BIOMEDICAL RESEARCH WORKFORCE WORKING GROUP

DRAFT REPORT

A Working Group of the Advisory Committee to the Director

National Institutes of Health

June 14, 2012

EXECUTIVE SUMMARY

A working group of the NIH Advisory Committee to the Director (ACD –charter and roster in Appendix A) was tasked with developing a model for a sustainable and diverse U.S. biomedical research workforce that can inform decisions about training the optimal number of people for the appropriate types of positions that will advance science and promote health. Based on this analysis and recognizing that there are limits to NIH's ability to control aspects of the training pipeline, the working group was asked to make recommendations for actions that NIH should take to support a future sustainable biomedical research infrastructure.

The working group met 11 times in 2011 and 2012, including 4 in-person meetings and 7 teleconferences, with a goal to provide recommendations to the ACD in June 2012. In addition, a subcommittee consisting of social scientists (primarily economists) with expertise in the scientific enterprise and NIH-funded investigators with expertise in mathematical models was formed to gather and analyze data on the biomedical research workforce and develop a model (see roster in Appendix A).

This report summarizes the workforce data collected and the working group's recommendations. The working group did not have either the time or the expertise to propose details on how the recommendations should be implemented. This will require thoughtful consideration by NIH. The working group recommends that changes to existing programs be phased in gradually and pilot programs be conducted to test new ideas. The outcomes of all changes should be evaluated rigorously.

Additional workforce data can be found at http://report.nih.gov/investigators_and_trainees/ACD_BWF.

The overall purpose of the recommendations is to ensure future US competitiveness and innovation in biomedical research by creating pathways through undergraduate, graduate and postdoctoral training that provide excellent preparation in a timely fashion to:

- Attract and retain the best and most diverse scientists, engineers and physicians from around the world to conduct biomedical research as well as increase the number of domestic students from diverse backgrounds who excel in science and become a part of the Science Technology Engineering and Mathematics (STEM) workforce
- Prepare biomedical PhD students and postdoctoral researchers to participate in a broad-based and evolving economy

The working group appreciates that K-12 and undergraduate education are major factors that influence the success of building of the biomedical research workforce but has confined its recommendations to graduate training and beyond as NIH funding and training focuses on those stages.

Graduate Students

The working group recognizes that the overall number of PhD students in biomedical research is in large part determined by the budget of the NIH. The vast majority of graduate students in the US are supported on a combination of NIH training grants, fellowships and research project grants. The number of fellowships and traineeships has remained relatively constant over time, but the number of students supported on research grants has grown substantially without any mechanism in place to review the quality of training that students are receiving. Although the vast majority of people holding biomedical PhDs are employed (i.e. unemployment is very low), the proportion of PhDs that move into tenured or tenure-track faculty positions has declined from ~34 percent in 1993 to ~26 percent today. In contrast the proportion of non-tenured faculty has stayed relatively constant during the same period, while increasing in absolute numbers. The percentages of biomedical Ph.D.s in industry and government have remained relatively constant. The categories that have seen growth are sciencerelated occupations that do not involve the conduct of research and occupations that do not require graduate training in science.

Despite these changes, graduate training continues to be aimed almost exclusively at preparing people for academic research positions. Therefore, the working group believes that graduate programs must accommodate a greater range of anticipated careers for students. Graduate programs should reflect that range, and offer opportunities for students to explore a variety of options while in graduate school without adding to the length of training. Graduate programs also should openly communicate the career outcomes of their graduates to potential students.

Finally, the working group recognizes that there are aspects of the biomedical workforce that make it less attractive to potential graduate students. The overall length of training in the biomedical sciences (PhD plus postdoctoral research) is longer than in comparable scientific disciplines such as chemistry, physics and mathematics. For PhDs graduating in 2001, the median age for biomedical scientists was 32 and the median age for starting a tenure track position was 37; comparable ages for chemistry doctorates were 30 and 33. Furthermore, academic salaries at public research institutions for assistant professors in biomedical fields are low compared to other fields. According to the Oklahoma State University survey of public research institutions; average starting salaries in fiscal year 2011 for biomedical assistant professors were approximately $68,000 compared to $69,000 for chemistry, $79,000 for clinical and health fields and over $100,000 for economists. The long training period, together with disparities in earnings, may make a career in biomedical research less attractive than one in other scientific disciplines and professional careers.

Recommendations:

- NIH should create a program to supplement training grants through competitive review to allow institutions to provide additional training and career development experiences to equip students for various career options, and test ways to shorten the PhD training period. The best practices resulting from this program will help shape graduate programs across the country. The working group felt that including diverse types of training (e.g. project management and business entrepreneurship skills needed in the pharmaceutical and biotechnology industries, or teaching experiences needed for a successful faculty position in liberal arts colleges) would be particularly valuable for those who go on to conduct NIH-funded research as well as benefit those students who do not follow the academic research career track. For example:
  - Approximately 30% of biomedical PhDs work in the biotech and pharmaceutical industries in research and non-research positions. Their transition would be more effective if their training was better aligned with the required skill-sets for these careers. NIH and the institutions should explore ways to involve relevant employers in the public and private sector in designing training paths for those students who seek employment in that sector. It is possible that the pharmaceutical and biotechnology sectors would be willing to partner in supporting such programs. Another option would be for institutions to develop pilot programs in partnership with private foundations and industry to prepare Ph.D. graduates for careers that involve translational research and development. Finally, NIH should encourage the SBIR/STTR awardees to provide internships for graduate students and postdoctoral researchers to enable increased hands-on training at small businesses.
  - Institutions also could be encouraged to develop other degree programs, e.g. master's degrees designed for specific science-oriented career outcomes, such as industry or public policy. These could be developed as stand-alone programs or provide sound exit pathways for PhD students who do not wish to continue on the research career track. However, this

would require a change in the definition of "success" in the evaluation of NIH training grants.

- To encourage timely completion of graduate degrees, NIH should cap the number of years a graduate student can be supported by NIH funds (any combination of training grants, fellowships, and research project grants), with an institutional average of 5 years and no one individual allowed to receive support for more than 6 years. Note that a different cap may be needed for physician scientists (MD, DDS, MD-PhD etc.). NIH should continue to assess the pre-doctoral stipend level annually.
- To ensure that all graduate students supported by the NIH receive excellent training, NIH should increase the proportion of graduate students supported by training grants and fellowships compared to those supported by research project grants, without increasing the overall number of graduate student positions.
- NIH should revise the peer review criteria for training grants to include consideration of outcomes of all students in the relevant PhD programs at those institutions, not only those supported by the training grant. Study sections reviewing graduate training programs should be educated to value a range of career outcomes. This recommendation could be phased in relatively quickly.
- The very different requirements and characteristics of training programs at each NIH Institutes and Center (IC) constitute a substantial burden on the institutions. All NIH ICs should offer comparable training programs and fellowships and their requirements should be harmonized.

Postdoctoral Researchers

As the number of graduate students doubled over the past twenty years, it is not surprising that there was a comparable increase in US-trained postdoctoral fellows, along with a significant influx of foreign-trained fellows. There are very little reliable data on the number of postdoctoral researchers in the US and the length of their training (see below for specific recommendations to address the lack of data). This is due to a dearth of information about the numbers of foreign-trained postdoctoral researchers, as well as changes in the titles of postdoctoral researchers as they proceed through their postdoctoral positions. The lack of reliable estimates of the population size and rates at which people enter and leave the postdoctoral pool complicated the analysis.

Nonetheless, after analyzing the available data, the working group believes that the postdoctoral experience be considered an extension of the training period primarily intended for those Ph.D. graduates who intend to pursue research-intensive careers. Fellows should be given structured career development opportunities and there should be incentives provided by NIH to move postdoctoral fellows to more permanent positions as soon as possible. The working group also recognizes that postdoctoral fellows have spent years in graduate training, and should be compensated accordingly.

Recommendations:

- To ensure that all postdoctoral fellows supported by the NIH receive excellent training and mentoring, NIH should increase the proportion of postdoctoral researchers supported by training grants and fellowships and reduce the number supported by research project grants, without increasing the overall number of postdoctoral researchers.
- NIH should create a pilot program for institutional postdoctoral offices to compete for funding to experiment in enriching and diversifying postdoctoral training, including partnerships with other entities (industry, private foundations, government, etc.).

- The current stipends for NIH-supported postdoctoral fellows need to be adjusted to levels that better reflect their years of training. The working group recommends that the NIH should adjust the starting stipend levels of the Ruth L. Kirschstein National Research Service Awards (NRSA) to $42,000 and index the starting stipend according to the Consumer Price Index (CPI-U) thereafter. Stipend levels should increase with each year of experience in any postdoctoral position irrespective of their titles by 4% for the second and third years and 6% for years 4 through 7. The large jump between years 3 and 4 is meant to emphasize a transition from postdoctoral *training* to research production, and to incentivize PIs to move fellows to more permanent positions. This salary scale will apply to postdoctoral researchers supported by research project grants as well, and institutions should be encouraged to adopt this scale for all postdoctoral researchers, irrespective of the source of their support.

  NIH should evaluate this policy in the decade after implementation to determine whether the postdoctoral period has shortened. If it is not reduced, then perhaps NIH should experiment with a cap on the length of funding for postdoctoral researchers.

- NIH should require and adjust its own policies so that all NIH-supported postdoctoral researchers on any form of support (training grants, fellowships or research project grants) receive benefits that are comparable to other employees at the institution. Such benefits include paid time off, health insurance, retirement plans, maternity leave etc.

- To encourage larger numbers of PhD graduates to move rapidly into permanent research positions, NIH should double the number of Pathway to Independence (K99/R00) awards, and shorten the eligibility period for applying to this program from the 5 years to 3 years of postdoctoral experience.

- NIH also should double the number of the NIH Director's Early Independence awards to facilitate the "skip-the-postdoc" career path for those who are ready immediately after graduate school.

- NIH should require individual development plans (IDPs) for all NIH-supported postdoctoral researchers, whether on training grants, fellowships, or research project grants. Assessment of implementation of this requirement should be included in the review criteria of training grants.

Staff Scientists

The typical academic laboratory consists of a PI and one or a small number of permanent technical staff, with the majority of the research carried out by trainees. This creates a system in which a large number of future scientists are being produced each year, well in excess of the number of research-oriented jobs in academia, government and industry. The working group believes that even a modest change in the ratio of permanent staff to trainees could have a beneficial effect on the system without reducing the productivity of the research enterprise. Staff scientists - individuals with masters or PhD degrees - could play a more important role in biomedical research (one that may become increasingly necessary if the market for biomedical researchers strengthens outside of the United States in coming years).

Today, these scientists bring stability to many labs and provide important functions as part of institutional core facilities, but have a wide variety of titles and employment conditions. As an example, staff scientists constitute an essential part of the NIH intramural research program. In the extramural program, these scientists do not apply for their own grants, but are supported by research project, Center and Program Project grants. They should be differentiated from "soft money" scientists, whose employment depends upon their successful competition for research funds, a category that has been increasing over the last few years.

The working group encourages NIH study sections to be receptive to grant applications that include staff scientists and urges institutions to create position categories that reflect the value and stature of these researchers.

Salary Support

Originally the conduct of federally-funded research at universities and other extramural institutions was based on an understanding that institutions would provide the bulk of facilities and salaries to the researchers and the NIH would provide the majority of funds for conducting research. Over the past decades, this distinction has become increasingly blurred, with NIH providing an increasing proportion of faculty salary support and the institutions covering a larger percentage of the research costs. This is especially true during the start-up period, which has become significantly longer as young investigators struggle to receive their first R01 grants. The growth in "soft money" positions in academic medical schools, in which investigators are required to raise 100% of their salaries and research funds, has contributed to the negative views of a career in biomedical science, and has had the additional consequence of encouraging institutions to expand their physical space without making additional long term commitments to faculty.

The working group believes that institutions should provide some fraction of salary support for their researchers in order to qualify for NIH funding. That being said, the working group appreciates that any reduction in NIH salary may have major consequences on institutions.

The working group recommends that NIH consider a long-term approach (over a 20 year period) to gradually reduce the percentage of funds from all NIH sources that can be used for faculty salary support.

Physician Scientists

The working group was charged with addressing physician scientist training as well as PhD training. The economic and educational drivers which affect the training and career paths of the physician scientist workforce are very different from those underlying PhD research training and career paths and there was not sufficient time for the working group to examine this important part of the biomedical workforce in detail. In addition, the changing landscape of health care and the effects these changes likely will have on academic medical centers need to be projected carefully and considered when analyzing the future physician scientist workforce.

Therefore, the working group recommends that NIH conduct a follow-on study that focuses on physician scientists and involves people who train physician scientists, as well as economists who focus on medical education costs, career choices, and the role of these as incentives.

Information Collection, Analysis and Dissemination

The working group was frustrated and sometimes stymied throughout its study by the lack of comprehensive data regarding biomedical researchers. The timeframe and resources of the study did not allow for comprehensive data collection or the implementation of a comprehensive model of the biomedical workforce. It is evident from the data-gathering and analyses undertaken by the working group that there are major gaps in the data currently being collected on foreign-trained postdoctoral researchers and those who work in industry.

The working group also believes that it is imperative to provide as much information as possible to prospective graduate students and postdoctoral researchers on career outcomes both nationally and at their specific training programs so they can make more informed decisions about their future.

Recommendations:

- Institutions that receive NIH funding should collect information on the career outcomes of both their graduate students and postdoctoral researchers, and provide this information to prospective students/ postdoctoral researchers and the NIH. Such information should include completion rates, time to degree, career outcomes for PhD trainees, as well as time in training and career outcomes from postdoctoral researchers over a 15-year period. Outcome data should be displayed prominently on the institution's web site. This will require institutions to track the career paths of their students and postdoctoral researchers over the long-term. One way to do that would be to assign graduate students and incoming postdoctoral researchers an identifier that can be used to track them throughout their careers.
- NIH, working with other agencies in the Federal Government, should address the identified data gaps and collect information on the biomedical and scientific workforce on an ongoing basis.
- NIH should create a permanent unit in the Office of the Director that works with the extramural research community, the National Science Foundation (NSF) and the NIH ICs to coordinate data collection activities and provide ongoing analysis of the workforce and evaluation of NIH policies so that they better align with the workforce needs.

Diversity

Increasing diversity of trainees and the workforce is critical to the future of biomedical research in the US, particularly as the share of the US population comprised of underrepresented groups increases. The committee recognizes that this is the responsibility of the entire scientific community but feels NIH should set an example.

Although the working group recommendations are not aimed specifically at increasing diversity, the group feels that implementation of these recommendations will increase the overall attractiveness of the biomedical research career and consequently its attractiveness to underrepresented ethnic and racial minorities and women.

The working group is aware that another working group of the Advisory Committee to the NIH Director is focused on this issue but would like to highlight the need for much stronger coordination of the many diversity-related efforts at the NIH and for rigorous evaluation of the outcomes of all programs.

Conclusion

The working group is aware that similar recommendations have been made in the past by other groups that studied the biomedical research workforce. Many of those recommendations were not implemented, in part because of funding constraints and in part because of resistance from the scientific community. **Therefore, the working group urges NIH to provide the funds necessary to implement these recommendations and encourages institutions to work with NIH on the implementation.**

INTRODUCTION

Over the years, biomedical research, funded in large part by the National Institutes of Health (NIH), has contributed enormously to an increase in health and life expectancy in the US. As described in the 2007 NIH biennial report to Congress[1], life expectancy increased by 7.4 years from 1961 to 2004. Infant mortality has decreased from 26 deaths per 1,000 live births in 1960 to 6.9 in 2005. Biomedical research has and continues to expand our understanding of the physiology underlying many diseases (often at the molecular level), contributing, along with other factors such as changes in behavior, to numerous advances in treatments and improved health care. The change in the prognosis for HIV patients is one example of these benefits. In the 1990s, the discovery and development of antiretroviral drugs transformed HIV infection for many individuals from a death sentence into a chronic disease. In addition, the results of biomedical research have led to important changes in the US economy, launching the biotechnology industry and changing the way pharmaceutical companies develop new drugs and treatments.

Successful biomedical research relies on the talent and dedication of the scientific workforce and a continued supply of highly trained people of the best quality who can bring new insights to our understanding of biology and advance the translation of these insights into improved health for all. To this end, NIH supports training of graduate students and postdoctoral researchers both with dedicated training grants and fellowships and as employees on research project grants.

Training at NIH

The training of biomedical researchers has been an integral part of the NIH mission since its earliest days. In 1930 the Ransdell Act[2] established the National Institute of Health. By the early 1970s, the NIH included multiple institutes and the training programs had grown substantially; nearly 15 percent of NIH extramural funding was dedicated to research training. The National Research Act of 1974 amended the Public Health Service act by repealing existing research training and fellowship authorities and consolidating these authorities in the National Research Service Awards (NRSA) authority.

In 2002, Congress renamed the National Research Service Award program after Ruth L. Kirschstein in recognition of her many scientific accomplishments in polio vaccine development, and her tenure as the first woman director of an NIH Institute. Dr. Kirchstein was a champion of research training and a strong advocate for the inclusion of underrepresented individuals in the scientific workforce[3].

Today, NIH has authority to award NRSA individual fellowships to support predoctoral and postdoctoral training of individuals to undertake biomedical, behavioral, or clinical research at domestic and foreign, public and private institutions. The NRSA legislation authorizes NRSA institutional research training grants and limits institutional NRSA support to training and research at domestic public and non-profit private entities. Individuals trained in these programs must be citizens (or noncitizen nationals) of the United States or have been lawfully admitted for permanent residence by the time of the award.

Individuals receiving postdoctoral support under individual fellowships or institutional research training grants are required to pay back to the Federal government their initial 12 months of Kirschstein-NRSA postdoctoral support by engaging in health-related biomedical, behavioral and/or clinical research, research training, health-related teaching, or any combination of these activities. Arguably the most important feature of the service payback obligation is the requirement to monitor the payback

[1] http://report.nih.gov/biennialreport/
[2] P.L. 71-251, 46 Stat. L. 379
[3] http://www.nigms.nih.gov/Training/RuthKirschstein

obligations, which necessitates careful data collection and tracking of NRSA recipients. This data collection has allowed for comprehensive evaluation of the programs.

In FY2012, these research training programs comprise 3% of the NIH budget[4]. The number of NRSA training positions awarded has not changed substantially in the past decade[5]. For every graduate student and postdoctoral researcher supported by NRSA NIH research training programs, however, there are between 2 and 4 individuals who are supported as research assistants and associates working on NIH research project grants.

Assessment of Biomedical Research Workforce Training

Together with the NRSA act, Congress created a companion act that requires regular assessment of the needs for research personnel, the fields of training, and the kinds and intent of such training. That assessment is carried out by the National Research Council (NRC). Initially those studies were required every year and then every four years.

The last such study was completed in 2011[6]. This study, chaired by Roger Chalkley of Vanderbilt School of Medicine, found that, based on the observation of low unemployment rates of biomedical and behavioral scientists and models that predicted substantial growth in scientific employment opportunities over the next decade, the number of NRSA positions is adequate and should remain at the same level in biomedicine and should be increased in behavioral sciences.

As described later in this report, the data gathered by the ACD working group do not indicate such growth in employment opportunities. Rather, the numbers of positions available for biomedical PhDs that take advantage of their long training are less than the number of PhDs produced each year. As a consequence their career path is marked by uncertainty. Compensation is relatively low compared to other disciplines such as engineering and the physical sciences, and the NIH funding environment is highly uncertain for the near future.

The NRC report also recommended increases in the number of Medical Scientist Training Program (MSTP) students, increases in graduate and postdoctoral stipends, increases in the indirect cost rate on training grants and career development awards, and increases in efforts to enhance the diversity of the graduate and postdoctoral training programs. Finally, the report suggested improvements in the way workforce data are collected and managed, recommended changes in the content of training grant applications, and made a number of additional discipline and training content focused recommendations.

Other studies of the NRSA program have been conducted over the years. In 2001, NIH published an evaluation of *The Early Career Progress of NRSA Predoctoral Trainees and Fellows*, conducted by Georgine Pion of NIH and Vanderbilt University[7]. The study compared career outcomes of NRSA award recipients who completed their doctorate between 1981 and 1992 to students who did not receive NRSA predoctoral support (either in departments that had NRSA predoctoral training grants or in those that did not have such grants). The outcomes measured included educational attainment, postdoctoral training, research-related employment, success in applying for NIH and NSF research support, and research productivity as defined by publication and citation rates

[4] http://report.nih.gov/NIHDatabook/Charts/Default.aspx?showm=Y&chartId=5&catId=1
[5] http://report.nih.gov/NIHDatabook/Charts/Default.aspx?showm=Y&chartId=52&catId=17
[6] http://grants.nih.gov/training/Research_Training_Biomedical.pdf
[7] http://grants.nih.gov/training/career_progress/index.htm

The study found that predoctoral NRSA recipients completed their degrees in less time and were more likely to engage in postdoctoral research training, assume faculty positions, apply for and receive NIH and NSF grants, and publish highly cited papers than individuals who graduated at the same time in the same field without the benefit of NRSA support.

In 2006, NIH conducted a study of *The Career Achievements of NRSA Postdoctoral Trainees and Fellows: 1975–2004*[8]. The study evaluated career outcomes of postdoctoral researchers who received support from fiscal year 1975 through fiscal year 1992, comparing NRSA recipients to postdoctoral fellows supported by other means. Postdoctoral researchers on training grants were considered separately from those with fellowships. The outcomes measured were:

- success in obtaining NIH research grant support
- success in publishing in peer-reviewed journals
- success in obtaining and remaining in research-oriented employment

The study found that postdoctoral NRSA fellows performed better in all outcomes measured than comparison postdocs including those that were supported by NRSA training grants.

In addition to the studies that evaluated the NRSA programs specifically, analyses of the broader biomedical research workforce and training needs have been conducted over the years. One example is a study published by the National Research Council in 1998, *Trends in the Early Careers of Life Scientists*, chaired by Shirley Tilghman[9]. The committee examined the graduate and postgraduate training of life scientists and the nature of their employment on completion of training.

The study concluded that the level of PhD production in 1998 exceeded the availability of jobs in academe, government and industry where they can use their training as independent scientists. As a result, increasing numbers of PhDs occupy postdoctoral and other academic appointments outside the tenure and tenure track. The structure of the life sciences was built on the premise that the enterprise would continuously expand and absorb and employ the large number of graduate students and postdoctoral researchers. In the absence of such expansion there is a growing imbalance between the rate of training and the growth in research career opportunities. The 1998 committee suggested that the absence of suitable employment has led to a crisis of expectations that could discourage the best students from entering the field.

The 1998 committee recommended restraint in future growth in the number of graduate students, disseminating accurate information about career prospects, improvement in the educational and training experience of graduate students, funding mechanisms that shorten the postdoctoral period, and, focusing on preparing students for independent research positions rather than for "alternative" careers. It is notable that this report was released just before the doubling of the NIH budget, which may have affected the perception of the urgency of its recommendations.

Recognizing that the behavioral and biomedical research enterprise has grown in both size and complexity in the past decade - particularly with the doubling of the NIH budget between 1999 and 2003, and that the NIH budget is likely to remain flat or even decline in the near future, the NIH Director tasked the ACD in December 2010 with forming a workgroup that would develop a better understanding of current and future needs of the behavioral and biomedical research workforce in various sectors. These sectors include academia, industry, and government, including those who do research and those

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[8] http://grants.nih.gov/training/NRSA_report_5_16_06-2.doc

[9] *Trends in the Early Careers of Life Scientists*, Commission on Life Sciences, National Research Council, National Academies of Science, National Academy Press, Washington DC 1998. http://www.nap.edu/catalog.php?record_id=6244

who use their training in other ways. The working group would collect data on the complete biomedical research workforce to support a more comprehensive assessment of the workforce are needed to fill biomedicine-related positions now and in the future (see charter and roster in Appendix A).

The working group appreciates that K-12 and undergraduate education are major factors that influence the success of building of the biomedical research workforce but has confined its recommendations to graduate training and beyond as NIH funding and training focuses on those stages.

The working group met a total of eleven times in 2011 and 2012, including four in-person meetings and seven teleconferences, with a goal of providing recommendations to the ACD in June 2012. In addition, a subcommittee consisting of social scientists (primarily economists) with expertise in the scientific enterprise as well as NIH-funded investigators with expertise in mathematical models was formed to gather and analyze data on the biomedical research workforce and develop a model (see roster in Appendix A). The subcommittee met three times in 2011 and 2012, including two in-person meetings and one teleconference.

This report summarizes the workforce data collected and the working group's recommendations. Additional data can be found at http://report.nih.gov/investigators_and_trainees/ACD_BWF.