for biomedical students could require a detailed application explaining their goals for entering this program and a proposal for their work during the internship that should show a certain degree of relevance to their own research. These proposals could be vetted by a panel consisting of faculty members from each department involved in the exchange. Entry into the internship for graduate students from non-science departments would follow a similar path, including a research proposal that is somehow relevant to their work in their own department.

Internships in the graduate student exchange program could work on a basis similar to teaching assistantships. Biomedical graduate students could spend 10-15 hours per week working on their projects with faculty members from other departments while learning the skills outlined in their initial proposal. Similarly, graduate students from non-science departments would be expected to spend 10-15 hours per week in a lab working on their proposed research. The length of the internship would depend on the departments involved, but could range from one semester to several years.

The benefits of such graduate student exchange programs would be immediate and profound. By requiring that internship projects be somehow related to their own research, graduate students will be forced to consider their thesis work in a different light. For example, graduate students interested in the process of commercializing and marketing biotechnology would be forced to think of the commercial and social values of their work, in addition to the scientific value. The benefits of this alternative approach to their thesis work would offer new insights and potentially hasten the students' graduation. Graduate students who teach during their time as a student are able to better formulate hypotheses and design experiments than students who did not teach (Feldon et al., *Science* 2011). Enrollment in the internships proposed here should have a similar effect since they ask the students to reevaluate their thesis work and address problems with different techniques and thought processes.

The inclusion of graduate students from non-science departments in the graduate student exchange program is critical. While they may not grasp the nuanced scientific concepts tested in every experiment, they are smart, motivated individuals who are eager to learn and can serve as ambassadors for biomedical research once they finish the internship. This internship is an opportunity to improve science literacy among non-scientists and improve the public perception and understanding of biomedical research.

The role of the NIH in the graduate student exchange programs would be to fund pilot programs at select universities, follow the progress of students through these programs, and assess the students' and professors' opinions of the program. At the end of a 5-year trial period, the NIH could issue recommendations and offer financial support for the establishment of other programs around the country.

B. **Initiate a professional development grant program for postdoctoral scholars**.

The main source of extramural funding for postdocs is the National Research Service Award (NRSA). This is a highly successful program that awards grants on the basis of the scientific merit of proposed research and prior achievement. The NRSA program could serve as a model for a granting program that would improve postdoc professional development.

The application process for professional development grants would be similar to the current NRSA format in which postdocs make strong arguments for the importance of funding their research. In addition, applications for these new awards would include a section for the postdoc to propose a program of study with an advisor in another department or outside of the college or university altogether. Similarly, the professional development advisor would write a letter explaining the value of the postdoc's work to the department or organization. Professional development grants would be evaluated by a panel of scientists, similar to the NRSA, while considering the feasibility of the proposed skill development program.

Postdocs receiving a professional development grant would be expected to fulfill their lab obligations and make progress in their scientific endeavors. Training with their non-science advisor would take 10-15 hours of the postdoc's time each week. To optimize postdoc professional development, the NIH should limit professional development grants to 1 year. This would force postdocs and their scientific and outside advisors to develop a plan that allows postdocs to broaden their skill sets in anticipation of their next career steps without sacrificing the progress of their science.

Professional development grants would be appropriate for postdocs with a variety of career goals. For example, postdocs interested in establishing their own labs could learn managerial skills by interning with a management consulting firm. Alternatively, a postdoc studying lung cancer and interested in public relations might propose to work with a communications department faculty member or a local chapter of the American Lung Association. Finally, a postdoc interested in technology commercialization could intern in the college or university's technology transfer office during the grant period.

To measure the success of professional development grants, the NIH should analyze a variety of parameters over a 5-year trial period. First, the number and quality of applicants will serve as an indicator of the popularity and necessity of professional development grants for postdocs. Second, the scientific progress of postdocs during the granting period should be considered. The purpose of a professional development grant is to expand a postdoc's skill set while having a minimal impact on his or her lab productivity. Third, the postdoc and his or her scientific and outside advisors for the granting period should submit reviews of the professional development program to determine the usefulness of the experience. Additional metrics that assess the success and efficiency of professional development grants for postdocs could be considered as well.

Funding professional development grants would not require an increase in the budget allocation for the NIH. Rather, the NIH could convert a small fraction of NRSAs into 1-year professional development grants. Converting 2- to 3-year NRSA grants into 1-year professional development grants could fund 2 to 3 times as many postdocs as an NRSA in the same amount of time. Similar to the NRSA, the professional development grant would fund the postdoc's salary with a small allowance for lab supplies and travel to meetings.

Professional development is essential for postdocs to achieve their career goals regardless of the path they choose. However, scientific success is often a requirement for entry into any science-related field whether it is in academia, law, government, or business. Therefore, professional development grants would allow a large number of postdocs to receive NIH funding, accomplish their scientific goals, and improve their chances of success in their chosen career path.