BIOMEDICAL RESEARCH WORKFORCE WORKING GROUP REPORT

A Working Group of the Advisory Committee to the Director

National Institutes of Health

June 14, 2012

"The Government should provide a reasonable number of undergraduate scholarships and graduate fellowships in order to develop scientific talent in American youth. The plans should be designed to attract into science only that proportion of youthful talent appropriate to the needs of science in relation to the other needs of the nation for high abilities."

Vannevar Bush, *Science, the Endless Frontier*[1], *1945*

[1] United States Government Printing Office, Washington: 1945 - http://www.nsf.gov/od/lpa/nsf50/vbush1945.htm

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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 science-related 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[2], 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[3] 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[4].

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

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[2] http://report.nih.gov/biennialreport/
[3] P.L. 71-251, 46 Stat. L. 379
[4] 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[5]. The number of NRSA training positions awarded has not changed substantially in the past decade[6]. 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[7]. 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[8]. 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

[5] http://report.nih.gov/NIHDatabook/Charts/Default.aspx?showm=Y&chartId=5&catId=1
[6] http://report.nih.gov/NIHDatabook/Charts/Default.aspx?showm=Y&chartId=52&catId=17
[7] http://grants.nih.gov/training/Research_Training_Biomedical.pdf
[8] 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*[9]. 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[10]. 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

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

[10] *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.

Path to a Career in Biomedical Sciences

This section presents the data gathered by the working group on biomedical research training and the workforce as well as describes how the data inform our understanding of the current workforce.

Considerations about the Data

The various entities that collect data on the workforce have different field (areas of science) definitions. The definitions in the text box were used in the data that follows, unless otherwise stated.

In addition, due to the different definitions and various collection methods, different sources on the same topic may provide varying numbers. The working group focused on overall trends rather than specific numbers. The frameworks below represent the best effort to reconcile data from the different sources.

Field (Areas of Science) Definitions

- **Basic Biomedical**—Focus of our study (Biochemistry, Bioinformatics, Biological Sciences, Biomedical Engineering, Biophysics, Biotechnology, Cell Biology, Developmental Biology/Embryology, Endocrinology, Genetics, Immunology, Microbiology, Molecular Biology, Neurosciences, Nutritional Science, Parasitology, Pharmacology, Pharmaceutical Chemistry, Physiology, Toxicology, Veterinary Medicine, Zoology)
- **Clinical Sciences** (Biometrics and Biostatistics, Environmental Health, Epidemiology, Exercise Science, Health Sciences, Health Administration, Nursing, Pharmacy, Public Health, Rehabilitation Services, Physicians in Academic Medicine)
- **Behavioral & Social Sciences** (Anthropology, Audiology/Speech Pathology, Demography/Population Studies, Sociology, Psychology)
- **Other Life Sciences** (Agricultural and Food Sciences, Environmental Life Sciences
- **Chemistry** – used as a comparison field in this study

The "gold standard" for data about careers and training of US-trained PhDs in the sciences is the Survey of Doctorate Recipients (SDR[11]), a longitudinal study of individuals who received a doctoral degree from a US institution in a science, engineering, or health field. The SDR has been conducted every 2 to 3 years since 1973 for the National Science Foundation (NSF) in conjunction with the NIH. However, the SDR has some shortcomings that have limited this analysis. It does not include information on foreign-trained doctorates (an increasing share of the biomedical workforce), and the data are reported with a significant lag (the most recent data available to the committee were from 2008).

Data that were presented to the working group but not included in the report are presented in Appendix B and at http://report.nih.gov/investigators_and_trainees/ACD_BWF.

Graduate Students

The number of PhDs trained in biomedical science in the US has risen steadily over the past decade as evident from the data below. In contrast, the number of PhDs trained in Behavioral and Social Sciences and Chemistry has been stable over the same period (see Figure 1). The steep increase in the number of biomedical PhDs awarded began in 2004, just after the end of the doubling of the NIH budget (1999-2003). Given a 5-7 year training period, this illustrates a close relationship between the size of the NIH budget and the number of biomedical PhD slots.

[11] http://www.nsf.gov/statistics/srvydoctoratework/

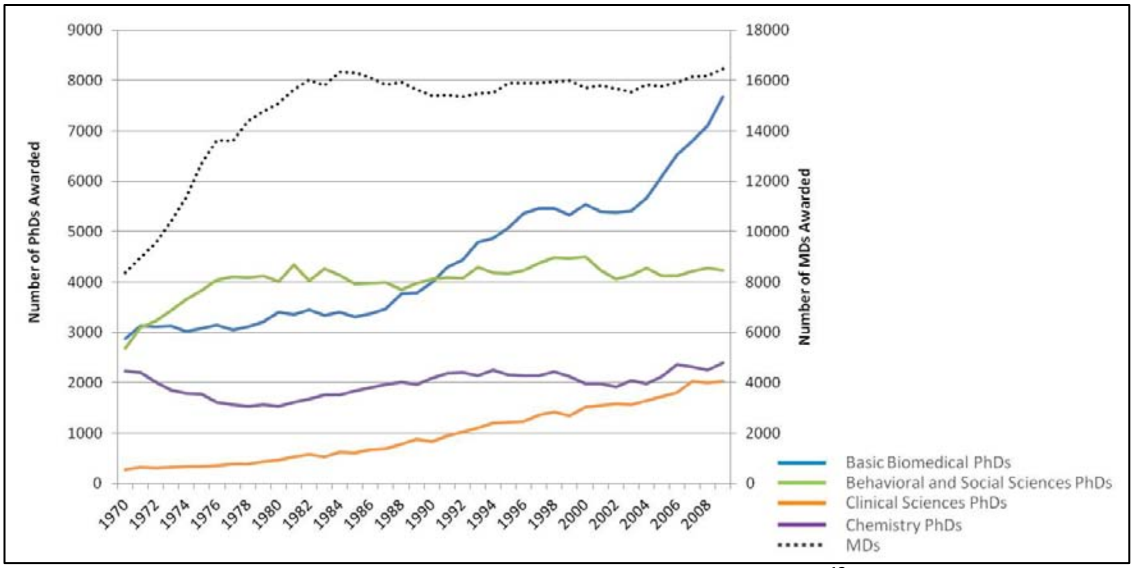

Figure 1: US Graduate Degrees Awarded, by Field[12]

NIH supports the vast majority of biomedical graduate students in the US on a combination of training grants, fellowships and research project grants. Many more students are supported on research grants than by training grants and fellowships. The number of students on research grants has grown considerably over the past decade, in parallel with the doubling of the NIH budget (Figure 2). On the other hand, the number of students supported by traineeships and fellowships has increased only modestly over the same period. Training grants uniquely provide the NIH with a mechanism for peer review of training, and permit the NIH to require attention to issues such as outcomes, diversity and professional ethics training. On the other hand, there are no training-related requirements for students on research grants. The existence of an NIH training program at an institution, however, can motivate graduate programs to provide all students at that institution with training that conforms to NIH guidelines and expectations.

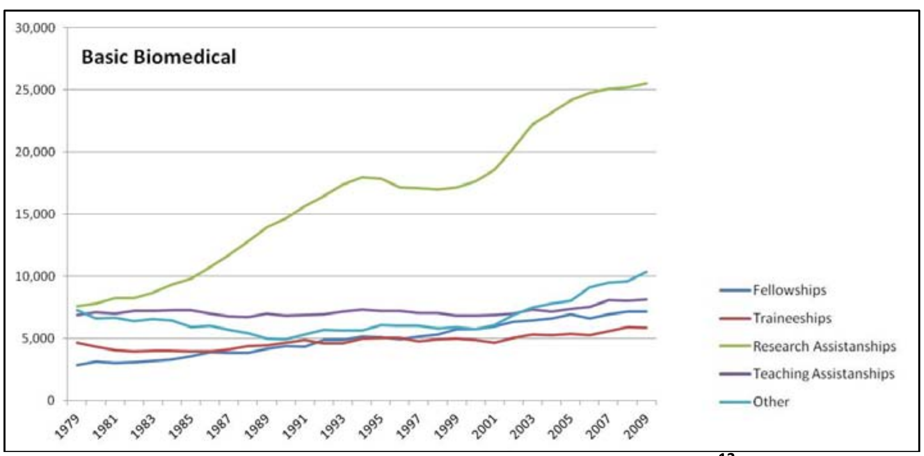

Figure 2: Doctorate Students by Type of Support[13]

Along with the increase in the number of biomedical PhD students trained in the US, there is a perception in the community that the length of PhD training also has increased. As shown in Figure 3,

[12] SED
[13] GSS

the time to degree and age at degree of biomedical PhDs actually have remained stable or decreased in the past 15 years.

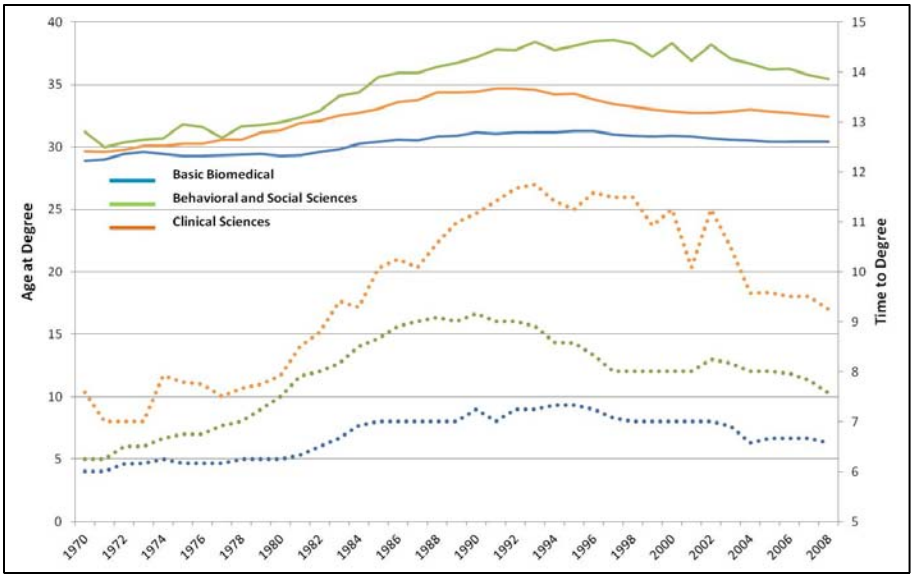

Figure 3: Time to Degree and Age at Degree[14]

Nevertheless, 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, particularly for those scientists who go on to tenure-track research positions. 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. This difference can be seen in the SED data presented below in Figure 7. In addition, the increasing age at which medical school faculty obtain their first tenure-track position has increased, as shown in Figure 17.

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 postdoctoral fellows. This increase was augmented by a significant influx of foreign-trained fellows. As the working group began its work, it quickly became clear that there are very little reliable data on the number of postdoctoral researchers in the US and how this number has changed over the years (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 training. The National Postdoctoral Association defines a postdoctoral scholar as "an individual holding a doctoral degree who is engaged in a temporary period of mentored research and/or scholarly training for the purpose of acquiring the professional skills needed to pursue a career path of his or her choosing.[15]" We have used the term postdoctoral researcher throughout this report. The lack of reliable estimates of the population size, and the rates at which people enter and leave the postdoctoral pool, greatly complicated the analysis conducted by the working group.

Nevertheless, the available data do provide some insights into the state of US-trained postdoctoral researchers in the biomedical sciences. Like graduate students, postdoctoral researchers primarily are

[14] SED
[15] http://www.nationalpostdoc.org/policy/what-is-a-postdoc

supported by the NIH with a combination of training grants, fellowships, and research grants. The vast majority of US-trained postdoctoral researchers are supported on research grants and that number has increased steadily for a long time (Figure 4). Note that data from other sources including NIH suggest that the number of postdoctoral researchers in the figure below may be under-estimated by as much as a factor of 2, due in part to the nomenclature problem and to the fact that the GSS (from which the data are derived) only includes postdoctoral researchers who are at degree-granting institutions.

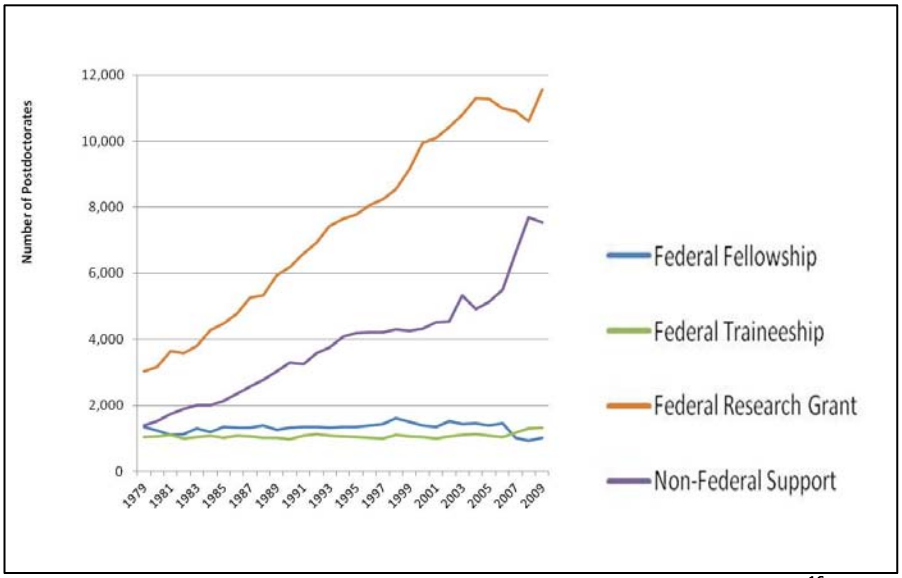

Figure 4: Biomedical Postdoctoral Researchers by Type of Support[16]

The other source of support that has been growing over the last five years is "nonfederal support", defined as support from state and local government; the institution, such as stipends; foreign sources, such as foreign governments, foreign firms, and agencies of the United Nations; and other US sources, such nonprofit institutions, and private industry.

A large number of postdoctoral researchers are foreign-trained. The available data suggest that their number has grown immensely over the past two decades (Figure 5). Non-US citizens (the majority of foreign-trained postdoctoral researchers) are not eligible for most NIH training grants or fellowships. The majority of these researchers are supported by research project grants.

[16] NSF Graduate Students and Postdoctorates Survey

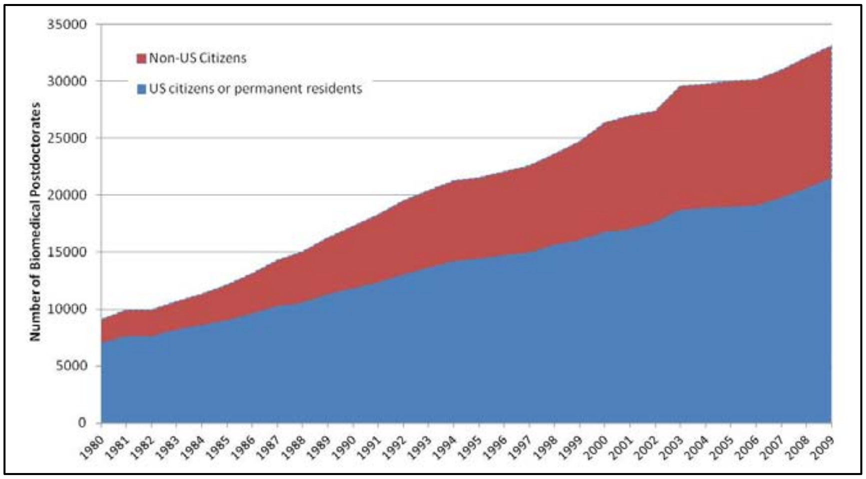

Figure 5: Biomedical Postdoctoral Researchers by Citizenship[17]

There is a perception in the biomedical community that the postdoctoral training period has lengthened over time. With the caveats in accessing accurate data listed above, data from the SDR suggest that most US-trained biomedical PhDs spend fewer than 5 years in postdoctoral positions, although that number has been steadily growing with time (Figure 6). Furthermore, there are a significant number who remain in postdoctoral training between 5-8 years. There is some indication that the researchers remaining in the postdoctoral position the longest are the ones who go on to tenure-track academic research careers. For example, in Figure 7, it is evident that the age at first non-postdoctoral job (many of which are in industry) has been consistently a year or two lower than the age of first tenure-track job. Note that the latest data in this graph (2002-2003) may be underreported due to a lag-time bias.

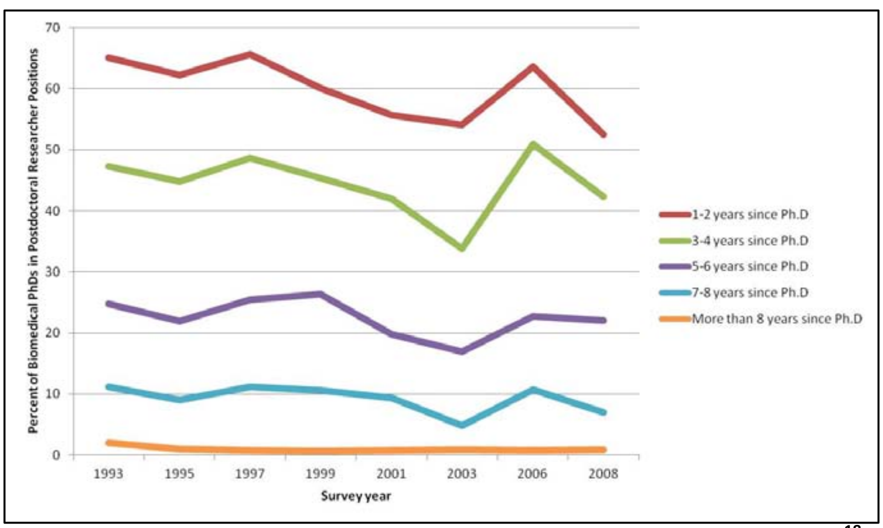

Figure 6: Years Biomedical PhDs Spend in Postdoctorate Training Positions[18]

[17] GSS
[18] SDR

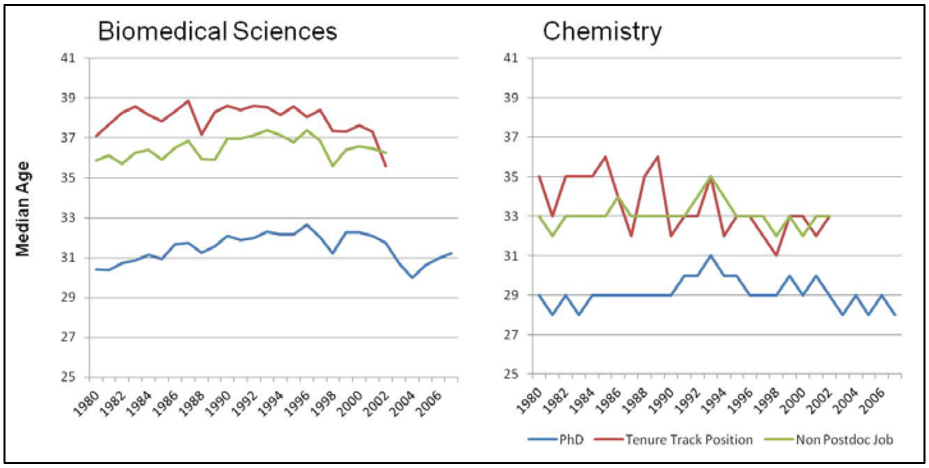

Figure 7: Age at First PhD, First Non Postdoctoral Job, First Tenure Track Job, for US trained Doctorates[19]

In addition, the scientific fields most likely to have postdoctoral researchers coincide with the top fields funded by NIH[20] (see box).

- **Fields where postdoctorates are more likely (top 10):**

Genetics	Developmental Biology
Biochemistry	Molecular Biology
Immunology	Cellular Biology
Endocrinology	Biophysics
Microbiology	Neuroscience

→7 are in the top 10 fields receiving NIH funding

- **Fields where postdoctorates are less likely:**

Biometrics/Statistics	Pharmaceutical Science
Nursing	Rehabilitation
Kinesiology	Health Science, Other
Public Health	Environmental Health
Veterinary Medicine	Health Sciences General

→ 9 are in the bottom 10 fields receiving NIH funding

The current stipend levels of postdoctoral NRSA awardees are listed in Table 1 below. When compared to stipends of postdoctoral fellows funded by other agencies such as NSF ($45,000[21]) and the Department of Energy ($65,000[22]), the NIH stipends for biomedical postdoctoral researchers are low.

[19] SED
[20] SDR
[21] http://www.nsf.gov/pubs/2011/nsf11499/nsf11499.pdf page 6
[22] http://www1.eere.energy.gov/education/postdoctoral/benefits.html

Level	Years of Experience	Stipend for FY 2012
Postdoctoral	0	$39,264
	1	$41,364
	2	$44,340
	3	$46,092
	4	$47,820
	5	$49,884
	6	$51,582
	7 or More	$54,180

Table 1: FY 2012 Ruth L. Kirschstein National Research Service Award (NRSA) Stipend Levels[23]

Career Outcomes

As mentioned above, data from the SDR, which is designed specifically to track the PhD labor force and is thus the major source for data on US-trained biomedical PhDs, extends only through 2008. Therefore, much of the information presented below about career outcomes does not take into account the past four years (including the recent recession). The working group gathered more up-to-date data from other sources and those are included where possible.

Even as the number of US-trained doctoral recipients in the fields analyzed generally increased from 1993 to 2008, the number of PhD recipients that are employed has declined slowly although unemployment has remained remarkably flat (Figure 8).

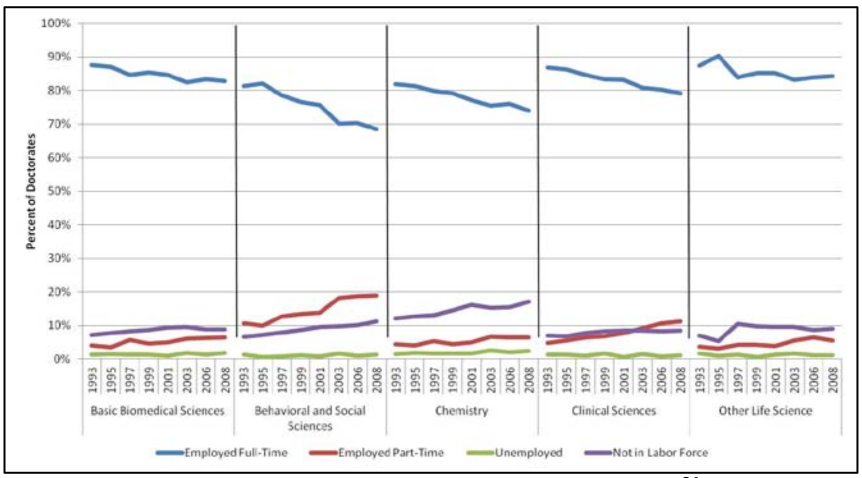

Figure 8: Employment Status of US Doctorates[24]

As can be seen in Figure 9, across science and engineering PhD fields 60-80% of graduates report that they are employed in occupations that are closely related to their PhD field. However, the percent in biomedical sciences decreased between 1997 and 2008 from 70% to just below 59%. Other fields do not show a decrease of this magnitude. Figure 10 shows that over 70% of biomedical PhDs begin

[23] http://grants.nih.gov/grants/guide/notice-files/NOT-OD-12-033.html
[24] SDR

working in research positions immediately after graduate school. By 11 years after their PhD 60% still work in a research occupation, but once again, the percentages among relatively recent graduates have steadily decreased since 1995. Taken together, these data indicate an increasing imbalance in the supply and demand of individuals in research-related occupations over time. Given the current state of the US economy, it is reasonable to predict that this imbalance will continue, and possibly grow.

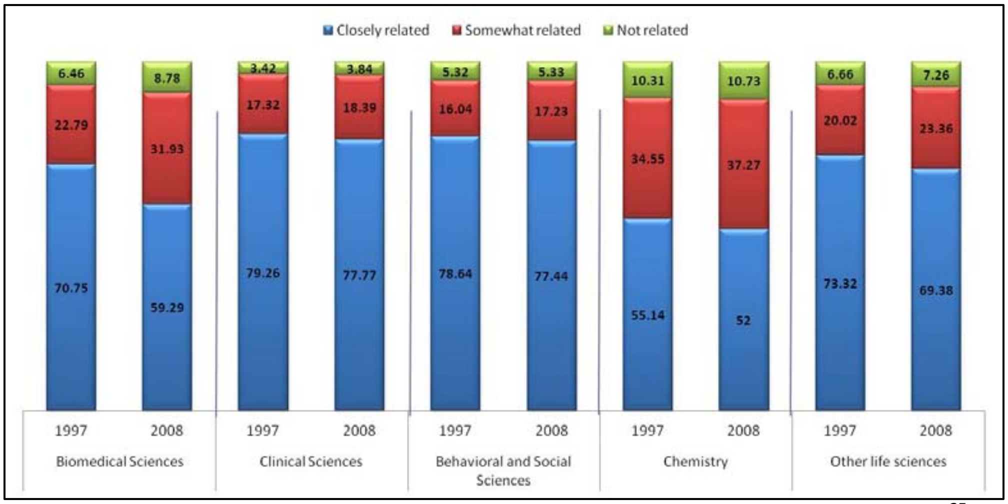

Figure 9: Relationship between Science and Engineering PhD Field and Occupation[25]

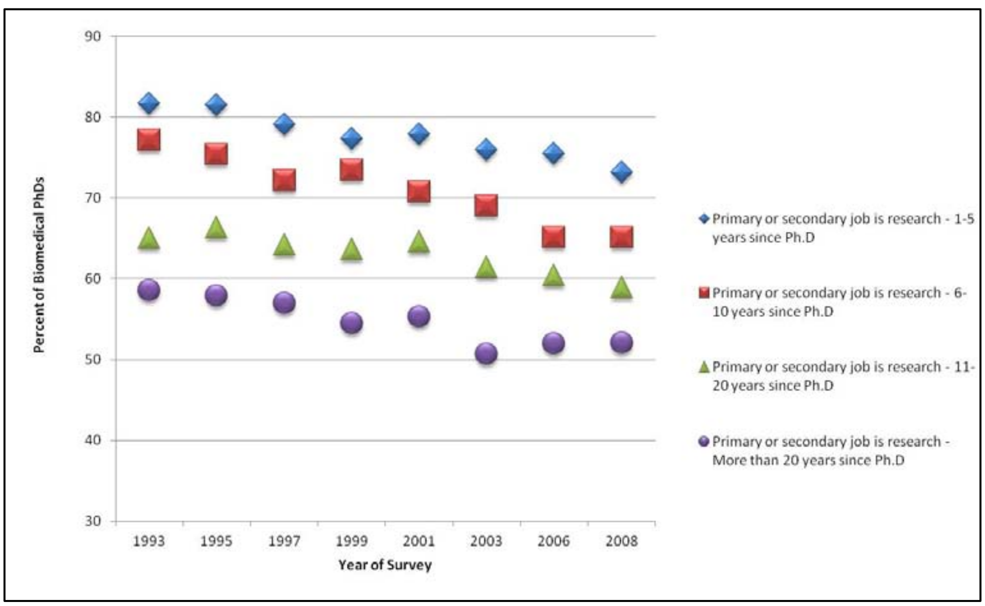

Figure 10: U.S. Trained Biomedical PhDs in Research Occupations, by Years since Degree[26]

Figure 11 shows employment of US-trained biomedical PhDs at various times after obtaining their degree. Most of the individuals in the academic non-tenure track group 1-5 years since their degree probably are postdoctoral researchers. The trend data 6-10 years and 11-20 years after the PhD show that the proportion of academic tenured or tenure-track positions has decreased over the past decade, while the proportion of non-academic non-research positions have increased over the same period.

[25] SDR
[26] SDR

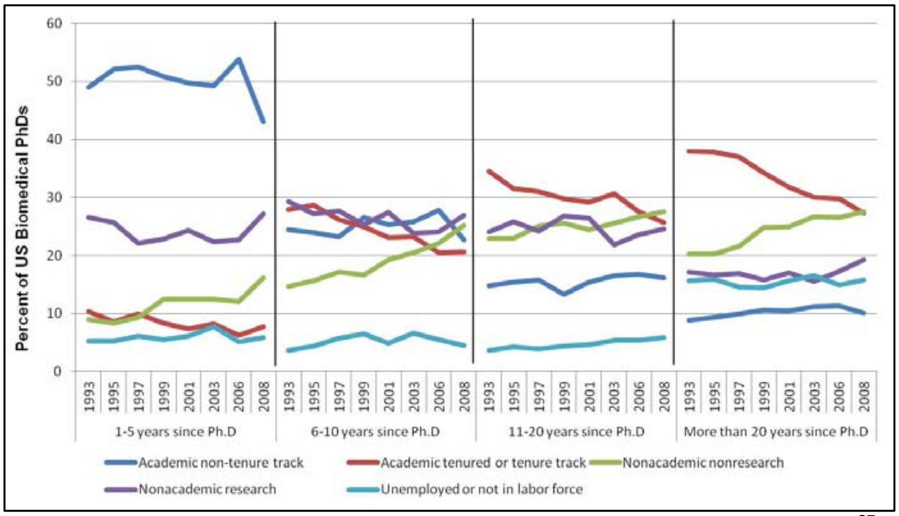

Figure 11: U.S. Trained Biomedical PhD employment, by Years Since Degree[27]

Focusing on PhD employment in the academic sector, it is evident from Figure 12 that the number of biomedical PhDs employed in this sector increased from 1993 to 2006. However the percentage of tenure or tenure-track positions decreased steadily during this period, as colleges and universities chose to increase their staff by increasing the number of non-tenure-track positions. These positions often are dependent on obtaining outside funding (mainly from NIH) to cover 100% of salary. There seems to be a decline in all positions between 2006 and 2008 and it remains to be seen whether this will continue when the 2010 data are released. Academic employment in other life sciences showed a similar trend but at a much lower level. In contrast, academic employment in chemistry was stable over the same time period.

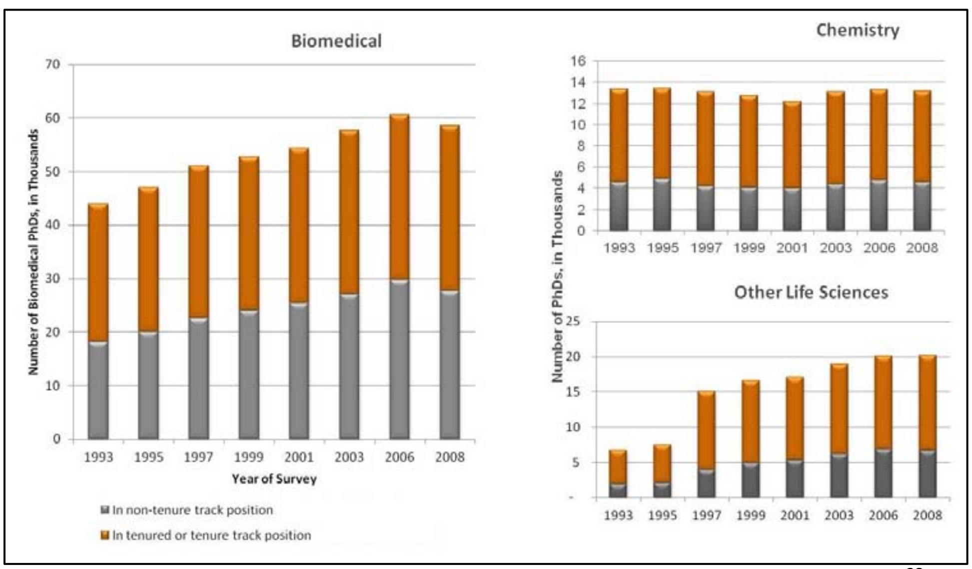

Figure 12: U.S. Trained PhDs in academic employment, by tenure track status[28]

[27] SDR
[28] SDR

The AAMC faculty roster provides the opportunity to take a closer look at employment in medical schools as Figure 12 includes all academic institutions. Figure 13 shows faculty appointments between 1980 and 2010. MD tenure-track appointments represent the largest component of medical school faculty appointments, but as summarized in the conceptual framework (Figure 20), the vast majority of those are in Clinical Departments where the primary focus is not research. Non-tenure track appointments increased during the early part of the millennium and stabilized in 2006.

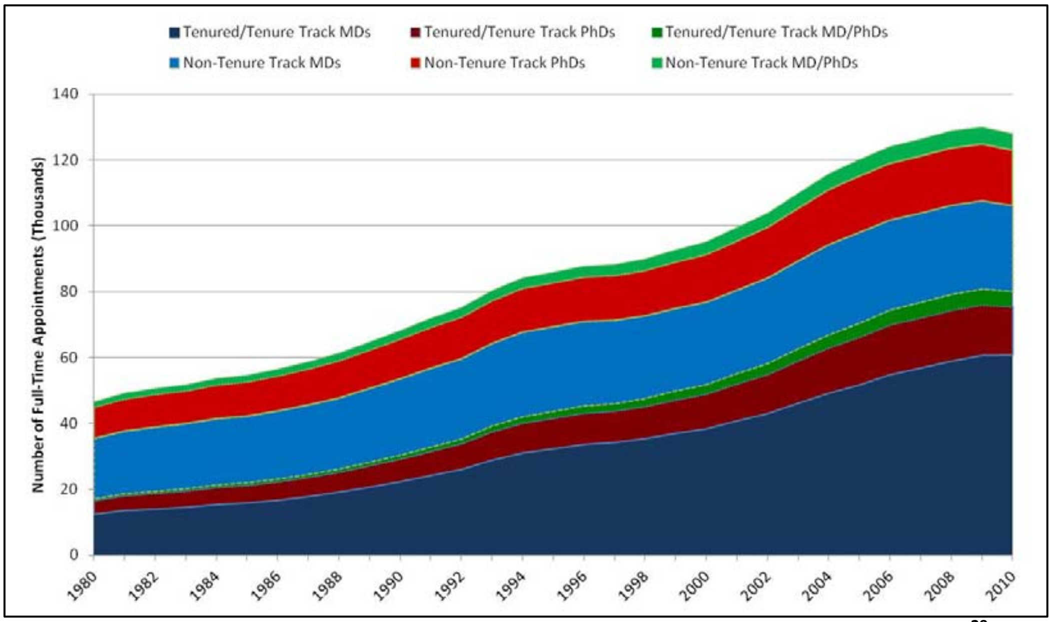

Figure 13: Number of Medical School Appointments, by Degree and Tenure Status[29]

The working group collected data on the MD and MD/PhD workforce, mainly from the AMA and AAMC and incorporated them into a conceptual framework (see Figure 20). However, neither organization provides much detail on the fraction of the MD workforce that conducts biomedical research, either as their main occupation or in addition to their clinical duties.

According to the AMA[30], 82% of physicians are strictly involved in patient care. This is consistent with data from the AAMC Medical School Graduate Questionnaire[31], which indicated that 16.7% of respondents in 2011 expected to be significantly involved in research during their medical career. This percentage has been relatively stable over the past 5 years.

One measure of the number of physician scientists conducting research is the percentage funded by NIH. As can be seen in Figure 14, researchers with an MD or MD/PhD comprise around 30% of NIH-funded Principal Investigators (PIs). Although the combined percentage has remained steady for many years, the percentage of MDs has declined and the percentage of MD/PhDs has increased slightly in the past few years. These percentages correspond to approximately 4,700 MDs and approximately 3,000 MD-PhDs in FY 2011.

[29] AAMC Faculty Roster
[30] Physician Characteristics & Distribution in the US – 2012 Edition
[31] https://www.aamc.org/download/263712/data/gq-2011.pdf

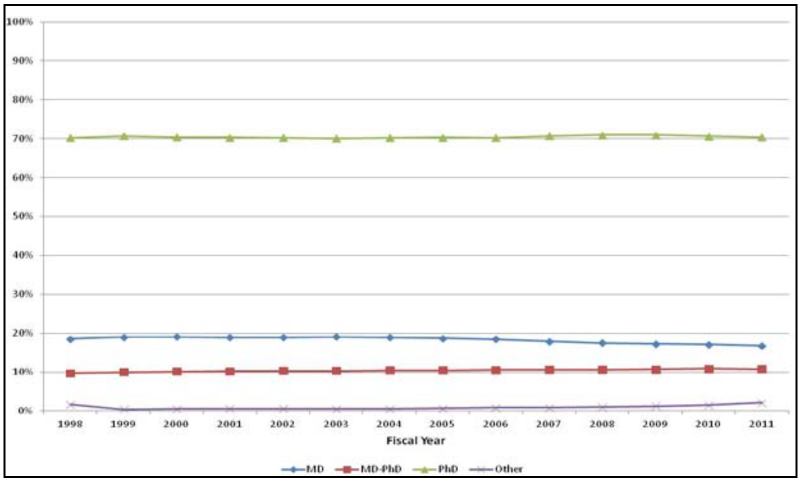

Figure 14: Distribution of NIH RPG Principal Investigators by Degree Type[32]

The working group gathered data from several sources to evaluate the status of biomedical PhD employment in industry. The SDR only includes data through 2008, while the Bureau of Labor Statistics Occupational Employment Statistics (OES) program includes data through 2011. The OES gives the number of people employed in a field by sector of employment but does not clearly indicate the number of PhDs. The number of PhDs in each occupation was estimated based on the SDR. Unlike the SDR, the OES sample includes both US- and foreign-trained workers.

To extend employment information beyond 2008 and try and reconcile the various data sources, Figure 15 compares the trends in employment of various biomedical occupations in the SDR (1993-2008) and the OES (2002-2011). The numbers in each occupation category are not identical but the trends are informative and show a general flattening or decrease in job growth in jobs over the past few years, with the exception of "medical scientists". These data should be considered in light of the fact that the number of newly minted US-trained biomedical PhDs has been increasing over the past decade, particularly after the doubling of the NIH budget and reached 9,000 in 2009. Although ~70% of these graduates go on to postdoctoral training, this number is an indication of the magnitude of the number of US-trained PhDs seeking positions. In addition, there are many non-US citizen PhDs in postdoctoral positions, most of whom are foreign-trained and many of these also are seeking positions. The SDR shows growth in biomedical employment (especially medical scientists) through 2008. However, the OES indicates that between 2008- 2011, biomedical employment has been flat in some fields and declined in others. Overall, based on the BLS quarterly census of employment and wages, the pharmaceutical and medicine manufacturing sector lost almost 16,000 jobs between 2008 and 2011[33]. This includes all levels (not just PhDs) and all parts of the sector (not just research and development) but provides an idea about the magnitude of the job loss.

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[32] NIH OSAR. RPGs include the following activity codes: R00, R01, R03, R15, R21, R22, R23, R29, R33, R34, R35, R36, R37, R55, R56, RL1, RL2, RL5, RL9, P01, P42, PN1, UA5, UC1, UC2,UC3, UC4, UC7, UH2, UH3, UM1, U01, U19, U34, DP1, DP2, DP3, DP4, DP5, RC1, RC2, and RC3

[33] http://data.bls.gov/pdq/querytool.jsp?survey=en; searched for Total US, NAICS 3254 Pharmaceutical and medicine manufacturing

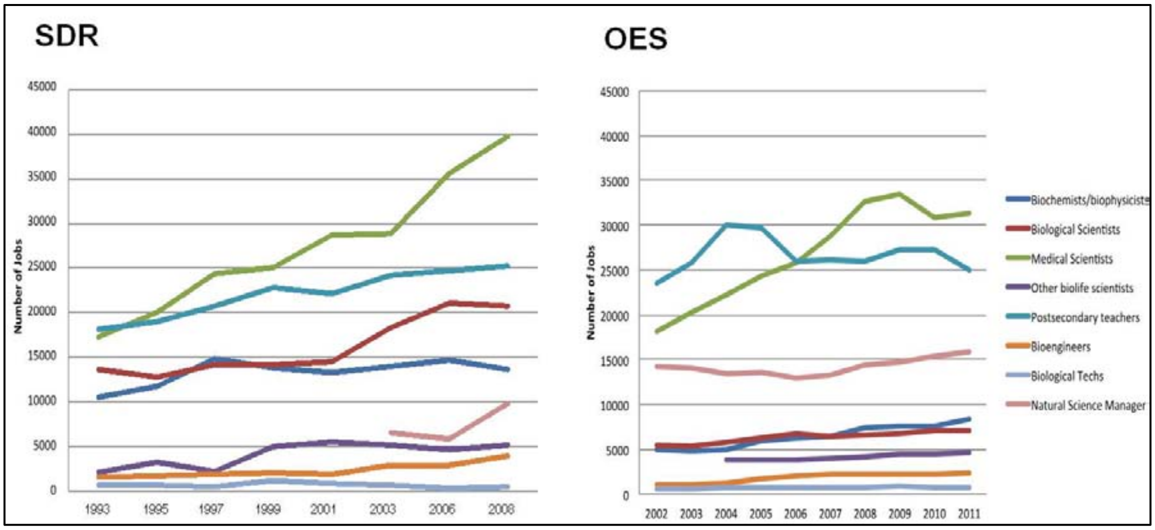

Figure 15: Estimated Change in Biomedical Employment Levels in Biomedical Occupations[34]

Compensation of Biomedical PhDs

Earnings potential is one measure of career attractiveness (although by no means the only one). The working group compared the earnings potential of biomedical PhDs to that of PhDs in other scientific fields and professions. As can be seen in Table 2 below, starting salaries of biomedical PhDs are lower than in other fields. However, this is no longer the case in the late career stage (30 years after the PhD). Figure 16 shows that lifetime earnings are comparatively low in biomedical fields but earnings growth is higher in the mid- to late-career. More specifically, 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.

Years Since PhD	BioMed	Comp/ Math	Physical Science	Social Science	Engineer
0	51,594	66,804	57,775	55,532	72,992
10	87,766	99,972	94,180	87,853	113,314
30	123,959	109,277	122,148	107,321	133,292

Table 2: Salary across Broad Fields by Years of Experience[35]

[34] SED and OES
[35] SDR

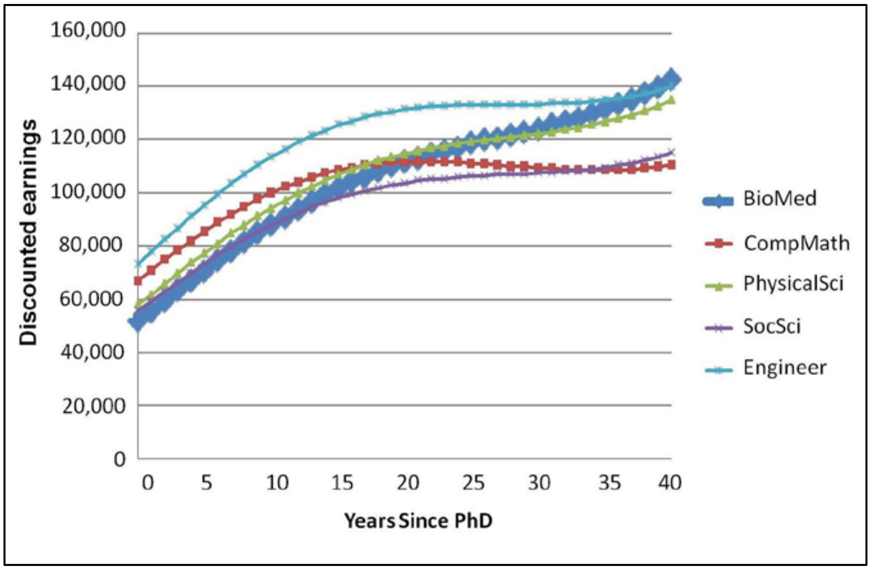

Figure 16: Discounted Earnings Profiles[36]

Trends in Age Distribution of Biomedical Researchers

The age at which researchers obtain a medical school faculty position and the age at which they receive their first R01 grant both increased steadily between 1980 and 2010 (see Figure 17 for a comparison between 1980 and 2010; data for the entire time series is posted at http://report.nih.gov/FileLink.aspx?rid=827). In addition, the percentage of older workers also has increased during that period (Figure 18). In 1980, less than 1% of PIs were over age 65, and in 2010 PIs over age 65 constituted nearly 7% of the total. In parallel, in 1980, close to 18% of all PIs were age 36 and under. That number has fallen to about 3% in recent years. These significant changes account at least in part, for the difficulties current trainees encounter in finding an independent academic research position. In addition, the increasing gap between entry into faculty and receipt of the first R01 suggests that institutions and other non-NIH funding sources are increasingly responsible for not just the initial costs of starting up a research program at a university, but in sustaining it for the first five years. These costs are going to be difficult for institutions to sustain over time.

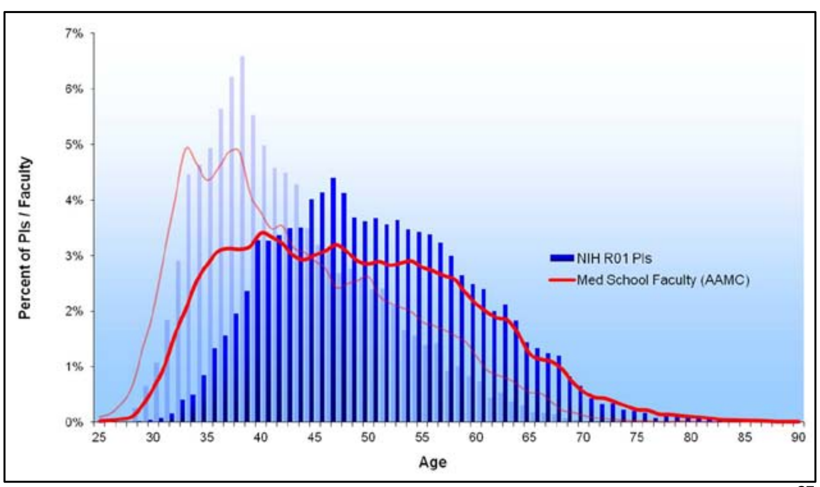

Figure 17: Age Distribution in 1980 (background) and 2010 (foreground)[37]

[36] SDR

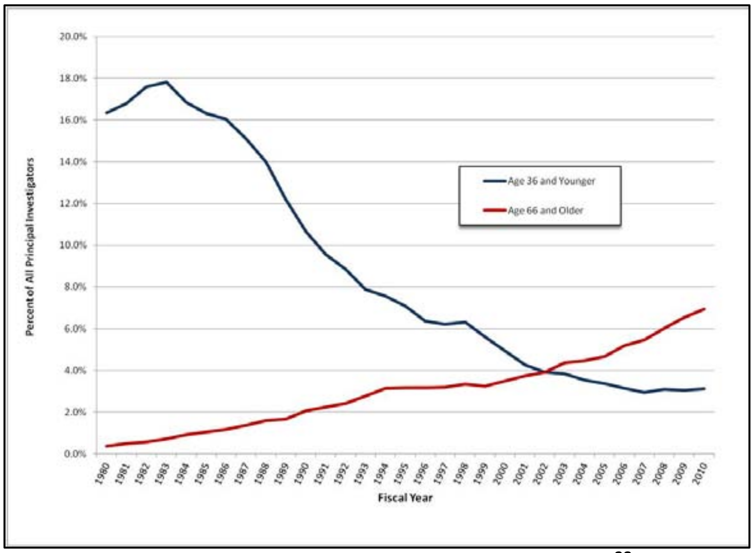

Figure 18: Age Distribution in 1980 and 2010[38]

[37] NIH and AAMC
[38] Source NIH and AAMC

WORKFORCE FRAMEWORKS

Based on the data presented above and additional analyses performed by the modeling subcommittee (see details in Activities sections below), conceptual frameworks were developed to provide static models of the workforce – one each for the PhD and the MD and MD-PhD workforces. The frameworks shown below were populated with information on each career stage and transition, summarizing the current state of the workforce as can be determined from available data. The post-training workforce boxes are color coded, with light blue denoting those in research positions and academic teaching positions.

Due to the lack of data on certain sectors of the workforce (see details of these data gaps in Appendix C), many of the numbers shown in the diagrams below are estimates. The color of the numbers indicates the level of confidence in the numbers due to the precision of both the underlying data and the methods by which estimates were derived (with red denoting rough estimates). The data sources and methods by which the numbers were derived are described in the footnotes and additional information can be found at http://report.nih.gov/investigators_and_trainees/ACD_BWF.

The PhD biomedical research workforce is summarized in Figure 19. It is important to note that the "Post-Training Workforce" box contains information on US-trained PhDs only as these are captured in the SDR. There is very little available information on the career outcomes of foreign-trained PhDs (one of the major data gaps).

The "Science Related Non-Research" box includes individuals employed by industry, government, or other who do not conduct research. However, this box is colored dark blue to indicate that many of the careers represented in this box are closely related to the conduct of biomedical research and require graduate training in biomedical science. Examples of such careers include program and review officers at NIH and managers in many biotechnology companies. The 18% in this box is comprised of 13% PhDs employed by industry, 2.5% by government, and 2.5% other. Therefore, all individuals employed by industry (research plus non-research occupations) comprise ~30% of the workforce and all individuals employed by government comprise ~9%.

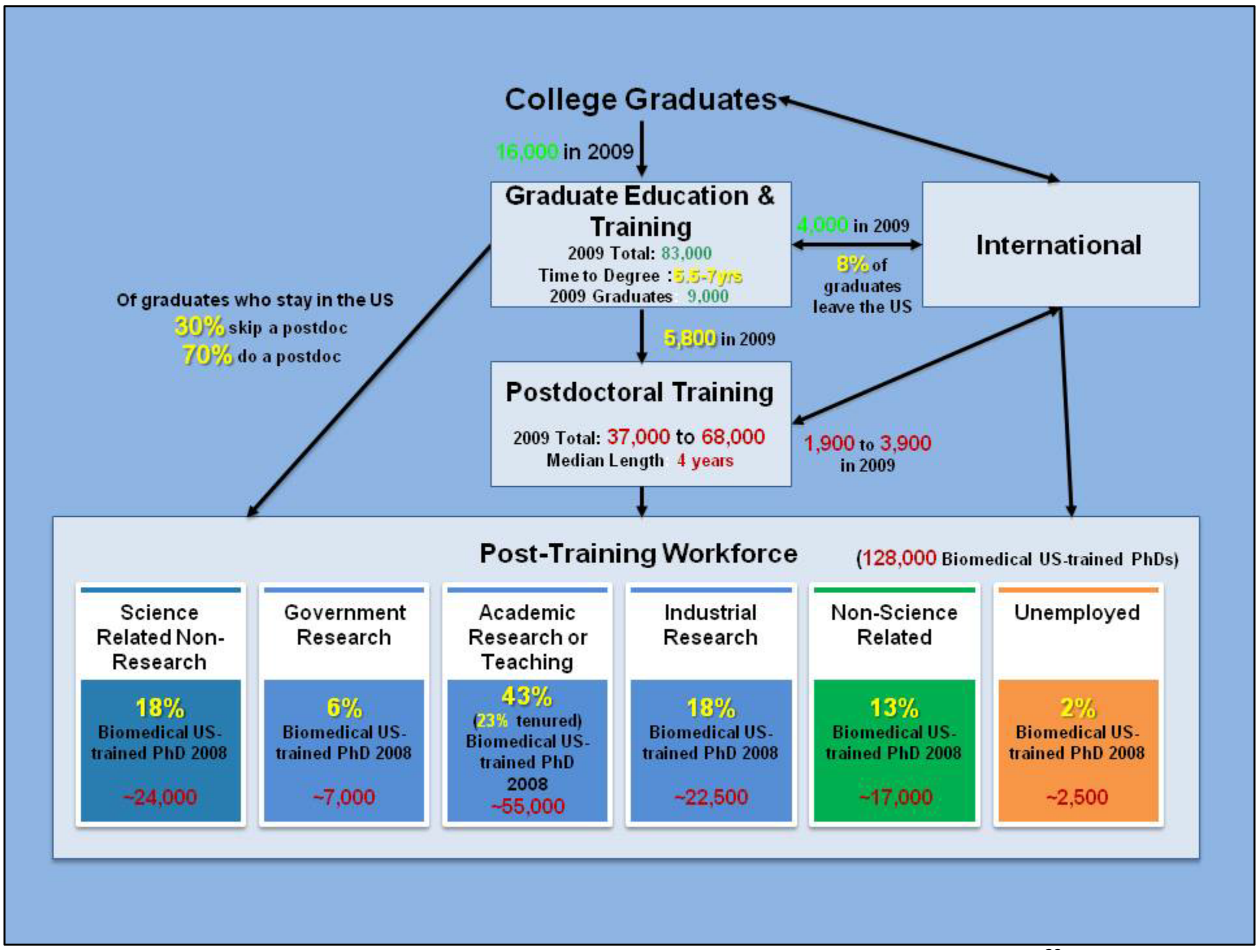

Figure 19: Conceptual Framework of the PhD Biomedical Research Workforce[39]

[39] Data Sources:
Graduate Education and Training - Green numbers: NSF GSS or SED; Yellow Time to degree range: NIH statistics, Council of Graduate Schools completion rates, and NSF time to degree. *International* - Yellow International return: Oak Ridge Institute for Science and Education reports authored by Mike Finn (http://orise.orau.gov/science-education/publications/default.aspx); *Red International to postdoc*: derived from comparing the ratio of temporary to permanent residents from the graduate student to postdoctoral populations; this is an estimated range because

The MD and MD-PhD workforce is summarized in Figure 20. Although there are a large number of MDs in the US, only a small fraction conducts research. The AAMC and AMA collect extensive data on MDs but the available data do not identify clearly those who conduct research. More information about this workforce is included in the Physician Scientists section of the Recommendations chapter.

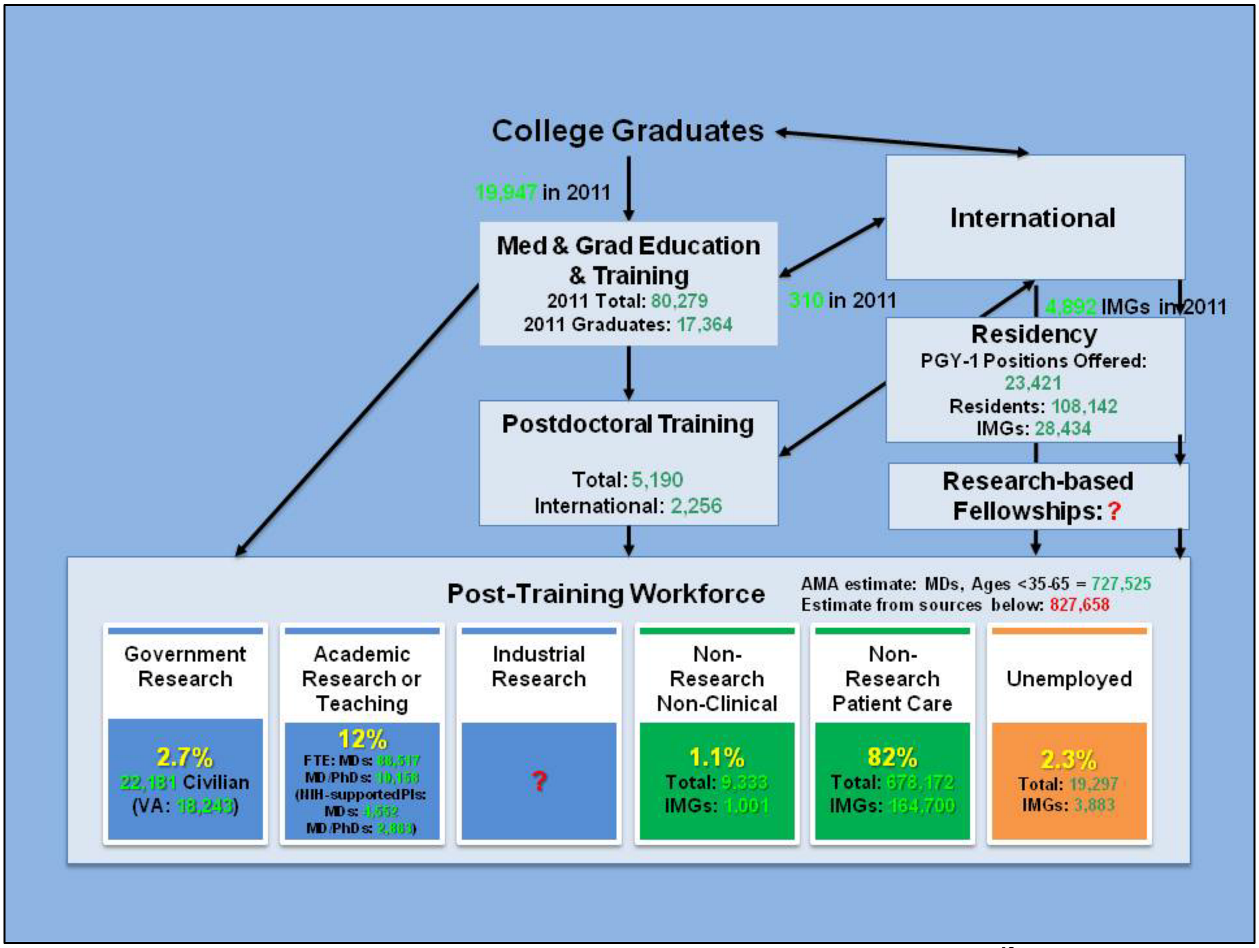

Figure 20: Conceptual Framework of the MD and MD-PhD Workforce[40]

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some people who are temporary residents as graduate students become permanent residents before starting their postdoctorate training. *Postdoctorate Training* - Minimum: GSS, Maximum: estimated from many sources, see additional details at website page, Median length: SDR, excluding postdocs > 8 yrs. *Workforce*: SDR

[40] Sources of Data:
Medical and Graduate Education & Training – Association of American Medical Colleges, Data Book 2011, 2012; *International* – FASEB/GSS; *Postdoctoral* – FASEB/GSS; *Residency* – Total PGY-1 Positions Offered - National Residency Matching Program, 2011, Total Residents – American Medical Association, Physician Characteristics and Distribution in the US – 2012 Edition, Internationally-Trained Residents – American Medical Association, Physician Characteristics and Distribution in the US – 2012 Edition; *Government* – FedScope http://www.fedscope.opm.gov/; *Academic* – Association of American Medical Colleges, Data Book - 2011, 2012; Note: Of the 86,527 FTE MDs, 97% are employed in Clinical Departments; Of the 10,158 FTE MD/PhDs, 86% are employed in Clinical Departments; PIs supported by NIH – NIH OSAR; *Non-Research Non-Clinical* – American Medical Association, Physician Characteristics and Distribution in the US – 2012 Edition*; Non-Research Patient*

Weighing all the data that were analyzed, the working group concluded that the combination of the large upsurge in US-trained PhDs, continued increased inflow of foreign-trained PhDs, and aging of the academic biomedical research workforce (i.e. increase in older researchers over time) make launching a traditional, independent, academic research career increasingly difficult. In addition, the long training time and relatively low early-career salaries when compared to other scientific disciplines and professional careers may make the biomedical research career less attractive to the best and brightest of our young people. Finally, the current training programs do little to prepare people for anything besides an academic research career, despite clear evidence that a declining percentage of graduates will find such positions in the future.

The working group's recommendations are aimed at modifying the career paths to biomedical research so as 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 STEM workforce.
- Prepare biomedical PhD students and postdoctoral researchers to participate in a broad-based and evolving economy.

Care – American Medical Association, Physician Characteristics and Distribution in the US – 2012 Edition;
Unemployed – American Medical Association, Physician Characteristics and Distribution in the US – 2012 Edition
IMGs: International Medical Graduates
PGY-1: Post-graduate year 1
FTE: full-time employed
GSS: NSF Graduate Student Survey
FASEB: Federation of American Societies for Experimental Biology

Recommendations

Graduate Students

Graduate training historically has been aimed almost exclusively at preparing people for academic research positions. However, as can be seen in the PhD framework summary (Figure 19), less than half of US-trained biomedical PhDs go on to a career in academia. Almost a quarter conduct research in industry or government settings and almost one fifth are in science-related occupations but do not conduct research (e.g. program and review officers at NIH or managers in the biotechnology industry).

Given the changing face of the biomedically trained workforce, the working group believes that graduate programs must accommodate greater diversity in anticipated career outcomes for students. Graduate programs should offer opportunities for students to explore options relatively early in graduate school, so that they are able to adjust their training to the kinds of careers they will pursue. Graduate programs also should openly communicate the career outcomes of their graduates to potential students. This would allow potential graduate students to choose graduate programs that are more aligned with their career aspirations. Some institutions already post comparable data on the web sites. For an example, Duke University posts information about outcomes of its PhD students by program (http://gradschool.duke.edu/about/stats.php).

The long training period through both PhD and postdoctoral training (Figures 3 and 6), increased age at which researchers obtain a faculty position (Figure 17), and the disparities in early-career earnings and life-long earnings potential compared to other scientific disciplines (Table 2 and Figure 16) may make a career in biomedical research less attractive than one in other scientific disciplines and professional careers. Therefore, the working group believes it would be desirable to shorten the overall training period (PhD and postdoctoral training) in biomedical sciences. This is reflected in the recommendations related to graduate students described below and those related to postdoctoral researchers in the next section.

Specific 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. This would mean that NIH-trained and other US-trained students would become available earlier and would likely be more competitive for the next phase of their career.
- The best practices resulting from this program will help shape graduate programs across the country. The working group felt that including multiple types of training (e.g. project management and business entrepreneurship skills needed in the pharmaceutical and biotechnology industries, or teaching experience 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 (Figure 19). 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, such as 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 decide not 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.

- Today, the vast majority of PhD students that receive NIH support are funded by research project grants (Figure 2) and yet the NIH has no influence over the quality of the training of these individuals. Training grants uniquely provide the NIH with a mechanism for peer review of training, and permit the NIH to require attention to issues such as outcomes, diversity and professional ethics training. Therefore, 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.

- Even though the NIH training programs are able to fund only a limited number of students, the existence of an NIH training program at an institution can motivate graduate programs to provide all students at that institution with training that conforms to NIH guidelines and expectations. To reinforce this, 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 IC constitute a substantial burden on the institutions. All NIH ICs should offer comparable training programs and fellowships and their requirements should be harmonized.

<u>Postdoctoral Researchers</u>

Despite the paucity of the data on the current state of postdoctoral researchers, it is evident that the postdoctoral period has become a holding pattern for many young researchers. Although a postdoctoral fellow is considered a trainee, in many laboratories fellows receive little additional preparation for their future careers, even for those in academic research. For example few postdoctoral fellows receive instruction in grant writing, laboratory and personnel management, and teaching, all skills that are necessary for a successful academic career.

The majority of postdoctoral fellows are funded by research project grants (Figure 4), which are able to support the growing number of non-US citizens (Figure 5). In addition, although the average postdoctoral period has increased only slightly over the years (Figure 6), there is some evidence that those postdoctoral researchers that go on to an academic tenure-track research career are staying in postdoctoral training for a longer period (Figure 7) while those going on to other careers such as those in industry move on after a shorter period of time to higher paid positions. The working group concluded that the decline in growth of academic positions has led to longer postdoctoral periods, in which fellows hope to generate more papers in order to be competitive for positions. This system leaves trainees in subordinate positions at a time when they are expected to be highly productive as independent investigators.

There is little information about the amounts and types of benefits received by postdoctoral researchers although anecdotal evidence suggests that there is a wide variation among institutions. In December 2011, the NPA conducted a test survey of institutional policies regarding postdoc compensation, benefits, and professional development opportunities[41]. Almost all the 74 institutions that responded provide health insurance benefits and about two thirds offer some amount of paid time off. Fewer than one third of the responding institutions provided retirement benefits. There was a significant difference in regard to postdoctoral researchers who are classified as employees as compared with those who are not classified as employees. For example, 64.5% of responding institutions provided paid sick leave to postdoctoral researchers classified as employees, while only 43% provided paid sick leave to those postdoctoral researchers not classified as employees. Note that almost all the 74 responding institutions were NPA members and thus may provide a higher than average level of benefits to their postdoctoral researchers.

After analyzing these and other data and receiving input from stakeholders, the working group concluded that the postdoctoral experience should include structured career development, and incentives should be provided by NIH to move postdoctoral fellows to more permanent positions as soon as possible. The working group recognizes that after a reasonable period of training – ideally three years – there is diminished value for the trainee in staying in a subordinate position. Also, the group feels that those postdoctoral researchers who do not go on to conduct research in an academic setting should receive training in the skills needed and information about other career options. Finally, the working group also recognizes that postdoctoral fellows have spent years in graduate training, and should be compensated accordingly including receiving a reasonable level of benefits.

Specific Recommendations:

- As mentioned above, the vast majority of PhD students that receive NIH support are funded by research project grants (Figure 4). Training grants uniquely provide the NIH with a mechanism for peer review of training, and permit the NIH to require attention to issues such as outcomes, diversity and professional ethics training. This is even more important for postdoctoral researchers than for PhD students as the students are all in a graduate program, regardless of their source of support, while many postdoctoral researchers supported by research project grants have no structured training at all. Therefore, 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.

[41] http://www.nationalpostdoc.org/policy/institutional-policies

- 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 – see current levels in Table 1) 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 (thus also affecting non-US citizens), 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.

- NIH should double the number of Pathway to Independence (K99/R00) awards, which provide a proven mechanism for postdoctoral researchers to achieve an independent research position, to encourage larger numbers of PhD graduates to move rapidly into permanent research positions. In order to hasten the transition, NIH should shorten the eligibility period for applying to this program from 5 years to 3 years of postdoctoral experience.

- The working group was supportive of the NIH Director's Early Independence award program that facilitates the "skip-the-postdoc" career path for those who are ready immediately after graduate school. Although this program is its early stages and it is too soon to evaluate career outcomes of those who have received such an award, the working group recommends that NIH also should double the number of these awards.

- To provide some structured training experience for all postdoctoral researchers, 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 MSc 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 which employed 1367 of these scientists in 2011[42]. In the extramural program, these scientists typically 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.

As a result of the wide variety of titles held by these researchers, it is difficult to determine the exact number of staff scientists in the extramural biomedical research workforce. However, an estimate can be obtained from SDR data. Figure 21 presents a rough estimate of these positions, counting people: 1) whose primary/secondary work activity is basic or applied research, 2) are working in Academia, 3) are non-tenure track, 4) are non-postdoctoral researchers, and 5) whose primary/secondary work activity is not teaching.

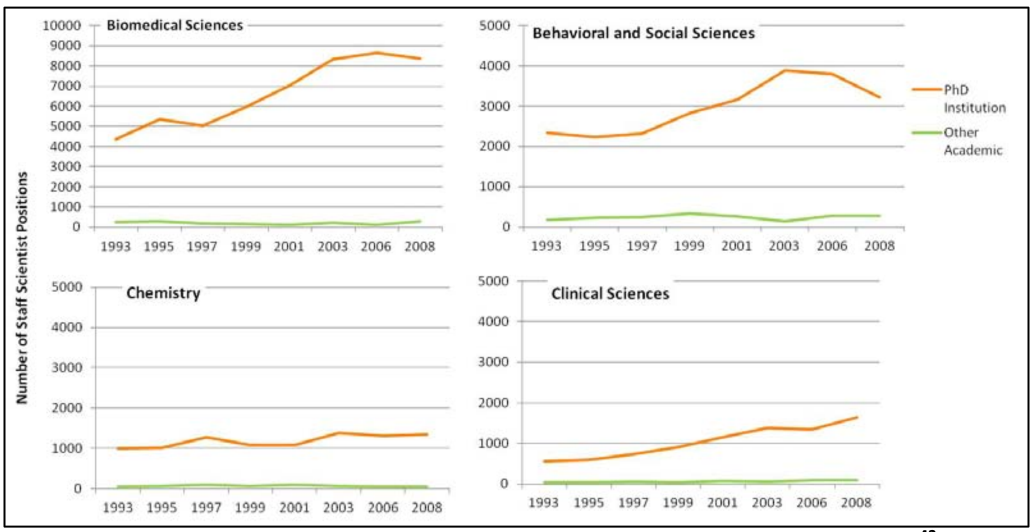


Figure 21: Staff Scientist Positions, by Degree Field and Organization Type[43]

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, it seems that this distinction has become increasingly blurred, with NIH providing an increasing proportion of faculty salary support and the institutions covering a larger percentage of

[42] NIH Office of Intramural Research
[43] SDR

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 (Figure 17). 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.

That said, however, there is little or no reliable information on the percentage of salary covered by federal grant dollars. Data from several sources suggests an overall range of 30% - 50% of salaries for faculty derived from federal funds. For example an Association of Chairs of Departments of Physiologists Survey found that the average proportion of faculty salary derived from research grants was 37% in 2009[44]. The AAMC Research Metrics Survey[45] found that medical school faculty with external research support received an average of 36% of total salary support from grants in FY 2009. The proportion of salary derived from grants ranges from 14% to 67% at different medical schools. The average was 29% for MD and 49% for PhD faculty. However, both these surveys included small numbers of institutions only. In addition, there is almost no information about how the distribution of NIH salary support has changed over the years.

The working group has identified this area as one of the major data gaps and made recommendations about how to collect this information in the future (see Appendix C). Collecting reliable information about salaries most likely would require the use of administrative data from institutions (such as the data collected by STAR METRICS[46]) and **NIH should require institutions that receive NIH funding to participate in programs that collect such data**.

That being said, the working group believes that institutions should provide some fraction of salary support for their researchers in order to qualify for NIH funding. The 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. NIH has a variety of training and career-development mechanisms for physician scientists, notably:

- The Medical Scientist Training Program (MSTP) supported by the National Institute of General Medical Sciences[47] which supports combined MD/PhD training.
- The NRSA F30 program that supports individuals for combined MD/PhD and other dual doctoral degree training (e.g. DO/PhD, DDS/PhD, AuD/PhD). This mechanism is not supported by all NIH ICs.
- The K08 career development award program that provides support and “protected time” to individuals with a clinical doctoral degree for an intensive, supervised research career

[44] http://www.acdponline.org/Surveys/2010Survey.pdf
[45] https://www.aamc.org/download/170836/data/aibvol11_no1.pdf
[46] https://www.starmetrics.nih.gov/
[47] http://www.nigms.nih.gov/Training/InstPredoc/PredocOverview-MSTP.htm

development experience in the fields of biomedical and behavioral research, including translational research.

- The K23 career development award program that supports the career development of investigators who have made a commitment to focus their research endeavors on patient-oriented research.
- Loan Repayment Program to recruit and retain highly qualified health professionals as clinical investigators, and specific programs for pediatric, health disparities, and contraception and infertility research[48].

About 30% of NIH PIs hold an MD or an MD-PhD and that combined percentage has not changed over the past two decades (Figure 14). Although extensive data are collected on the training and careers of MDs (summarized in Figure 20), comparatively little is known about those physician scientists who conduct research. In addition to the paucity of research-specific data, the working group recognized that 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.

There was not sufficient time for the working group to examine this important part of the biomedical workforce in detail. Furthermore, 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.

Points that should be considered during such a follow-on effort include:

- There appears to be a growing deficiency in the pool of physician scientists who are sufficiently trained to become academic, independent, tenure-track scientists addressing basic and/or translational questions.
- The MD-PhD Programs have been highly successful in training future academicians, with ~75-80% of these graduates continuing on as independent academic faculty, although this group constitutes only 3% of the total MD pool, they are increasingly successfully competing for K and Research Project grants. Based on demand and empirical evidence, the National Research Council twice has recommended expansion of MD-PhD training. Note that this mechanism is currently not supported by all NIH ICs.
- The NIH requirement that MSTP must diversify the MD-PhD student pool has resulted in the recruitment of the best and brightest of under-represented minority applicants, nurturing them through the MD-PhD career track, and contributing to a more diverse physician scientist workforce. As such, these MSTP-specific efforts have an important impact on overall medical and graduate student diversity at each MSTP medical school.
- The MD-only pool entering academic scientific careers is diminishing at a significant rate. The K award mechanism appears to enhance Research Project Grant success for both this group and the MD-PhDs, thus expansion of this funding mechanism should be considered.
- There are several systematic and external disincentives that impede medical students and residents from pursuing careers as academic physician scientists, including:

[48] http://www.lrp.nih.gov/about_the_programs/index.aspx

  - Increased emphasis on volunteer clinical activities, rather than research experiences as criteria for admission to medical school, which diminishes the importance of research from the very beginning and thus students fail to establish relationships with research mentors early in careers
  - New medical curricula that de-emphasize science and provide minimal time for research while in medical school
  - Significant accrual of debt, deterring fellows from pursuing academic careers (the Loan Repayment Program provides some relief in this regard)
  - Increased Graduate Medical Education (GME) regulation of residency training, with little flexibility for substantive research experiences
  - Few American Board of Internal Medicine fast-track and/or Physician Scientist Training Programs
- Further impediments occur when MDs become faculty, such as:
  - Significant work load due to electronic record keeping and regulatory compliance, which consumes much more time when in the clinics
  - Requirement to raise one's salary, with no or little protected time
  - Little to no career guidance at start of academic appointment

<u>Information Collection, Analysis and Dissemination</u>

The working group was frustrated and its activities were held back 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.

In general, there are two fundamental types of data that are valuable – aggregate-level data and individual-level longitudinal data – and two broad sources for each type of data – administrative records and surveys. Aggregate level data is necessary to determine the number of people in various positions, but individual-level data and especially longitudinal individual data, in which individuals are tracked over time, makes it possible to identify the characteristics and trajectories of individuals and is important for rigorous modeling and evaluation. Survey data is valuable for addressing targeted questions, especially questions that do not leave accessible administrative records, but is costly to collect and therefore usually collected on limited samples and frequently it takes a long time until these data are ready for analysis. Administrative data can cover an entire population and be obtained through near real-time feeds. Our ability to use administrative data is improving rapidly and NIH already has and is continuing to develop a wealth of such data (e.g. the STAR METRICS project).

The main sources of data on graduate students and postdoctoral researchers - The Graduate Student Survey (GSS), the Survey of Earned Doctorates (SED), and the Survey of Doctorate Recipients (SDR) - omit large portions of the postdoctoral population. The GSS reports only on institutions that offer the PhD Institutions such as independent research centers without graduate programs and national labs are not surveyed and the postdoctoral researchers that work in those settings are not counted. A separate survey reports on postdoctoral researchers at national labs including the NIH intramural program. The SDR and the SED only include information on US-trained doctorates.

Another factor is the growth in job titles attached to what are effectively postdoctoral research positions. Often after 5 years, postdoctoral researchers continue in a non-tenure track, postdoctoral-like positions with another title. The NSF has estimated that all of these factors may result in a 2 fold undercount of postdoctoral researchers employed in the US. Anecdotal evidence suggests that another factor may relate to the institutional contacts that provide the annual report to NSF for the GSS. Some institutions apparently rely on the graduate dean's office rather than a postdoctoral contact. There is some evidence that NSF is addressing these issues. For example, in recent years the GSS survey has been extended to count recent PhDs in non-postdoc positions that are outside tenure or tenure track job series. Also in recent years, NSF has attempted to collect more complete demographic information on postdoctoral researchers (citizenship, sex/gender, race, ethnicity, foreign/domestic doctorate, etc.). This kind of information should be made available as soon as possible.

The SDR, on the other hand, includes only those individuals who have records in the Survey of Earned Doctorates (SED), i.e. individuals who have doctoral degrees from domestic institutions. The NSF is in the process of developing an Early Career Doctorate study where the frame includes individuals who have earned a doctorate from any domestic or foreign institution within the past 10 years and are in postdoctoral position, faculty positions, or various non-postdoc, non-faculty positions. The information for this frame will be provided by GSS institutions along with Federally Funded Research and Development Centers and the NIH Intramural Program. Unfortunately, data from this survey are not currently available.

Data on MDs and MD/PhDs are primarily collected by AAMC and the AMA, neither of which identifies the level of research involvement with enough detail to predict long-term trends in the involvement of MDs in research. Moreover, the AAMC has preferred to share data in aggregated form rather than the underlying individual-level data. This makes it very difficult to predict and potentially explain the observed, slow decrease in the participation of MDs as PIs on NIH research grants or perform rigorous analysis and modeling.

The best sources of information on industrial employment of biomedical researchers are the NSF Scientists and Engineers Statistical Data System (SESTAT) and the Bureau of Labor Statistics (BLS) surveys and data collections that result in the Occupational Employment Statistics (OES) data. However, SESTAT has a 3-4 year lag and the OES does not include information on education levels, making it difficult to identify jobs for those with PhDs. Because of changes in survey methodology, the BLS says that OES data cannot be used reliably for time series or trend analysis. In addition, there is currently no centralized source of information on the number of job openings and employment opportunities for biomedical researchers with the PhD.

Finally, the working group 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.

Specific 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. This could be part of a unique researcher ID system that would allow tracking of all researchers throughout their career. The ID would need to relate to any NIH ID assigned to the individual.

- 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 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.

Appendix C contains more detailed recommendations to address specific data gaps.

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.

Activities of Working Group and Sub-committees

The working group met a total of eleven times in 2011 and 2012 to define the issues that should be addressed, hear from stakeholders, review and discuss data and input provided by the modeling subcommittee and the NIH Training Advisory Committee (TAC) workforce committee, and to develop recommendations for the ACD. Following are details of these activities.

Modeling Subcommittee

The modeling subcommittee, composed of social scientists (primarily economists) with expertise in the scientific enterprise as well as NIH-funded investigators with expertise in mathematical models, was charged with providing input to the working group, particularly on the data and modeling aspects of the workforce charge (see roster in Appendix A). The subcommittee met three times in 2011 and 2012, including two in-person meetings and one teleconference. Additionally, the subcommittee maintained extensive informal communication with each other and outside experts in various areas who provided input to the subcommittee.

The subcommittee reviewed the options for constructing a model of the current biomedical research workforce, taking into account the availability of data and the time period of the study. The subcommittee decided to take a two-tiered approach that includes descriptive analyses and a conceptual framework (model). This entailed a number of analyses of key aspects of the workforce and the development of conceptual frameworks to organize the analyses – one each for the PhD and the MD and MD-PhD workforces (see section on Current Workforce above). The conceptual frameworks were populated with information on each career stage and transition. The data were organized according to the conceptual framework to build a comprehensive resource upon which recommendations were based. These conceptual frameworks are designed to be developed into a full dynamic model at a subsequent stage.

In addition, the subcommittee discussed the unintended incentives and disincentives underlying the US biomedical research enterprise and drafted a memo to the working group outlining the incentives related to NIH policies and practices that might be affecting the behavior of biomedical research institutions, researchers, and students, particularly those that operate in directions opposite to other important NIH goals. This memo is attached as Appendix D.

Summary of Subcommittee Findings and Recommendations

The subcommittee reviewed all the workforce data gathered and analyzed (see below for list), and drafted recommendations for the working group to consider in its deliberations. These recommendations are attached as Appendix E and summarized below.

While the US biomedical research enterprise is highly productive, data show a weak market for biomedical PhDs in the period after attaining a PhD and “boom and bust” dynamics during and after the NIH doubling period. The weak early career outcomes are visible in the form of the long and uncertain postdoctoral fellowships frequent in biomedicine, especially for researchers focused on academic research careers; an age at first research program grant close to 42; and a large outflow of women during the postdoctoral years. Although people are motivated by a wide range of factors, the relatively weak market can also be seen in early-career earnings that are among the lowest among research doctoral scientists. The boom and bust dynamics are also visible in trends in the lengths of postdoctoral fellowships and space investments.

A number of factors underlie the weak early careers. Although the US has benefitted tremendously from an inflow of highly-trained foreign researchers, the availability of foreign-trained researchers has depressed the market for domestic biomedical researchers. Moreover, our production of biomedical researchers exceeds new job openings. Consequently a decreasing share of biomedical researchers is using their research training on their jobs. Compounding these issues, a large body of established senior researchers makes it harder for young researchers to launch independent careers. The subcommittee also noted that relatively little information on either the outcomes of people from specific programs or information on the overall job market is available to help people contemplating careers in biomedical research make informed decisions.

Based on this broad analysis, the subcommittee sketched 12 recommendations to facilitate the working group's discussions (included in Appendix E). These were organized into 3 categories:

(1) **The nature and characteristics of biomedical graduate training and postdoctoral fellowships.** These recommendations combined efforts to improve the quality of training (e.g. by shifting trainees from research grants to training grants and exploring ways of scoring the training aspects of research proposals); to address the factors that lead trainees, including underrepresented minorities, to leave the biomedical research enterprise; and to improve the early-career outcomes of biomedical researchers.

(2) **The allocation of resources by NIH.** These recommendations focused on policies that could stabilize the biomedical research system; shift resources in ways that would assist researchers in launching independent careers; and gradually shift lab staffing from temporary postdoctoral researchers to staff scientists to reduce reliance on trainees.

(3) **Collecting, analyzing, and disseminating data to inform potential trainees about career prospects and to inform NIH's own policy making.** Some of these recommendations focused on informing potential trainees about prospects in particular training programs and in general. Others focused on filling critical gaps in data on the biomedical research enterprise and establishing an ongoing effort to analyze the biomedical research enterprise to inform NIH policy.

The subcommittee emphasized that the first two sets of recommendations should be implemented gradually.

Data gathered and Analyzed

- AAMC and AMA data on career tracks of MDs and MD-PhDs
- Data from OPM on biomedical doctorates employed in the US federal civilian workforce and in the Public Health Service
- Demographic Characteristics for Graduate Students and Postdoctoral fellows from the Survey of Earned Doctorates , the Survey of Doctorate Recipients and the Graduate Student Survey in Basic Biomedical Science, Clinical Sciences, Behavioral & Social Sciences, and Chemistry (used as a comparison). Data include:
    - US Graduate Degrees Awarded
    - Time to Degree and Age at Degree
    - Age at PhD, First Non Postdoc Job, First Tenure Track Job
    - Doctoral Students and Doctorates Awarded by Citizenship/Visa Status and Field
    - Gender, Race, and Ethnicity of Doctorate Students and Doctoral Recipients
    - Doctorate Students by Type of Support
    - US PhDs with Postdoctoral Research Plans
    - U.S. Trained Biomedical PhDs in postdoctoral researcher positions, by Time Since Degree
    - Biomedical Postdoctorates by Citizenship
    - Postdoctorates by Field and Type of Support

- Employment Trends from the National Survey of College Graduates, the Survey of Doctorate Recipients, the National Science Foundation (NSF) Industrial Research & Development Survey, the Occupational Employment Statistics (BLS), and job openings from Wanted Technologies.
  - Employment trends for college graduates and doctorates in a biology field
  - Pharmaceutical industry R&D employment (from NSF data to 2008, and BLS data from 2008-2010)
  - Up to date data on trends of job openings in biotechnology and pharmaceutical sectors from wanted.com
  - Trends in Employment Status of US Doctorates
  - Age Distribution of PhD Workforce, by Field
  - U.S. Trained Biomedical and Chemistry PhD employment, by Years Since Degree
  - Employment and Un-/Under-employment of US Biomedical Doctorates, including Employment in Permanent versus Temporary Positions and Unemployed
  - Employment Status by Gender and Field
- Academic Employment and Resource Allocations from the Survey of Doctorate Recipients
  - Trends in Employment of US-Trained Doctorates in Tenured Academic Positions, by Degree Field
  - U.S. Trained PhDs in academic employment, by tenure track status and by Degree Field
  - Proportion of Faculty, by Degree Field and Tenure Track Status
  - Tenure Track Faculty by Degree Field and Institution Type
  - Tenure-Track Faculty by Degree Field and Gender
  - Tenure Track Faculty, By Degree Field and Race/Ethnicity
  - University Assignable Research Space, by Field
  - Staff Scientist Positions, by Degree Field and Organization Type
  - Proportion of Staff Scientists, by Degree Field and Gender
  - Proportion of Staff Scientists, by Degree Field and Citizenship
- Relationship between Degree and Employment from the Survey of Doctorate Recipients
  - US Doctorate Employment: Relationship to Degree Field, by Field and Years Since Degree
  - Relationship between Life Sciences, science and engineering PhD field and occupation
  - U.S. Trained Biomedical PhDs in research occupations, by Years Since Degree
  - US Doctorate Employment: Hours of Work by Degree Field
- NIH Funding Trends
- Market analysis of the biotechnology sector and job market (from publicly available reports).
- Healthcare and Pharmaceutical spending (from publicly available reports).
- Stay rates of foreign doctoral students (from publicly available reports by Mike Finn, Oak Ridge Institute for Science and Education)
- Earnings of Doctoral Recipients

Suitable comparisons were sought to benchmark outcomes where possible. The resulting data are incorporated into various sections of this report, included in Appendix B, or posted at http://report.nih.gov/investigators_and_trainees/ACD_BWF.

Stakeholder Input

The working group met on the NIH campus on June 21, 2011 and heard various stakeholder perspectives on the biomedical research workforce and its future direction. Specifically, the speakers were asked to address the question: "Given the current fiscal climate and the prospect of little or no growth in the near future, and within your area of expertise, what in your view are the major issues the task force should consider?"

The working group heard from representatives of the National Postdoctoral Association and several scientific societies, a Dean of an academic Medical School, a Director of an MSTP program, and people involved in two recent National Research Council studies - *Study on Research Training and the Biomedical, Behavioral, and Clinical Research Sciences* and the *Report on Expanding Underrepresented Minority Participation, Director, National Research Council's Board on Higher Education and Workforce.* The participants of the meeting are included in Appendix F.

Soliciting Public Comment

The working group solicited input from the community by means of a Request for Information (RFI), published on August 17, 2011 in the NIH Guide (http://grants.nih.gov/grants/guide/notice-files/NOT-OD-11-106.html).

The RFI described 8 issues the working group had identified as important to consider in an analysis of the biomedical research workforce:

- The balance between supply, including the number of domestic and foreign trained PhDs and post-docs, and demand, i.e. post-training career opportunities.
- Characteristics of PhD training in biomedical research, including issues such as
    - The length of the PhD training period.
    - Recommendations for changes to the PhD curriculum.
    - Training for multiple career paths (including bench and non-bench science).
- Characteristics of clinician-research training including issues such as
    - The balance between MDs and MD-PhDs
    - Career development of clinician-researchers.
- Recommendations for changes to the curricula for training clinician-researchers.
- Length of Post-doctoral training[49].
- The ratio of PhD students and postdoctoral fellows on training grants to those supported by research grants.
- Possibilities for professional/staff scientist positions and the level of training required for such positions (e.g. PhD or MSc degrees).
- Issues related to the attractiveness of biomedical research careers (e.g. salary, working conditions, availability of research funding)
- The effect of changes in NIH policies on investigators, grantee institutions and the broader research enterprise.

The RFI asked 3 specific questions about these or any other relevant issues the working group might consider:

1. For any of the areas identified above and any other specific areas you believe are worthy of consideration by the working group, please identify the critical issues(s) and impact(s) on institutions, scientists, or both.
2. Please identify and explain which of the issues you identified are, in your opinion, the most important for the working group to address and why
3. Please comment any specific ways you feel these issues would or should affect NIH policies or processes.

[49] Broadened to "Post-doc training characteristics" in the analysis of RFI responses

219 entities (individuals and institutions) responded to the RFI, with 75% providing personal input. A full report of the responses and the resulting analysis is included as Appendix G. Following are the main points.

The comments were parsed into 498 "quotations" representing unique ideas, with an average of 2.3 quotations per commenter. The analysis identified four primary issues in addition to the original eight primary issues included in the RFI[50]. The distribution of primary issues, as cited by commenters, is shown in Figure 22.

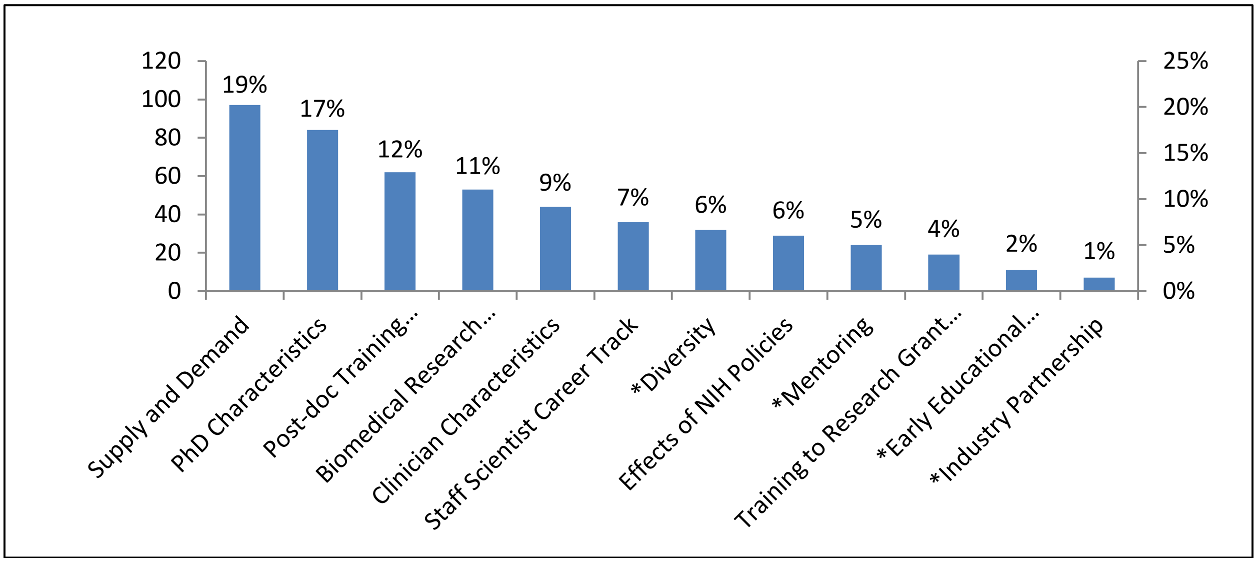


Figure 22: Distribution of Primary Issues

Commenters found that most, if not all, of the primary issues were critical to the development of a sustainable biomedical workforce. About two thirds of the comments included a secondary issue in addition to the primary issue. The secondary issues mentioned by the commenters were recorded to help describe the overlapping and interlocking nature of the issues.

In cases where the primary and secondary issues are similar, the secondary issue covers only certain aspects of the primary issue. For example, the secondary issue of Career Appeal covers the specific issue of working conditions; whereas the primary issue of Biomedical Research Career Appeal includes all issues related to the attractiveness of biomedical research careers (e.g. salary, availability of research funding, working conditions).

The overlapping issues were:

- Funding. Uncertainty and lack of funding, distribution of funding, restricted paylines, success rates, and excessive competition
- Multi-disciplinary training. Need for multi/ inter/ trans-disciplinary research training to prepare individuals for a wide range of academic and non-academic career opportunities
- Salary. Inadequate compensation and benefits
- Length of Training. Amount of training time too long to be feasible for majority
- Non-US Citizens. Foreign students and post-doctoral fellows
- Career appeal. Working conditions (e.g. heavy workload, perception of being perceived as cheap labor, long work hours)
- Mentoring. Quality of career development and the need for pre-college preparation

[50] Identified with an asterisk in the chart

- Diversity. Under-represented minority post-doctoral, fellows and junior faculty

Supply and demand was the most important issue identified by commenters as it affects all other issues. Respondents felt that the imbalance between supply and demand is large and thus excellent candidates cannot find work in academia. Generally, commenters agreed that NIH is training more scientists than the workforce can support; exceptions included certain specialties such as veterinary research, biostatistics, and medical informatics. Supply of research funds is largely viewed to be inadequate and, in the current environment, creates a demand for cheap labor to perform the research. The top secondary issues identified in these responses were the prevalence of non-US Citizens and funding levels for research.

Many solutions were proposed, some on the supply side, some on the demand side. Supply side remedies included reduction in trainees, and a branching career path. Demand side remedies included funding increases and revisions of funding structures. Institutions favored solutions that addressed funding distribution and increased flexibility in training outcomes. Individuals overwhelmingly called for a reduction in the number of post-doctoral fellows by various long-term measures, such as early identification of individuals who will not choose to perform a post-doctoral fellows and redirection to MS programs or non-research careers, or by limiting the long-term supply of post-doctoral fellows by various methods.

PhD characteristics - commenters suggested that deficiencies in career development and failure to train for a branching career pathway are contributing to bottlenecks at the senior post-doctoral fellow stage. Many commenters asserted that variability in mentoring and career development resources in different programs results in too much variation in the PhD experience. Over half the commenters mentioned multi-disciplinary training in their response.

The most popular proposed solutions were improved career development programs that integrate alternative career pathways, increased structure in the PhD experience, and expansion of funding mechanisms to support career development.

Length of Post-doctoral Training was more broadly defined as *Post-doctoral Fellow Training Characteristics* since there were too many comments that could not be captured under the original, definition. While there was some dissent, most agreed that post-doctoral training is too long and is largely the result of a bottleneck of individuals looking for faculty positions. Inadequate mentoring was another challenge cited by many as a possible cause for the lengthening of the training period. Some suggested that the inherent instability of a training position may affect the scientific work being done by these scientists. Multiple secondary issues were mentioned in these responses, pointing to the fact that post doctoral training seems to be at the heart of many of the issues being considered.

Post-doctoral fellowship experiences seem to affect career appeal. The post-doctoral fellow lifestyle was viewed as untenable for many mid-30s professionals – most commenters expressed concern that salary and benefits are insufficient. The most popular solutions addressed salary, transition funding, and additional structure to the training process, including increased career development activities.

Biomedical Research Career Appeal was largely viewed as a consequence of graduate and post-doctoral experiences. Students and post-doctoral fellows are largely unhappy due to the dismal economy and job outlook. Research careers are currently less appealing than careers in competing fields, including MD and MPH programs. Funding and salary levels were the two secondary issues mentioned most often in these responses.

In general, commenters thought that the issue of career appeal is an important one and affects several other issues. Both institutions and individuals agreed that a career in biomedical research is less appealing today as a result of lower starting salaries for graduates and the increasing competition for limited research funding. Individuals seemed more concerned than institutions with career aspects such as family-friendly work environments, long hours, high stress, and benefits packages. Institutions expressed greater concern with regulatory burdens placed on current investigators. Many individuals viewed long-term institutional commitment unfavorably, citing the erosion of tenure positions and the increasing burden to fund one's own salary.

Some commenters pointed out that lack of information about graduate degrees and career opportunities led many to be dissatisfied with their career in biomedical research. Improved mentoring and career development, as well as anything that addresses the supply and demand imbalance, were perceived as the best solutions.

Individual commenters cited the pressure to increase clinic time as the main reason why the *clinician-scientist* path is less attractive and attainable. Commenters felt that the time required to conduct research is often not adequately compensated by the institution (in terms of pay, recognition or career advancement). Commenters believed that MD-PhD degrees are valuable, but that the increasing cost of medical school, requirements and length of training, and the limited opportunities in academia make the MD-PhD career path less attractive. Multi-disciplinary training and funding levels were the two secondary issues mentioned most often in these responses.

Institutions and individuals agreed that a broader approach to training was needed and clinical/translational training should begin sooner – in medical and undergraduate school. Both individuals and institutions suggested that funding support from NIH is needed to provide clinicians with protected time to maintain research activities.

Individual commenters supported the idea of creating a permanent *staff scientists career track*. They saw this as a way for all parties to reap the benefits of training support provided by NIH. Institutional commenters where divided, some taking a cautious approach to the idea of utilizing staff scientist in the lab, citing possible adverse effects including potential loss of innovative ideas (currently provided by graduates) and the reduction in project budgets to cover the salaries for these positions. Funding levels was the secondary issues cited most often in these responses.

Commenters believed that the biomedical workforce cannot be evaluated without addressing the need for *diversity*. They expressed the fear that the current economy and funding climate will have an adverse affect on the diversity of the workforce. Most commenters agreed that diversity should remain a priority in any proposed policy changes but there were few specific recommendations. Half these responses mentioned funding levels and 21% mentioned salary levels.

Effects of NIH Policies were mentioned throughout the responses. Commenters cited NIH policies and practices that positively and negatively affected the workforce, and offered possible solutions. Commenters addressing the issue of funding policies expressed a range of reasons for being dissatisfied with the current funding review system. The predominant reason, for both institutions and individuals, was that securing funding has become increasingly difficult, particularly for new investigators. 88% of these responses mentioned funding levels.

Commenters reported that the quality of *mentoring* varies immensely, and it has a significant effect on mentee's perspectives and career paths. Institutional commitment to career development resources also was reported to vary. Mentoring can improve or compound other issues such as diversity, length of training, and biomedical research career appeal. Institutions and individuals both described conflicts of time and interest for PIs when mentoring students and post-doctoral fellows. Of commenters addressing non-academic career paths, most agreed that training for these paths is inadequate. Multi-disciplinary training and funding levels were the secondary issues mentioned most often in these responses.

Anything that would improve current funding success rates could address this conflict. Also, many commenters suggested that all NIH-funded students and post-doctoral fellows should have documented individual development plans (IDPs).

Few commenters (19) addressed the issue of *training to research grant ratio*. Those that did comment felt that there was a need for more training grants because their flexibility allows for better career development of funded trainees. This belief was held by institutions as well as individuals. Funding levels and mentoring were the secondary issues mentioned most often in these responses.

Institutions requested an in-depth evaluation be conducted to understand the potential impact of moving students and post-doctoral fellow support off of research grants and onto training grants.

Some commenters suggested that some of the primary issues may have roots as early as K-12 education. *Early education intervention* programs prior to graduate school would likely have downstream effects on issues such as Biomedical Research Career Appeal, Diversity, and Supply and Demand. Funding levels and mentoring were mentioned most often. Suggestions generally called for an increase in funds devoted to programs that would affect the K-12, undergraduate, and post-baccalaureate student populations.

Industry Partnership – Some commenters viewed the relationship between industry and academia as imbalanced in terms of benefits and burdens. Specifically, industry was thought to share more of the benefits and academia was thought to share more of the burdens. Although fewer than ten commenters made specific reference to partnerships between academia and industry, this was defined as a primary issue since so many individuals felt that industry was a vital part of the branching career pipeline for biomedical workers. Individuals submitted all but one of the comments on this issue.

<u>NIH/TAC Workforce (NTW) Committee</u>

As part of its deliberations, the Working Group asked for input from NIH staff. The NIH TAC took a lead role in this process - the NIH/TAC Workforce (NTW) committee was formed and met several times to develop scenarios intended to provide a framework for discussion about how NIH supports research training and possible avenues for change.

The NTW committee was asked to provide input for discussion by the ACD Working Group rather than fully-fledged recommendations. Therefore, the group developed scenarios from two opposing positions – A) NIH should primarily support the training of independent research scientists; or B) NIH should support training for a wide range of research and non-traditional careers. The group focused on scenarios for NIH funding of training:

- At the predoctoral career stage
- At the postdoctoral career stage
- At the early career stage
- Of clinician scientists

Following is a summary of the full NTW report (which outlines the pros and cons of each scenario), which is included as Appendix G.

NIH support of research training and education is focused at the predoctoral, postdoctoral, and early career stages of a biomedical scientist's career. NIH also supports diversity-promoting programs at all these career stages, as well as at the high school and undergraduate levels. A recurring theme is the importance and effectiveness of NIH formal research training programs (namely, institutional training, fellowship and career development awards) versus training supported by research grants. Peer review of the formal training programs includes the science proposed, as well as the proposed training and the training potential. Formal training awards can be targeted to emerging scientific disciplines and to areas of national need. Of particular note, formal training programs have played a vital role in creating incentives for increasing the diversity of the workforce pipeline.

The NTW committee did not distinguish among the careers of individuals engaged in biomedical research in academia, industry, government, or any other sector; these were not considered 'non-traditional' or 'alternative' careers. The committee felt it was important not to confuse these careers with truly 'alternative' or non-traditional careers, such as science policy, law, finance, and teaching at K-12 levels or at institutions where there is little or no research activity.

The NTW committee drew a distinction between the career paths of the majority of biomedical research scientists who are PhD recipients, and the much smaller population of clinician scientists (individuals holding MD, DO, DDS, DVM, DN, or equivalent clinical doctorate degrees who are research scientists). Clinician scientists generally do not receive support from the NIH for their clinical training, except for those enrolled in formal combined degree programs. The NTW committee noted the differences in immediate career options for clinicians, who may fall back on clinical practice for their livelihoods, and PhD researchers, whose options are more limited. On the other hand, clinician scientists face demands on their time for research activities that are not generally encountered by PhD scientists.

There are more policy options and leverage at the beginning of the career but it is not easy to address the current population of individuals already at the Early Career stage. In the Early Career stage, the committee struggled with how to retain highly trained individuals in the research workforce without affecting the research grant budget. For this reason, the committee chose not to recommend reduction the large postdoctoral pool directly but to make changes earlier in the training pipeline and allow workforce supply and demand to self-correct.

The scenarios in each career stage represent moderate to significant policy changes required of the NIH, depending on the desired outcome. There were varying levels of support for the different scenarios from the full NTW committee; however, most disagreement was manifested in the scenarios for the Early Career stage, for the reasons mentioned above. Committee members noted that solutions that work for one biomedical discipline may not work for another, and that particular NIH Institutes and Centers might have unique issues. Finally, for all scenarios, there was concern that some of the policy changes could affect efforts to create a more diverse workforce, but there was agreement that adjustments in policies were possible to minimize or eliminate these effects.

1. *Predoctoral Career Stage*

    a. Training Graduate Students Exclusively for Research Careers. Focuses on the selection (at the time of graduate school admission) of those students most likely to pursue careers as research scientists. Incentivizes graduate schools to be more selective in their admissions process, making them more financially responsible for supporting students who do not successfully compete for formal training awards and restricting the use of NIH research grants for such support.

    b. Tracking Graduate Students into Research or Non-Traditional Careers. Acknowledges the large number of students who enroll in biomedical science graduate programs but moves them into 'non-traditional' career training tracks. This scenario accepts the current graduate admissions process, but requires institutions receiving NIH support for research or formal training to track the career intentions of supported students. Formal NIH training support would be reserved for those students exhibiting clear plans to engage in research careers. Students who intend 'non-traditional' careers, although ineligible for formal NIH training programs, could be hired as research assistants on research grants to help support their training for careers other than research science. Alternatively, students who intend 'non-traditional' careers but wish to pursue the research doctorate could earn multiple degrees (for example, both the PhD and MBA). Note that implementation of this scenario depends on students self-identifying their career plans at an early stage.

c. Training Graduate Students for a Wider Range of Science-Related Careers. Acknowledges a broader range of career outcomes, but retains students in the research doctorate track. Institutions would be required to provide broader training within the research doctorate program that would prepare all students for both research and 'non-traditional' careers. This broader training would take place while students pursued their research doctorate degrees. One disadvantage of this scenario is that providing meaningful training in multiple areas could require a significant increase in time to the PhD degree.

2. *Postdoctoral Career Stage*

   a. Training Postdoctoral Fellows Exclusively for Research Careers. Limits NIH formal training support to individuals most likely to continue in careers as research scientists, with greater emphasis on high quality career development experiences. If this scenario were implemented, the number of postdoctoral positions on research grants would be significantly limited.

   b. Training Postdoctoral Fellows for a Wider Range of Careers. Align the postdoctoral experience to the reality that not all individuals will move on to careers as independent research scientists. NIH formal training programs would be changed to include a broadening of training experiences beyond laboratory research. The breadth of these experiences would be determined by the historical outcomes of postdoctoral scientists and the resources available at the host institution. Support of postdoctoral scientists on research grants would continue to be allowed, but additional requirements would be instituted so that they would receive the same level and type of training no matter their funding source (research awards, fellowships, or training grants).

   Note that both scenarios call for maintaining the NIH career development award programs for those postdoctoral scientists most likely to become independent or lead scientists, with a shift toward more support of transition to independence programs.

3. *Early Career Stage*

   a. Supporting Research Scientists after Postdoctoral Training during Difficult Economic Periods. The award would allow senior postdoctoral researchers to initiate independent research projects. This scenario is unique in that the award program would be counter-cyclical; when academic, industrial and government research scientist openings are abundant, NIH would limit the number of awards. Likewise, when these openings are very limited, NIH would increase the funding of this program. Note that the NTW committee was not very enthusiastic about this scenario because of concerns that implementation would drain dollars from regular research grants, and would simply postpone resolving disparities between supply and demand.

b. Supporting Career Staff Scientists. Proposes a program to support staff scientists as part of a team of individuals providing core services to laboratories with NIH research grant support. These individuals would not be expected to become independent research scientists but would rather bring new technical competencies to the institution and provide intellectual input to the supported laboratories. The purpose of this program would be to provide an NIH supported career pathway for highly trained research doctorates who might otherwise leave the workforce, while at the same time perhaps creating a more efficient research infrastructure.

4. *Clinician Scientists*

a. Making Research Careers More Attractive for Clinician Scientists. While there are many PhD holders seeking limited research jobs, the number of clinician scientists at the postdoctoral level (post-residency) is much smaller. Additionally, only a small fraction of medical students express interest in careers as independent research scientists. MD/PhD programs, however, have been quite successful in placing graduates in independent research positions, when compared to PhD programs

The NTW committee focused on the challenges to becoming a clinician scientist and considered the critical need for a comprehensive workforce infrastructure to support clinical-translational research as beyond the scope of this exercise. The clinician scenario includes actions that NIH could take to support the careers of clinician scientists at three career stages: medical school, residency, and early career. For medical students, NIH could support more programs for short-term research experiences during medical school, and create more awards for ‘year out’ programs. At the residency level, NIH could create awards that support ‘fast-tracking’ in residency programs, thereby allowing clinicians to begin research careers sooner. At the early career stage, the NIH Loan Repayment Program could be extended to more clinicians by broadening the eligibility criteria. Finally, the NIH could create incentives for more team approaches to research that involve collaborations between clinician scientists and PhDs.

GLOSSARY

AAMC	American Association of Medical Colleges
ACD	NIH Advisory Committee to the Director
AMA	American Medical Association
BLS	Bureau of Labor Statistics
FY	Fiscal Year
GSS	NSF Graduate Student Survey
IC	Institutes and Centers at NIH
NIH	National Institutes of Health
NPA	National Postdoctoral Association
NRC	National Research Council
NRSA	Ruth L. Kirschstein National Research Service Awards
NSF	National Science Foundations
NTW	NIH/TAC Workforce committee
OES	BLS Occupational Employment Statistics program
OSAR	Office of Statistical Analysis and Reporting, Office of Extramural Research, NIH
PI	Principal Investigator
RFI	Request for Information
RPG	Research Project Grant
SDR	NSF Survey of Doctorate Recipients
SED	NSF Survey of Earned Doctorates
STEM	Science, Technology, Engineering and Mathematics
TAC	NIH Training Advisory Committee

APPENDICES

A: Working Group Charge and Modeling Subcommittee Roster

Working Group Charge

1. Develop a model for a sustainable and diverse U.S. biomedical research workforce that can inform decisions about training of the optimal number of people for the appropriate types of positions that will advance science and promote health. Developing the model will include an analysis of the current composition and size of the workforce to understand the consequences of current funding policies on the research framework. The model should include an assessment of present and future needs in the academic research arena, but also current and future needs in industry, science policy, education, communication, and other pathways. The model will also require an assessment of current and future availability of trainees from the domestic and international communities.
2. Based on this analysis and input from the extramural community, using appropriate expertise from NIH and external sources, and recognizing that there are limits to NIH's ability to control many aspects of the training pipeline, the committee will make recommendations for actions that NIH should take to support a future sustainable biomedical infrastructure.

Modeling Subcommittee Roster

Bruce Weinberg, Ph.D., Professor of Economics, Ohio State University, *co-chair*

Donna Ginther, Ph.D., Professor of Economics & Director, Center for Economic and Business Analysis, University of Kansas, *co-chair*

David Blau, Ph.D., Professor of Economics, Ohio State University

Stephen Eubank, Ph.D. Professor of Physics, Virginia Bioinformatics Institute & deputy director, Network Dynamics and Simulation Science Laboratory, Virginia Tech

Richard B. Freeman, Ph.D. Herbert Ascherman Chair of Economics, Harvard University & director of the National Bureau of Economic Research/Sloan Science Engineering Workforce Project

Peter K. Sorger, Ph.D. Professor of Systems Biology, Harvard medical School and Professor of Biology and Biological Engineering, Massachusetts Institute of Technology

Paula Stephan, Ph.D. Professor of Economics, Georgia State University

Michael Teitelbaum, Ph.D. Senior Advisor, The Alfred P. Sloan Foundation

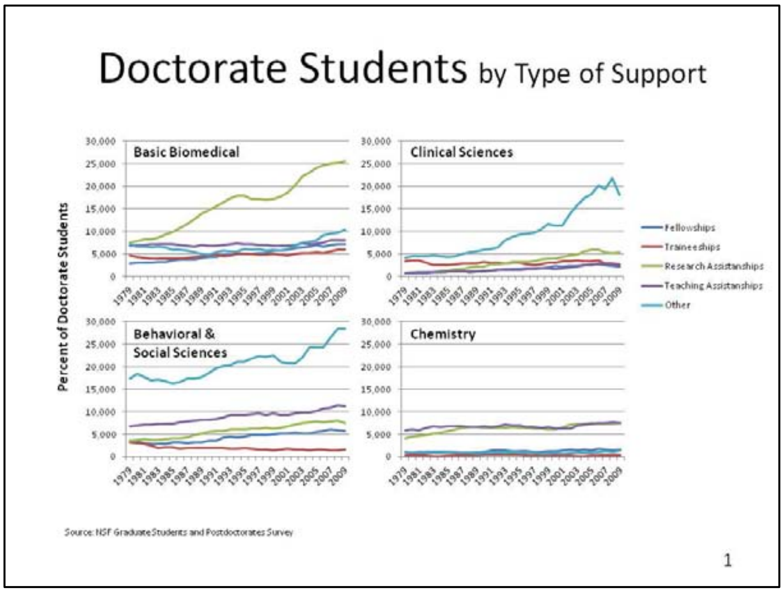
B: Additional Workforce Data

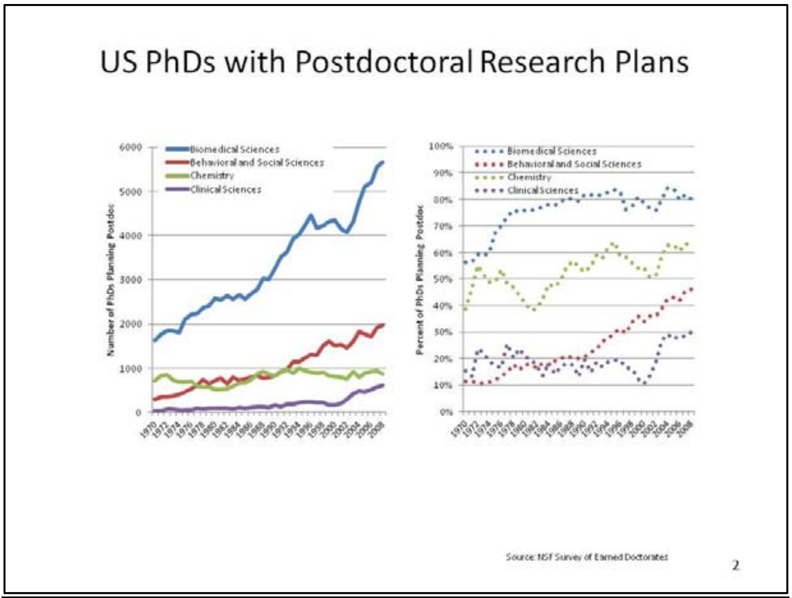
Additional Workforce Data

This appendix contains data presented to the working group that were not included in the body of the report and alternate presentations of some the data included in the report.

Note that the various entities that collect data on the workforce have different definitions for areas of science and professions. In addition, due to these different definitions and various collection methods, different sources on the same topic may provide varying numbers. Additional information can be found at http://report.nih.gov/investigators_and_trainees/ACD_BWF.

Graduate Students




US PhDs with Postdoctoral Research Plans
Biomedical Sciences
Behavioral and Social Sciences
Chemistry
Clinical Sciences
Number of PhDs Planning Postdoc
6000
5000
4000
3000
2000
1000
0
Percent of PhDs Planning Postdoc
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1970
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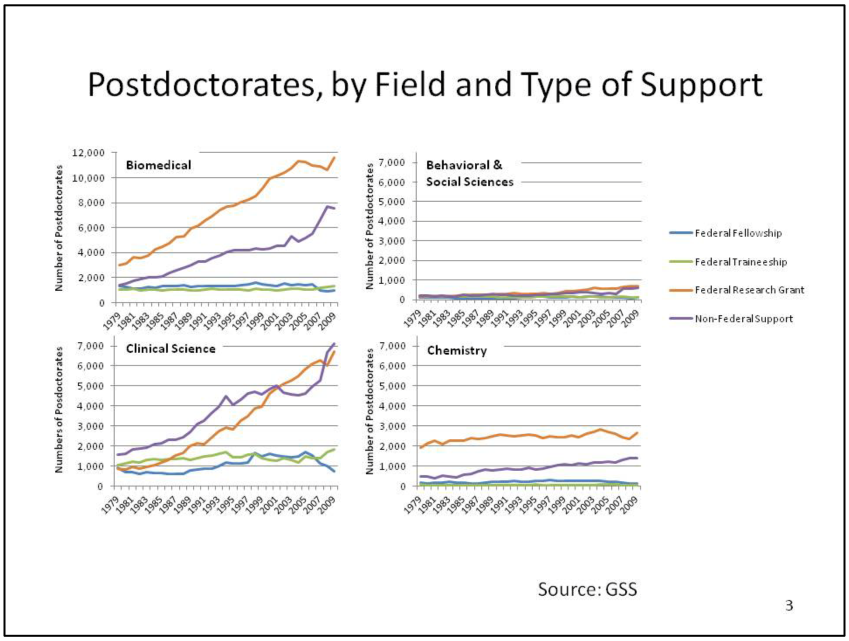
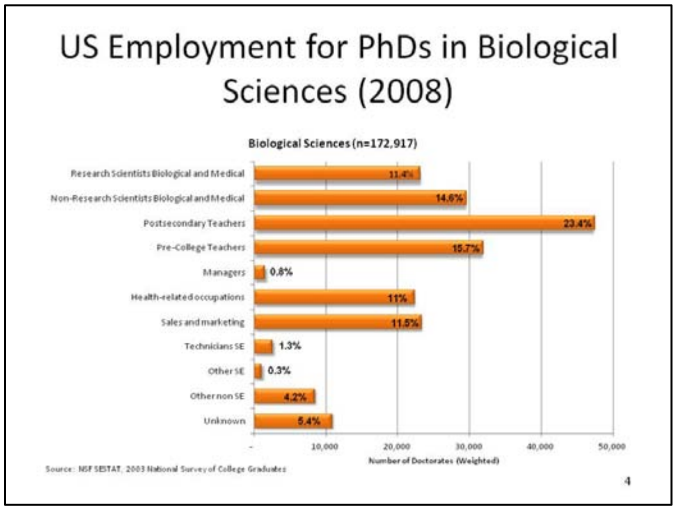
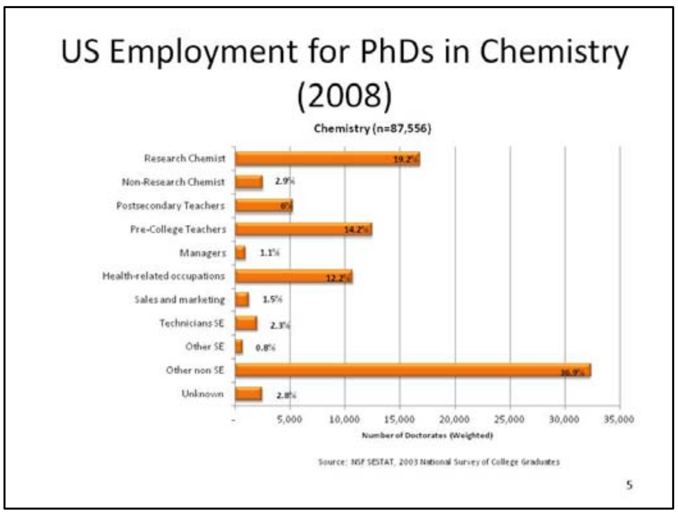
2008
Source: NSF Survey of Earned Doctorates
2

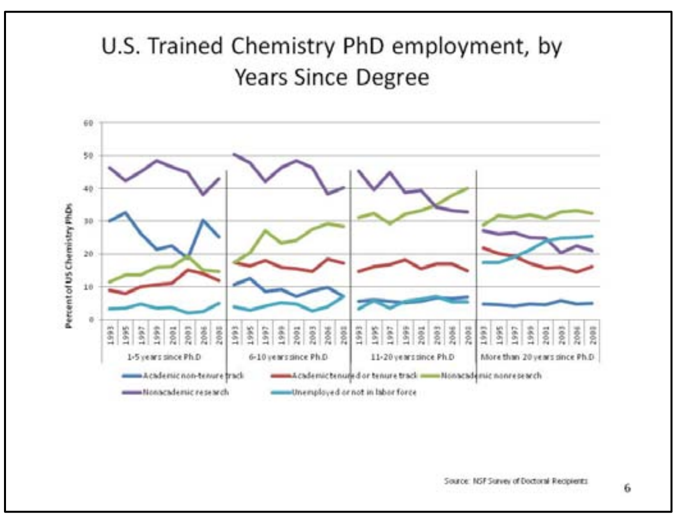
Postdoctoral Researchers

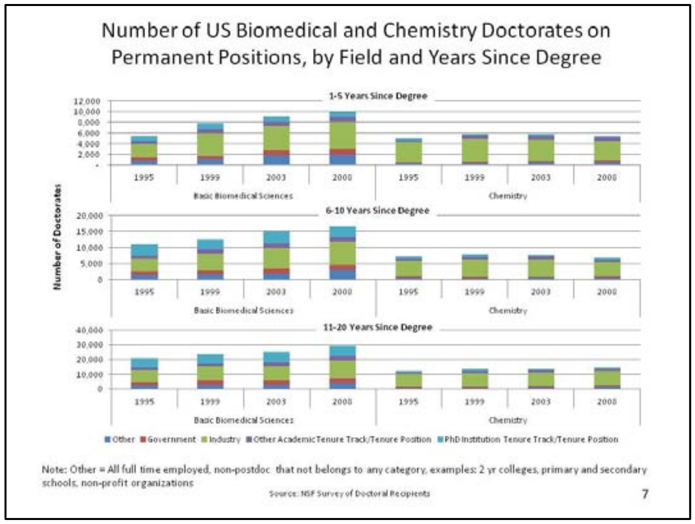


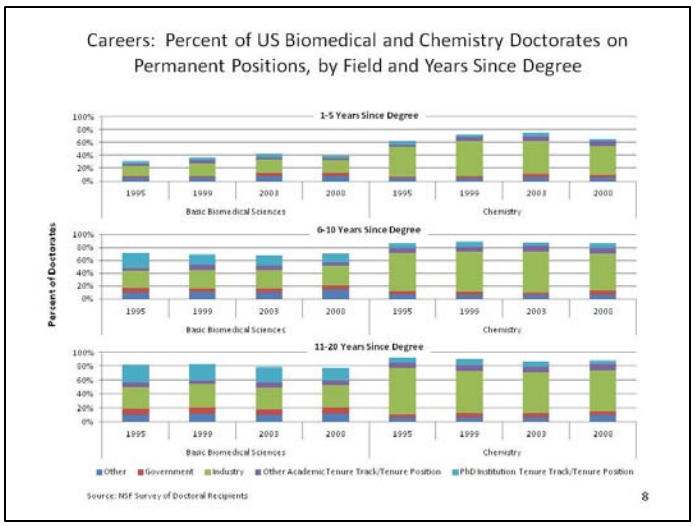
Career Outcomes

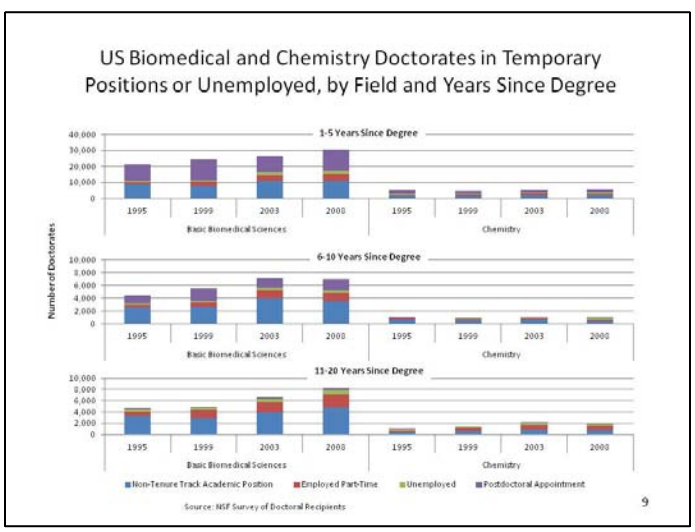







Number of US Biomedical and Chemistry Doctorates on Permanent Positions, by Field and Years Since Degree
1-5 Years Since Degree
6-10 Years Since Degree
11-20 Years Since Degree
Number of Doctorates
Basic Biomedical Sciences
Chemistry
Other
Government
Industry
Other Academic Tenure Track/Tenure Position
PhD Institution Tenure Track/Tenure Position
Note: Other = All full time employed, non-postdoc that not belongs to any category, examples: 2 yr colleges, primary and secondary schools, non-profit organizations
Source: NSF Survey of Doctoral Recipients
7


Careers: Percent of US Biomedical and Chemistry Doctorates on Permanent Positions, by Field and Years Since Degree
1-5 Years Since Degree
6-10 Years Since Degree
11-20 Years Since Degree
Percent of Doctorates
Basic Biomedical Sciences
Chemistry
Other
Government
Industry
Other Academic Tenure Track/Tenure Position
PhD Institution Tenure Track/Tenure Position
Source: NSF Survey of Doctoral Recipients
8


US Biomedical and Chemistry Doctorates in Temporary Positions or Unemployed, by Field and Years Since Degree
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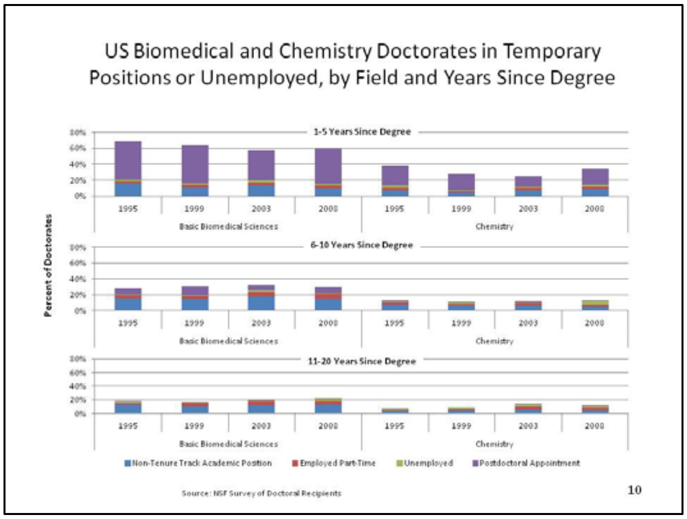
6-10 Years Since Degree
11-20 Years Since Degree
Number of Doctorates
Basic Biomedical Sciences
Chemistry
Non-Tenure Track Academic Position
Employed Part-Time
Unemployed
Postdoctoral Appointment
Source: NSF Survey of Doctoral Recipients
9


US Biomedical and Chemistry Doctorates in Temporary Positions or Unemployed, by Field and Years Since Degree
1-5 Years Since Degree
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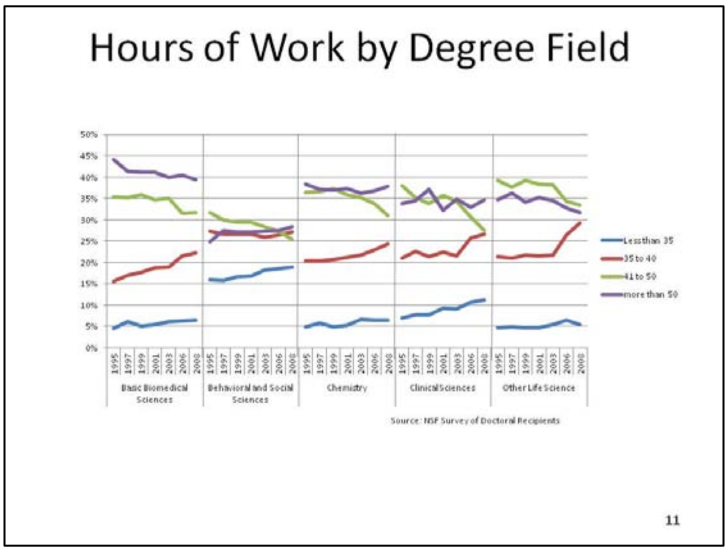
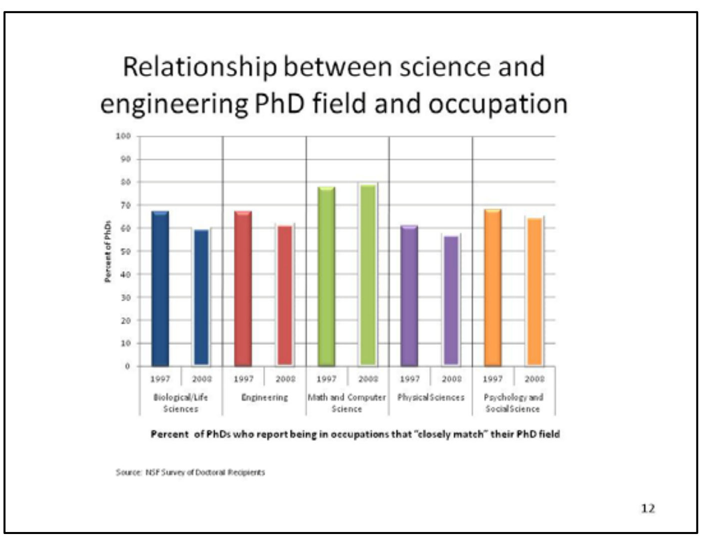
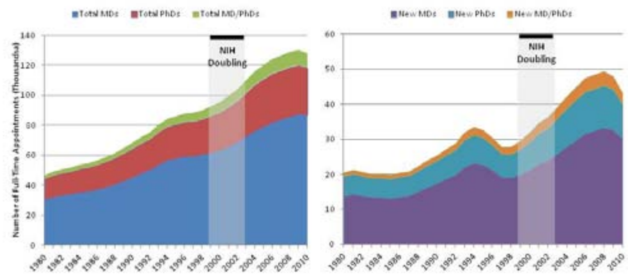
Percent of Doctorates
Basic Biomedical Sciences
Chemistry
Non-Tenure Track Academic Position
Employed Part-Time
Unemployed
Postdoctoral Appointment
Source: NSF Survey of Doctoral Recipients
10


Hours of Work by Degree Field
Less than 35
35 to 40
41 to 50
more than 50
Basic Biomedical Sciences
Behavioral and Social Sciences
Chemistry
Clinical Sciences
Other Life Science
Source: NSF Survey of Doctoral Recipients
11

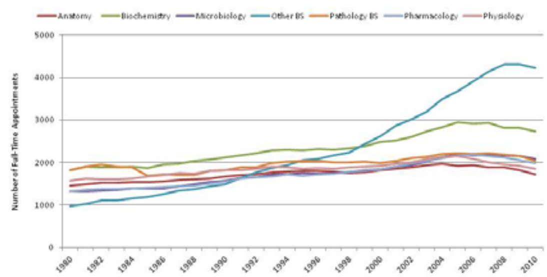

Relationship between science and engineering PhD field and occupation
Percent of PhDs
Biological/Life Sciences
Engineering
Math and Computer Science
Physical Sciences
Psychology and Social Science
Percent of PhDs who report being in occupations that "closely match" their PhD field
Source: NSF Survey of Doctoral Recipients
12

Number of Total and New Medical School Appointments, by Degree



13

Full-time Medical School Faculty Appointments, by Department Type

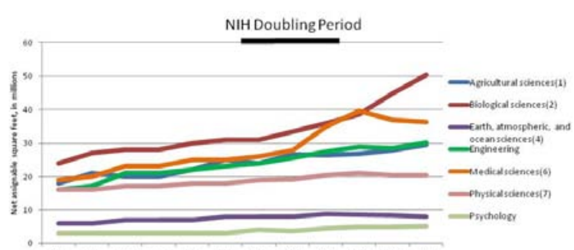


BS=Basic Science

Source: AAMC Faculty Roster

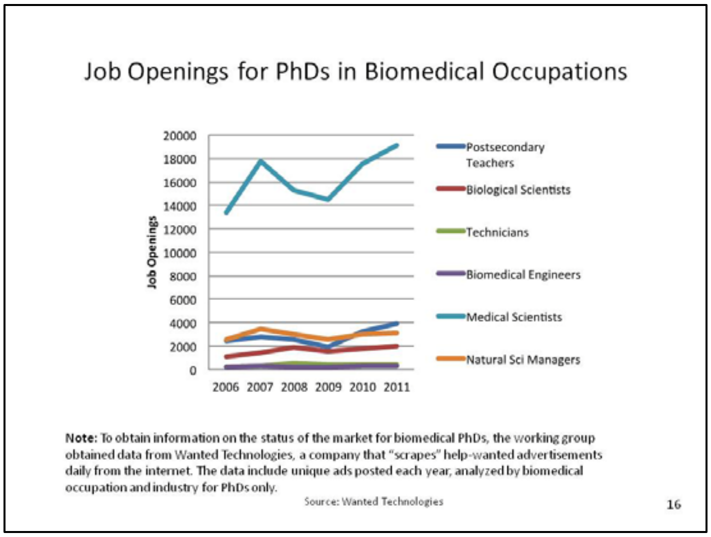
14

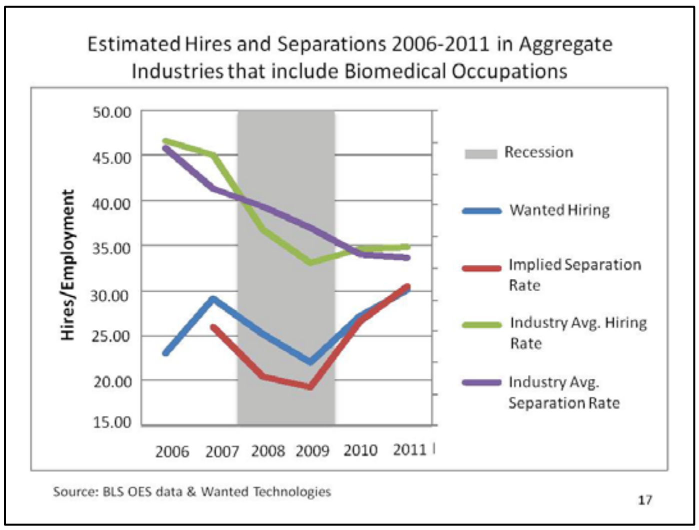
University Assignable Research Space, by Field

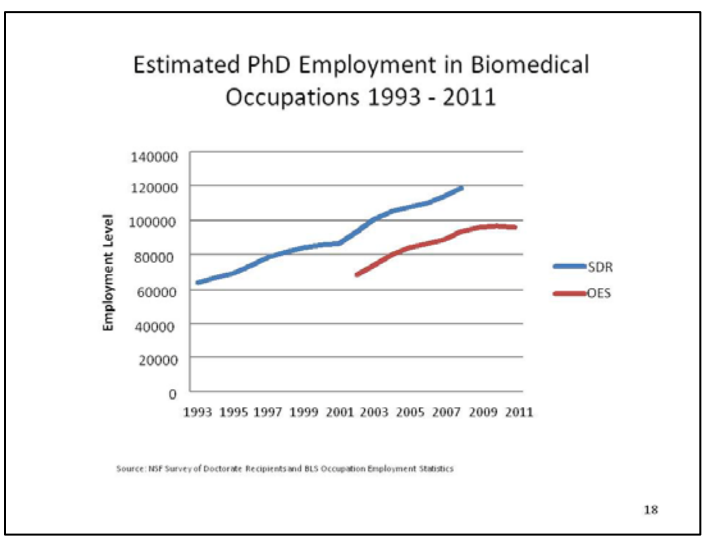


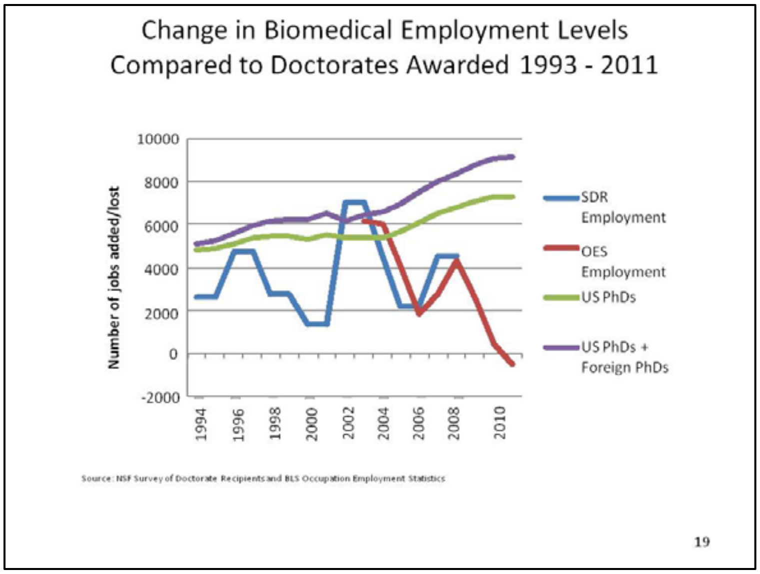
Source: NSF Survey of Science and Engineering Research Facilities

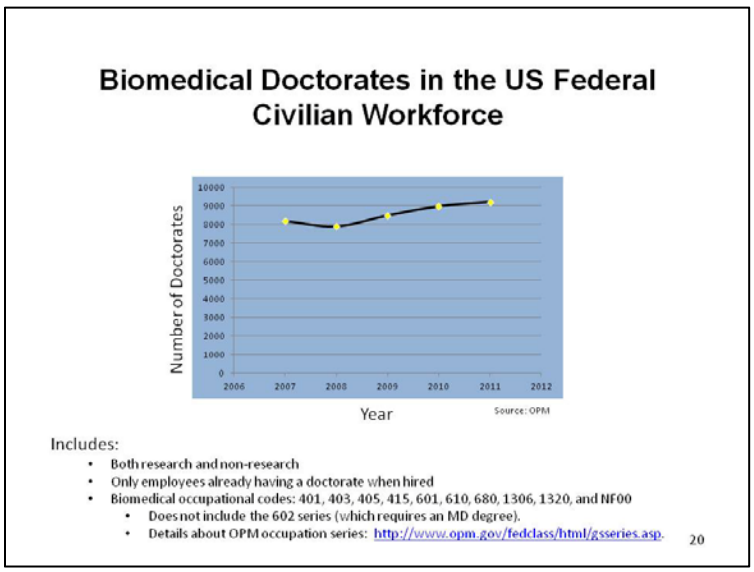
15


Job Openings for PhDs in Biomedical Occupations
Job Openings
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
2006 2007 2008 2009 2010 2011
Postsecondary Teachers
Biological Scientists
Technicians
Biomedical Engineers
Medical Scientists
Natural Sci Managers
Note: To obtain information on the status of the market for biomedical PhDs, the working group obtained data from Wanted Technologies, a company that "scrapes" help-wanted advertisements daily from the internet. The data include unique ads posted each year, analyzed by biomedical occupation and industry for PhDs only.
Source: Wanted Technologies
16

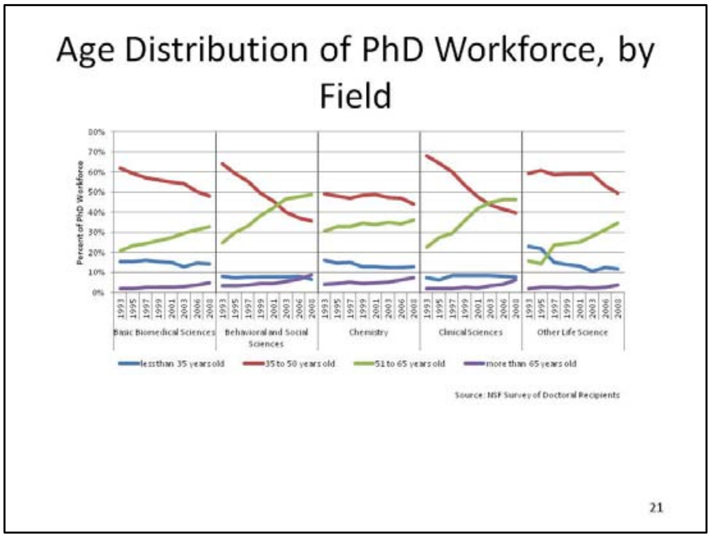

Estimated Hires and Separations 2006-2011 in Aggregate Industries that include Biomedical Occupations
Hires/Employment
50.00
45.00
40.00
35.00
30.00
25.00
20.00
15.00
2006 2007 2008 2009 2010 2011
Recession
Wanted Hiring
Implied Separation Rate
Industry Avg. Hiring Rate
Industry Avg. Separation Rate
Source: BLS OES data & Wanted Technologies
17


Estimated PhD Employment in Biomedical Occupations 1993 - 2011
Employment Level
140000
120000
100000
80000
60000
40000
20000
0
1993 1995 1997 1999 2001 2003 2005 2007 2009 2011
SDR
OES
Source: NSF Survey of Doctorate Recipients and BLS Occupation Employment Statistics
18


Change in Biomedical Employment Levels
Compared to Doctorates Awarded 1993 - 2011
Number of jobs added/lost
10000
8000
6000
4000
2000
0
-2000
1994
1996
1998
2000
2002
2004
2006
2008
2010
SDR Employment
OES Employment
US PhDs
US PhDs + Foreign PhDs
Source: NSF Survey of Doctorate Recipients and BLS Occupation Employment Statistics
19


Biomedical Doctorates in the US Federal Civilian Workforce
Number of Doctorates
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
2006
2007
2008
2009
2010
2011
2012
Year
Source: OPM
Includes:
• Both research and non-research
• Only employees already having a doctorate when hired
• Biomedical occupational codes: 401, 403, 405, 415, 601, 610, 680, 1306, 1320, and NF00
• Does not include the 602 series (which requires an MD degree).
• Details about OPM occupation series: http://www.opm.gov/fedclass/html/gsseries.asp.
20

Demographics



C: Recommendations to Address Specific Data Gaps

1. **Data on graduate students and postdoctoral researchers:**

   a. The NIH should work closely with the NSF and encourage the development of a more comprehensive approach to collecting information on the numbers of individuals in student and postdoctoral-like positions, tracking a sufficient number of individuals using an appropriate frame to provide a clear understanding of the features of available career tracks for those with both domestic and foreign doctorates. The SED and SDR should be modified to collect information about the career aspirations of doctorates and postdoctoral researchers.

   b. The NIH should work closely with the NSF to shorten the lag between the collection and release of data. For SESTAT data, including the SDR, reports often lag the initial collection by 3 or 4 years. This does not accommodate changes caused by rapid economic shifts including the recent recession.

   c. The NIH should work closely with NSF to ensure that the SDR includes those with foreign doctorates. Although the sample may not allow inferences for all postdoctoral researchers, it should be possible to add those with foreign degrees in the NIH Commons to the sampling frame.

   d. The NIH should ensure that all students and postdoctoral researchers supported by NIH on both research and research training grants are identified and the necessary variables are collected to assess the impact of NIH funded experiences on their subsequent careers.

   e. The NIH should explore the use of institutional reports like STAR METRICS to count the number of postdoctoral researchers and graduate students. It may not be possible to match STAR METRICS data to IMPAC II data, but such linkages would help identify the number of positions associated with specific awards and award types.

   f. The following types of data are important and not widely available:

      i. Flow rate over time of International PhD postdoctoral researchers

      ii. Flow rate over time of International PhDs going directly into the workforce by sectors (could be differentially going to academia or industry)

      iii. Rate over time of foreign PhDs that leave the US

      iv. Detailed information on the characteristics and trajectories of postdocs

   The NIH should work with the NSF to make sure such data are collected.

2. **Data on MD and MD/PhDs:**

   The NIH should work with the AAMC and the AMA to encourage the inclusion of better indicators of research involvement in the Faculty Roster and other surveys. It should also explore ways of using administrative data to address gaps in data on MDs and MD / PhDs. The following types of data are important:

      i. Flow rate over time of international MDs going into research

ii. Flow rate over time of recent MD graduates to residency or postdoctoral positions

iii. Number of MDs and MD/PhDs in government positions with distinction between research and patient care

iv. Number of MDs and MD/PhDs in industrial positions

v. Residency:

  a. Number of MDs and MD/PhDs doing research

  b. Number of residency programs that support research

vi. Fellowship programs:

  a. Data on the number of MDs and MD/PhDs doing research during their fellowship

  b. Data on how many fellowship programs support research

vii. Flow rate over time of MDs and MD/PhDs out of residency and/or fellowship programs into the research workforce

viii. Longitudinal, microdata on individuals and their backgrounds linked to future outcomes

3. Data on industry employment:

  a. The NIH should work with NSF and the BLS to improve the relevant data available in SESTAT and the OES.

  b. ii.b. NIH should also explore the extent to which data on industry employment can be obtained by tracking trainees administrative data combined with the Longitudinal Employer – Household Dynamics (LEHD) program, a state/federal partnership.

  c. The following types of data are important:

    i. Number of PhDs and postdoctoral researchers employed in industry

    ii. Number of foreign PhDs and postdoctoral researchers

4. Data on researchers and especially faculty who receive salary support from NIH research grants.

  a. The NIH should work with the NSF to include questions in the SDR on the percentage of salary covered by federal grants.

  b. NIH should further explore the use of administrative data such as that collected by STAR METRICS to identify the proportion of salary derived from federal sources.

  c. NIH should consider ways to identify and track staff scientists and people with other titles functioning as staff scientists. One way would be to expand and perhaps automate the collection of all-personnel data on annual progress reports to increase the ease of preparing extramural staff enumeration reports through programs such as STAR METRICS.

5. **Data linking NIH Administrative records to other sources**

   IMPAC II contains abundant information on PIs and those in NRSA training positions. In many cases, this information has been linked to other data sources including the SED and the AAMC Faculty Roster. There are, however, other data sources that could be used to provide a more-complete picture of the scientific workforce.

   a. Examples include the following:

      i. Routinely linking IMPAC II to the SDR would allow researchers to investigate the impact of NIH training on career outcomes. The NIH should work with the NSF to make sure that access is provided to as much of SDR data as possible.

      ii. Linking PIs to postdoc and graduate student employees on NIH funded grants and then to publication data would allow NIH to routinely identify how training and affiliation with certain labs funded by NIH research grants affect subsequent research careers.

      iii. The NIH should explore the utilities associated with STAR METRICS and eventually with SciENcv to make sure that relevant data are collected in a format that makes the analysis of both the stock and the flow of researchers in various sectors.

6. **Aggregate information on the number of job openings for biomedical PhDs:**

   There is currently no centralized source of information on the number of job openings and employment opportunities for biomedical researchers with the PhD. Several organizations collect this kind of information and aggregate analyses are available.

D: Incentives Memo

MEMO TO: Biomedical Workforce Working Group, Advisory Committee to the Director, NIH

FROM: Modeling subcommittee

SUBJECT: Some unintended incentives and disincentives underlying the US biomedical research system:

Date: October 21, 2011

The subcommittee discussed the response of investigators and institutions to NIH policies. This memo outlines some of the incentives and disincentives related to NIH rules and practices that might be affecting the behavior of biomedical research institutions, scientists, and students (including potential students). We agreed that the emphasis should be on unintended rather than intended incentives, and of course especially those unintended disincentives that might be in opposition to other important NIH goals.

The memo reflects the subcommittee discussion (but much of the background is highly nuanced, making it possible that some of the characterization is not entirely correct) and is offered as input to the working group. We hope it will serve as a catalyst for further discussion, correction, or clarification. Please note that while many of these incentives and disincentives seem to be substantially under NIH influence, others may be mandated by law or regulation outside of NIH control.

The underlying concern is that the US biomedical research system has been showing repeated signs of a lack of stable equilibrium. An incomplete list of such symptoms might include the following:

1. While the US biomedical research system is heavily funded, far more than for any other fields of basic science,[51] it appears to have a tendency to expand beyond the available funds. When the 14-15% annual budget increases of the doubling period ended in 2003, there was widespread discussion of a new "funding crisis", although the funds available were nearly double those of only 5 years earlier (somewhat less if adjusted for inflation).
2. According to one well-informed analysis, the biomedical research system is structured for continuous growth, and becomes unstable unless NIH receives at least a 6 to 8% annual budget increase.[52]
3. Careers for junior biomedical scientists appear to be unattractive relative to other fields requiring lengthy post-baccalaureate education and postdoctoral training. Average remuneration for biomedical researchers is among the lowest reported for scientists, notwithstanding that the largest volume of Federal funding goes to the biomedical sciences.

[51] NIH's research budget is more than 4 times that of the National Science Foundation. Among US government agencies the NIH budget is exceeded only by the R&D budget of the Department of Defense, but the latter is heavily concentrated upon the "D" or development side of R&D. For an informative overview, see Congressional Research Service, Federal Research and Development Funding: FY2011, March 10, 2010, http://assets.opencrs.com/rpts/R41098_20100310.pdf

[52] David Korn, et al.,"The NIH Budget in the 'Postdoubling' Era," Science, 296, 24 May 2002, p. 1402.

4. The system generates far more research proposals than can be funded. The trends suggest increasing time devoted by biomedical researchers to proposal preparation, as the numbers of proposals per researcher increase and success rates remain low or decline further.

Much of these symptoms of instability are structural in nature, driven by a number of destabilizing and presumably unintended feedback loops (see discussion in Teitelbaum, 2008[53]). Careful analyses of these system dynamics, accompanied by appropriate adjustments of current incentives and disincentives, may enable NIH to incrementally guide the research system that it funds and supports toward a more stable equilibrium, without doing injury to its outstanding quality and significant contributions to human welfare. Indeed, in addressing such system issues it is critical to attend to the system equivalent of the Hippocratic Oath: any prescriptions to mitigate negative symptoms should, above all, "do no harm."

To this end, improving our understanding of the outcomes of at least the following incentives and disincentives may provide useful insights and guidance.

#1: Incentives that may increase financial leverage and vulnerability of research institutions and researchers

Issue 1-A:

NIH practices allowing unlimited percentages of faculty salaries to be covered by NIH grant funds:

NIH imposes no limits on the percentage of faculty salaries that can be paid from NIH research funds (although there is a cap on the overall amount of salary that can be paid).[54] Payment of large fractions of a faculty salary under an NIH grant appears to be most common in medical schools rather than in arts/sciences faculties.

In contrast the NSF generally limits salary compensation for senior project personnel to no more than two months of their regular salary in any one year. NSF does allow payment of full salaries for other personnel such as postdocs.

Unintended incentives:

- Faculty
    - o Faculty whose own salaries and benefits depend heavily upon external grant funding face strong incentives to commit substantial proportions of their time and effort in

[53] Michael S. Teitelbaum, "Structural Disequilibria in Biomedical Research," Science 321, 1 August 2008, pp. 644-5.
54Payment must be in proportion to the effort devoted to the research project, and there is a cap on the amount of salary that can be charged to an NIH grant, linked to the Federal Executive Pay scale – until recently $199,700, reduced by Appropriation action in later 2011 to $179,700 for grants with Initial Issue Date on/After 12/23/2011.. http://grants.nih.gov/grants/policy/fy2012_salary_cap_faqs.htm

pursuit of new/renewed external research funding, not only in support of their research interests but also of their own personal compensation.
  - Due to the difficulties and uncertainties of obtaining external research funding, faculty in such circumstances also are subject to higher risks of funding gaps that threaten research programs, stipend support for their postdoc research assistants, etc.
- Institutions
  - Current NIH policy allows/incentivizes institutions to encourage faculty to maximize the proportion of their salaries and benefits paid by external but ultimately "soft" funding sources such as NIH research grants.
  - Salary paid under NIH research grants also is included in the base for calculating indirect costs; the resulting additional indirect funds may be especially attractive to university administrators.
    - In the words of Bruce Alberts, "NIH actually rewards institutions for paying faculty salaries with unguaranteed "soft money" from research grants by providing increased overhead payments. Amazingly, any institution that draws on its own finances to pay its professors is doubly disadvantaged: It must not only use its own funds but also loses the overhead on the salaries that it would otherwise accrue."[55]
  - Since money is fungible, substitution of "soft" for "hard" funds may incentivize the institution to expand its faculty and attempt to capture additional external direct and indirect funding beyond levels that otherwise would be possible.
  - This seems to be more of an issue in medical schools, less so in the Arts and Sciences units, where tuition and teaching constitute a larger part the revenue stream and faculty effort of science departments.[56]
  - This strategy may work well when NIH funding is growing robustly, but can become a significant and even threatening burden when real NIH budgets are flat or declining.
  - Faculty positions (including even those protected by tenure) and labs become increasingly unstable as success rates drop.
  - It is important to note that NIH limitations on payment of investigator salaries would make participation in NIH supported research financially more difficult for many institutions at a time when there are recession-related funding pressures on clinical revenues, endowment income, charitable donations, and state support.

Issue 1-B:

<u>Indirect cost regulations incentivize debt financing of biomedical research facilities:</u>

OMB Circular A-21, which controls NIH practices regarding institutional indirect costs, generally allows inclusion of the costs of debt service in indirect cost calculations, but prohibits inclusion of the imputed value of similar laboratory facilities that are not debt financed.[57]

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55 Bruce Alberts, "Overbuilding Research Capacity," Science, Vol. 329 (10 September 2010), p. 1257.
56 S. A. Bunton, W.T. Mallon, "The Continued Evolution of Faculty Appointment and Tenure Policies at U.S. Medical Schools," Academic Medicine, 82, 3 (March 2007), 282.

[57] Indirect cost claims are based on the assignment of space, i.e. unused research space cannot be included.

Unintended incentives:

- Presents universities with incentives to borrow funds for building, renovation, or re-financing of biomedical research facilities. (The extreme case might be the "condo labs" format that reportedly has appeared at some institutions).
- Resulting increases in financial leverage implies heightened financial pressures on institutions unless sufficient grant funds can continually be obtained to cover debt-servicing costs. This is especially problematic for institutions during times of real declines in NIH budgets.
- However, A-21 also has several countervailing provisions, requiring for example that institutions provide at least 25% of the equity in cases in which debt financing exceeds $1 million. In addition, NIH staff knowledgeable about OMB Circular A-21 have expressed the view that while the effects of such unintended incentives are possible in theory, they may not be widespread.
- To address such issues, options might include the gradual phasing in of: (1) a limit on NIH salary reimbursement to, for example, 50%; (2) An overhead cost penalty proportionate to an institution's fraction of soft-money positions; (3) Eliminating incentives that currently favor debt-financing of laboratory facilities by limiting indirect cost reimbursement for debt service, or by allowing such reimbursement for the imputed costs of wholly-owned facilities.

#2: Heavy reliance upon NIH research funding for support of graduate students and postdocs

Issue: Approximately 2/3 of NIH-supported graduate students and postdocs are supported under R01 and related research grants. This may be compared with only 22% supported under NRSA and related training-type funds.[58] As recently as 1980 these proportions were the opposite, with about 2/3 of NIH support graduate students and postdocs supported under training-type funding.

Unintended incentives:

- Under the current structure, if NIH research funding increases the number of "slots" for graduate students/postdoc research assistants should be expected to expand accordingly. This expansion would occur even in the absence of any plausible growth in career demand for those who are thus supported. Data from the 1998-2003 doubling suggest that the number of graduate students indeed does increase in response to increased research funding. Meanwhile the postdoc population seems to grow at about 4 percent per year relatively independent of NIH research funding (something of a puzzle that warrants some examination).
- The instability/unpredictability of annual NIH budgets further complicates the situation, given that there are multi-year lags between entry and completion of both the PhD and the postdoc.
- A gradual, incremental shift from the current 2/3 of NIH graduate students supported under research grants to about 50% was recommended by the 2000 NRC committee report commissioned by NIH.[59] This would enable NIH to better relate the number of PhD students and postdocs it supports to plausible demand and career prospects for PhD researchers, vs. the

[58] Committee to Study the National Needs for Biomedical, Behavioral, and Clinical Research Personnel, National Research Council, *Research Training in the Biomedical, Behavioral, and Clinical Research Sciences* (Washington, DC: National Academies Press, 2011), p. 13. http://www.nap.edu/catalog.php?record_id=12983 .

[59] Committee on National Needs for Biomedical and Behavioral Scientists, "Addressing the Nation's Changing Needs for Biomedical and Behavioral Scientists," National Research Council, 2000. http://www.nap.edu/catalog/9827.html

current system in which the numbers of graduate student/postdoc "slots" are driven by the volume of research grant funding available.[60]

#3: Insufficient information provided on career outcomes of recent PhDs and postdocs.

Issue: Most biomedical departments provide prospective new graduate students and postdocs with little or no credible information as to the career outcomes experienced by those most recently filling such positions.

The situation is notably different for e.g. law or business schools at the same university. (However, see recent lawsuits filed by former law students against an increasing number of US law schools, alleging fraud in the career data provided by these schools.)[61]

Unintended incentives:

- Prospective new graduate students and postdocs who are offered financial inducements to enter a lengthy PhD/postdoc sequence may a lack realistic understanding of their prospects in the biomedical research labor market beyond the PhD/postdoc, particularly their prospects for obtaining a tenure-track research faculty position. Indeed availability of Federal financial inducements may lead students to overestimate funding prospects after degree completion, e.g. by suggesting that NIH is anticipating a shortage of individuals to fill anticipated post-training positions.
- Non-alignment of demand in the labor market with supply of completing PhD/postdocs likely contributes to long time-to-PhD, lengthening postdoc and cognate temporary positions. This can result in frustration (even anger) among those who feel they have been misled.
- This may provide impetus to toward unionization of graduate students and postdocs (e.g. University of California), and also create a negative feedback loop of communication from discouraged graduate students/postdocs to undergraduate majors in the department, who may be thereby deterred from continuing to pursue a science career.
- This may also have unintended effects upon the type of person attracted to careers in biomedical research. Those individuals with the greatest range of opportunities or those that have plans and aspirations for a certain standard of living may opt for other careers.
- To address such concerns, NIH could consider: (1) establishing a small expert analytic unit (presumably in-house) charged with monitoring trends and prospects for education and careers that are central to the current and future biomedical research workforce;[62] (2) supporting a

[60] During the budget doubling, the total number of training slots remained flat although the training budget increased due to increased stipends.

[61] Katherine Mangan, "Law Schools on the Defensive Over Job-Placement Data," Chronicle of Higher Education, October 16, 2011. http://chronicle.com/article/Crisis-of-Confidence-in-Law/129425/?key=SzgmclZmNCsRNH00YG0SZDpXPXRqZk4kZ3NJPn5wblpRFw%3D%3D See also: http://www.law.com/jsp/nlj/PubArticleNLJ.jsp?id=1202517930210&Another__law_schools_targeted_over_jobs_data&slreturn=1

[62] The mandates for such a group might include:

website with information on outcomes of PhD education and postdocs, including links to other sources such as scientific society websites; (3) urging or requiring grantee institutions to collect and provide credible data on career outcomes of their former PhDs and postdoc; (4) supporting a web-based career clearinghouse for biomedical researchers.

#4: Postdocs as cheapest source of research assistance on NIH-funded grants

Issue: Despite NIH's genuine efforts to bring postdoc stipends into better balance with other categories, postdocs may still represent the lowest-cost source of sophisticated research workers in NIH-funded labs. Stipends are higher than in the past but still modest relative to postdocs' age and education, and postdocs often do not receive benefits (e.g. retirement plans) provided to other employees. The National Science Board reports that the growing number of postdocs has become a "major concern in science policy," yet even basic data on the topic are not available. By far the largest numbers of postdocs appear to be in biomedical fields, supported by NIH funding.[63]

Unintended incentives:

- Use of temporary postdocs as the primary lab workforce brings new ideas, abilities, and energy into labs, as often noted. However it also brings lack of experience as compared with longer-term research staff. It also places people in a subordinate role during what is often a highly creative portion of the career.
- May tend to extend years in postdoc status, increasing opportunity costs (see below) for trainees.
- Unintentionally limit independent creative contributions by researchers in their late 20s and early 30s, such as those made in the past by now-prominent senior biomedical researchers.
- May make postdoctoral positions less attractive, especially for women as they extend into the 30s. There is some evidence of declining interest in postdocs among recent US-citizen PhDs, but this does not affect recruitment of postdocs since institutions have ready access to large international pools of recent PhDs (see related item, below). The large, available pool of postdocs reduces the creation of stable, long-term employment of lab technicians and staff scientists.

#5: Unlimited access to international postdocs/graduate students

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- provide ongoing insights on education and workforce trends to the NIH Director, Institutes, and the public;
- develop new analyses from both existing data collected by the NSF and other Federal agencies, as well as from internal NIH administrative data;
- develop credible data on postdocs in US institutions, most of whom appear to be in biomedical fields;
- develop new data series such as measures of the changing "inventory" of postdocs relative to prospective career openings;
- track ongoing trends and composition of enrollments and completions of biomedical PhDs and postdocs
- assess knowledge and views of entering PhD students and postdocs about career paths, both in terms of general trends and what they think their own personal outcomes will be.

63 National Science Board. 2012. Science and Engineering Indicators 2012. Arlington VA: National Science Foundation (NSB 12-01), pp. 3-36 to 3-40.

Issue: NIH funding policies, US immigration policies, and the intersection between them all are lacking in coherence and coordination. Moreover there has been no serious assessment of the costs and benefits as well as no reliable way to measure the number of foreign-trained postdocs.

Under NIH rules, international students and postdocs can be financed without limitations under NIH research grants, but the same students/postdocs are excluded from support from NIH training funds. Under current immigration law, universities have essentially unlimited access to rapidly growing global pools of prospective graduate students and postdocs.

For postdocs, the international category may now represent a majority in biomedical research; China may be largest source country. Unlimited numbers of international postdocs are admissible on temporary H-1B visas -- the numbers are capped for corporate employers, but there are no numerical limits for universities and nonprofit research institutions. The large numbers of H-1B visas are uncoordinated with very limited numbers of permanent visas for those with high levels of education and skills. Combined with per-country limits this lack of coordination has led to large backlogs of former H-1B visa holders awaiting permanent visas and competing for employment opportunities in order to secure these visas.

Unintended incentives:

- Ready access to global labor markets makes large numbers of science workers available but depresses the domestic market for biomedical researchers. If postdoctoral positions are allowed to become unattractive to citizen PhDs, US universities can and will readily recruit international postdocs without making adjustments to postdoc conditions.
- Many international postdocs are self-recruiting, and some bring partial funding from their home governments. Most have few postdoctoral opportunities available in their own countries.
- Living stipends for graduate students and postdocs are still low by US standards, but may be high by the standards of a low-income country.
- The primary economic cost to would-be biomedical researchers is the income and benefits they forego (what economists call “opportunity costs”) in the course of lengthy PhDs and extended postdocs. As compared with US-citizen PhDs with comparable talents and knowledge, PhDs from low-income countries have lower opportunity costs -- their earnings at home would be lower, and unlike US-citizen PhDs they are not eligible for regular employment in the US.
- International postdocs also benefit from additional incentives that do not accrue to citizen postdocs – the possibility of a permanent visa allowing US employment, or the prestige of having held an international research position if they decide to return to their home country.

#6: Instability/unpredictability of NIH funding streams

Issue: The annual Congressional appropriations process means that NIH funding is very difficult to anticipate beyond a year or two. Due to the same Congressional budget process and substantial lobbying by health-related associations and universities, NIH research funding is subject to booms and comparative “busts” (e.g. the 1998-2003 doubling, followed by flat/declining budgets until 2009, followed by 2 years of ARRA stimulus funding).

Unintended incentives:

- PhDs and postdocs
    - If financed by temporary booms in research funding, expanded numbers of completing PhDs and postdocs emerge following a multiyear lag, by which time the expansive funding period may well have ended.
    - Results may include: extension of temporary employment status; discouragement; departure from research careers, etc.
- Newly-hired faculty
    - Additional faculty hired during boom phase experience increasing competition for research grant funding after boom wanes.
    - Challenging NIH pay lines, especially for more junior investigators, may disrupt promising research careers.
    - If newly-hired faculty are dependent on soft money for substantial portions of their salaries as well as for research itself, serious personal financial challenges may result.
- Established research faculty:
    - When NIH pay lines decline to low levels, even highly productive researchers with established records of success with NIH grants may experience lengthy gaps in renewal support, thereby disrupting successful research careers and sometimes even leading to closure of successful research labs.
    - Lower success rates lead researchers to devote more of their time to writing proposals, which in turn leads to more time/effort expended in the peer review process.
    - If the terms of successful grant proposals are shortened or cut to stretch limited funding, this may also imply more time writing proposals, leading also to more time/effort expended in peer review.
    - Shorter-term grants also are less appropriate for supporting graduate students/postdocs.
- Institutions:
    - Those that either expanded their faculties or used debt-financing to expand research facilities -- in anticipation of continued increases in research funding and indirect support -- likely will face serious problems during budget stringencies in covering unfunded faculty salaries and in servicing their debt.
    - Problems are magnified if institutional revenues from endowments or state contributions are also reduced, as has been happening in recent years.
    - Budget instability also may contribute to reliance on postdocs (inherently temporary positions) and discourage institutions from hiring more-permanent staff scientists.

#7: Increased specialization, narrowing of research and training

Issue: High levels of competition for NIH research funding in a peer review process may incentivize increasingly narrow, focused, and hence less risky research proposals. Even if the grant proposals themselves remain innovative, the uncertainty of obtaining renewed funding after the first grant period may lead researchers to pursue potentially less risky (and perhaps less innovative) avenues of research to achieve their aims.

Unintended incentives:

- Many biomedical researchers believe that the greatest potential for scientific advances lie in broader, interdisciplinary research efforts.
- Narrower and more specialized research in turn leads to a narrower focus for PhD and postdoc training financed by such grants.
- The uncertain career prospects faced by PhD students and postdocs suggests they would be better prepared to pursue successful research careers if their training provided a broader set of scientific skills and the flexibility to apply their knowledge to a wider range of scientific challenges.

E: Memo from Modeling Subcommittee

To: ACD Committee on Future of Biomedical Workforce

From: Donna Ginther and Bruce Weinberg on behalf of Biomedical Workforce Modeling Subcommittee

RE: Assessment of Labor Market for Biomedical PhDs

March 24, 2012

This memo provides the assessment of the Biomedical Modeling Subcommittee (BMW-MSC – see Appendix A for roster) regarding the current market conditions of the biomedical research workforce and provides recommendations for the BMW working group to consider.

The BMW-MSC met in person twice (on August 5, 2011 and March 6, 2012) and held a number of phone meetings and email exchanges to discuss training and career outcomes for biomedical PhDs. These discussions led to the approach taken to provide the BMW working group with data on the biomedical research workforce. This approach included:

- Performing a number of descriptive analyses of key aspects of the workforce
- Beginning work on a model to serve as a conceptual framework to organize the analyses, which could be developed into a full dynamic model
- Populating the conceptual framework with information on each career stage and transition
- Linking to data on each career stage and transition to build a resource upon which recommendations can be based.

In addition, the BMW-MSC drafted a description of some unintended incentives and disincentives underlying the US biomedical research system. This document was discussed at the BMW working group meeting on October 25, 2011.

In general, the market for biomedical PhDs is soft in the period after attaining the PhD or, more typically, undergoing postdoctoral training. The subsequent career path is marked by uncertainty. It is also appears to be uneven, with trainees having some skill sets (e.g. quantitative reasoning) doing well and others much less well. A long time is spent in training; the age of becoming an independent, NIH-funded researcher exceeds 40. In 2008 only 21% of basic biomedical PhDs within 6-10 years of their degree had tenured or tenure track academic jobs compared to 28% in 1993. Pay is relatively low compared to other disciplines such as engineering and the physical sciences and the NIH funding environment is highly uncertain.

The weakness of the biomedical labor market has been discussed for decades. The current situation is not merely the result of current economic conditions, but the recent recession surely compounds the current mismatch. The long-standing weakness is due to an imbalance between the supply of freshly trained talent and the limited number of permanent post-training positions. The excessive supply stems from an enterprise that is both labor-intensive and located in academia with its nearly endless supply of students and postdocs (from domestic and foreign sources). Students and postdocs are highly motivated and productive and because of the implied training aspects they are willing to work for reduced wages for extended periods of time. Individuals can wait 10 to 15 years for a more permanent job with higher rates of remuneration. The problem is exaggerated by a system that is skewed toward established researchers who themselves have strong incentives to maximize their productivity at the lowest cost. The subcommittee offers evidence to support this description of the system and offers recommendations designed to lessen the dependence on trainees as a source of labor, improve their training, enhance retention, and thus make careers in biomedical research more appealing.

Following are specific points supporting these conclusions. Also note that the data are incomplete but we have tried to list the caveats in each case.

Education and Postdoctoral training

Relative to other disciplines, there has been a significant increase in the number of people receiving basic biomedical PhDs over the past two decades. This increase is correlated with the doubling of the NIH budget and is driven by an expansion in women and temporary residents obtaining degrees. The median age at which these basic biomedical PhDs are awarded peaked in the 1990s and fell somewhat in the most recent decade. In addition, the age of achieving a first tenure track job peaked at 38 years and trended lower in the most recent decade.

The average duration of postdoctoral training in biomedical research is reported as approximately 4 years. That being said, however, the interval between the age at which the PhD is awarded and that of the first tenure track job suggests that those postdocs taking academic jobs are spending longer - approximately 6 years - in postdoctoral training. Doing postdoctoral training does increase the probability of having a research career in academia, government or industry. However, those who start a postdoctoral position have approximately 12% lower earnings if they work outside of tenure track academia compared to those that start in those sectors.

In conclusion, the length of time people spend in training and temporary positions in biomedical research is generally longer than in other disciplines, the age of starting an independent career is late, and postdoctoral training is associated with significantly lower lifetime earnings.

Demographics

The average age of receiving the first NIH R01 award for PhDs has been close to 42 since 2000. The age is higher for researchers with an MD or an MD/PhD. The percent of PIs over 66 years old that receive NIH funding has increased significantly in the past decade. The share of workers ages 35-50 in basic biomedical workforce was less than 50% in 2008.

Approximately 50% of PhDs in life sciences are awarded to women. However, women are significantly less likely to take tenure track jobs in the life sciences. There is a substantial loss of underrepresented minorities (URMs[64]). About 17% of life science bachelor's degrees are awarded to URMs (2004), but URMs received only 10% of life science PhDs in 2009.

In conclusion, lengthy postdocs and a lack of academic jobs make biomedicine an unattractive career for women and URMs. Older researchers perform well in the NIH funding process, raising the hurdle for younger investigators. NIH has policies in place aimed at mitigating this.

Industry Careers

Almost 70% of biomedical PhDs initiate postdoctoral training after they graduate. By 6-10 years after graduating, nearly 33% are employed in industry. Industry employment increased almost 5 percentage points between 1993 and 2008.

The Pharmaceutical industry increased R&D employment significantly through 2008, however it remains to be seen whether that trend has continued.

[64] The following racial and ethnic groups have been shown to be underrepresented in biomedical research: African Americans, Hispanic Americas, Native Americans, Alaskan Natives, Hawaiian Natives, and natives of the US Pacific Islands.

Academic Careers

Since 1973 the share of tenured and tenure-track academic positions in academia has declined while the share of non-track academic jobs has increased. In 2008 only 23% of basic biomedical positions were tenured or on the tenure track with the majority (15%) employed at PhD granting institutions. However a roughly equal numbers (22%) of biomedical positions were non-tenure track positions.

Staff scientist jobs, which are defined as non-tenure track jobs where individuals primarily do research and do not teach, have grown significantly in medical schools and universities. In general, these jobs pay poorly and have few salary guarantees.

In conclusion, there is a shortage of tenure-track research positions relative to the number of people who are pursuing postdoctoral training after receiving a PhD in basic biomedical research. Staff scientist positions are temporary and poorly paid.

Career Characteristics

In 1997 70% of basic biomedical PhDs worked in an occupation related to their degree. By 2008 this number had dropped to 60%. In addition, people with biomedical PhDs at all stages of careers are less likely to do research in 2008 than in 1993.

Salaries of people with biomedical PhDs are low relative to those with PhDs in other areas or those with professional degrees. Over 70% of people with basic biomedical PhDs report working more than 40 hours per week.

The returns to experience, the rate at which earnings increase with experience, are much higher for biomedical PhDs, partially reflecting the low pay associated with the postdoc.

In conclusion, biomedical research jobs are relatively low-paying, especially at the outset of the career and early-career positions offer few opportunities for independent research.

Overall summary

Careers in biomedical research are unattractive relative to other research doctorate sectors and high-skilled occupations, despite the fact that the early training stages provide a substantial level of support to many people. Some contributing factors are:

- It is difficult to launch an independent career.
- There are relatively few opportunities outside of biomedical occupations and industries
- The pay is low when compared to other fields such as engineering and the physical sciences.

  The funding of the major supporter of the enterprise, i.e. NIH, is uncertain and favors established, white investigators

Note: The BMW-MSC has found that there is a substantial amount of missing and/or poor quality data[65]. Therefore, any recommendation will be based on incomplete information. In addition, all recommendations will involve significant tradeoffs and possible unintended consequences.

Policy Recommendations of the BMW-MSC

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[65] Estimates of postdoctoral fellows are educated guesses; in particular data on people trained outside of the US are limited. There is incomplete information on academic positions, in particular data on the sources of support of academic biomedical researchers are lacking. The data on non-PhD MDs doing research are limited. Finally, there is limited information on demand.

Following are policy recommendations drafted by the BMW-MSC, based on the subcommittee's discussions as well as ideas drawn from the BMW working group discussions. The recommendation list is followed by a detailed description of each one, including the rationale behind it, the projected impact, and options for implementation.

1. Characteristics of biomedical research training and career prospects of trainees
    a. Increase the share of trainees, especially for postdoctoral researchers, supported by fellowships relative to research grants
    b. Encourage NIH to investigate ways to use the application and review process to improve the training experience of those trainees who continue to be supported by RPGs
    c. Address career amenity issues
    d. Gradually reduce entry to the system by graduate students and foreign postdoctoral researchers
2. Allocation of NIH resources
    a. Reduce reliance on soft money, particularly for faculty
    b. Shift the balance of resources among researchers at various career stages and at different funding levels
    c. Gradually reduce the dependence on trainees to staff labs and and develop a more permanent staffing model
    d. Push to stabilize science funding
3. Information about the biomedical research workforce
    a. Provide systematic information ("Prospectuses") to students and postdoctoral researchers to improve decision making about biomedical careers
    b. Establish an NIH-hosted job posting clearinghouse
    c. Develop and securely distribute data infrastructure on the biomedical research enterprise
    d. Support ongoing research on the biomedical research workforce and enterprise

Detailed Description

1. Characteristics of biomedical research training and career prospects of trainees

a. Increase the share of trainees, especially for postdoctoral researchers, supported by fellowships relative to research grants

Background: Biomedical researchers experience long periods of postdoctoral training relative to researchers in other fields.

Impact: Shifting support from research grants to postdoctoral fellowships will maintain the number of individuals in such positions, but will shift the "balance of power" toward the postdoctoral researchers. Fellowships also benefit the recipient by focusing on specific career development needs rather than the completion of a mentor's research project. This can be thought of as a "voucher program" for biomedical trainees, generating pressure for senior researchers to attract trainees by supporting their timely transition into independent research careers. Offering a larger number of independent fellowships will allow more postdocs to obtain experience competing for sponsored support and will facilitate their transition to independent positions.

Increasing the availability and quality of such opportunities to capable postdoctoral researchers will increase the attractiveness of biomedical careers for the best undergraduate and graduate students. This change should be accompanied by an initiative (below) to provide systematic information to graduate students and postdoctoral researchers about outcomes of people attending graduate programs and completing postdoctoral training at specific institutions.

Implementation: Gradually reduce support for graduate students and postdoctoral researchers on research grants and increase support through fellowships and career awards, perhaps aiming for a 50/50 allocation. Options would be to expand the number of NRSA individual postdoctoral fellowships or expand the use of the K99-R00 (kangaroo) award.

b. <u>Encourage NIH to investigate ways to use the application and review process to improve the training experience of those trainees who continue to be supported by RPGs</u>

Background: Many biomedical researchers experience multiple, long postdoctoral training periods. Even if resources are shifted to fellowships from training grants, many will continue to be supported by RPGs. The application and review process for RPGs do not place weight explicitly on the training aspect of these postdoctoral researchers. Thus there is little incentive to provide a successful trainee experience with high quality outcomes.

Impact: Requiring RPG applications to list the outcomes of recent trainees and place weight on these outcomes in the review process would provide strong incentives for researchers to improve placements for their trainees. In addition, requiring information on formal structures such as independent development plans (IDPs) and requirements for training in responsible conduct of research in annual progress reports may also provide incentives for mentors.

Implementation: RPG applicants would be required to list all graduate students, postdoctoral researchers, and other trainees in the past 10 years along with their positions and achievements (publications, patents, etc.) to date. NIH is encouraged to investigate ways to incorporate consideration of this information into the review process in a way that does not penalize placement in non-academic positions that utilize research training. It is possible that NIH could collect this information and provide it to the reviewers instead of requiring each applicant to compile the data. In addition, RPG annual progress reports would include information on IDPs and the training of the students and postdoctoral researchers supported on the grant.

c. <u>Address Career Amenity Issues</u>

Background: There are concerns about the fact that many postdoctoral researchers spend long periods in temporary positions with relatively low pay and often few benefits such as health care and access to retirement plans. In addition, attrition from the biomedical research enterprise is much higher for women than for men. This attrition is due in no small part to concerns about work-life balance at the early stages of many biomedical research jobs, an issue that affects both women and men. The combination of poor career amenities and the lack of work/life balance may also make careers in biomedical research less attractive and thus may be a factor in the fact that a very low proportion of undergraduate URMs choose this career path.

Impact: Addressing these career amenity issues may address many issues with the current biomedical research framework. First, it can ensure a more diverse biomedical research workforce which may improve innovative outcomes and ensure that the issues facing women are addressed by the biomedical research enterprise. Second, addressing these issues may make biomedical research careers more attractive to URMs. In fact the two previous benefits will become more important as the United States population becomes increasingly diverse, accentuating the importance of improving the attractiveness of biomedical careers to members of underrepresented groups. Third, this kind of change will help the NIH more comprehensively address health disparities and therefore the requirement to address the health needs of the nation through biomedical research. Fourth, increasing the share of researchers that remain in the system could reduce training costs incurred by NIH and trainees.

Implementation: NIH should work to increase institutions' awareness and usage of the family-friendly policies already in place (e.g. options for funding time off for family needs, providing opportunities to describe delays in scientific productivity, supporting re-entry through supplements, and requiring child care at NIH-supported conferences). In addition, institutions should provide pay and benefits to postdoctoral researchers that are more comparable to permanent staff in similar positions.

d. <u>Gradually reduce entry to the system by graduate students and foreign postdoctoral researchers</u>

Background: Labor market outcomes for biomedical research PhDs are and have been weak relative to those experienced by recipients of research PhDs in other fields, especially in the early career stages (i.e. post-training).

Impact: Gradually reducing entry of graduate students will eventually reduce the supply of domestically trained postdoctoral researchers, thereby increasing competition for postdoctoral candidates among PIs and research institutions and strengthening their labor market at time of exit from a postdoctoral position. Reducing the number of temporary graduate and postdoctoral research staff also will generate conditions for a more permanent staff scientist corps (see below). This policy also will have the advantage of reducing NIH expenditures in the near term. Moreover, increased competition among students for slots in graduate programs will allow programs to be more selective and to expect stronger future outcomes. This may make biomedical research careers more attractive to the strongest undergraduates.

Implementation: NIH should gradually and modestly reduce the number of graduate students and postdoctoral researchers supported by Research Project Grants (RPGs). Support for graduate students and postdoctoral researchers on fellowships and training grants should be maintained or increased (e.g. using some of the resources shifted out of RPGs).

2. Allocation of NIH resources

a. <u>Reduce reliance on soft money, particularly for faculty</u>

Background: As detailed in Michael Teitelbaum's "Unintended Consequences" memo (see Appendix 2), the ability to substantially leverage NIH support by financing biomedical research largely or entirely through soft money makes the biomedical research enterprise prone to booms and busts. Given the limits to NIH's ability to stabilize federal support for biomedical research, it behooves the biomedical research enterprise to consider ways to gradually reduce such leverage and to diversify sources of research support. Moreover, reliance on soft money has built an environment in which researchers are under intense pressure to shift time from research to proposal generation.

Impact: Gradually reducing reliance on soft money would reduce the vulnerability of the biomedical research system to the fits and starts of NIH budgets, and provide an additional source of support for biomedical research. Viewed from NIH's perspective, institutions highly leveraging NIH support corresponds to low (or even no) leveraging of NIH investments. A combination of institutional investments, particularly in faculty, and gradually shifting resources from institutions that do not provide hard money support to those that do provide it has the potential to increase total resources devoted to biomedical research. If such a measure results in a net reduction in translational research and diminished focus on real biomedical problems, it would obviously be undesirable. However, the net effect could actually be an increase in the capacity for research, including translational research, since it would lead to a reduction in time devoted to generating proposals.

Implementation: Given the wide range of practices within and between institutions, any hard money requirements have the potential to be disruptive, especially for established researchers. We therefore recommend that changes be implemented very gradually even relative to our other recommendations and that multiple approaches be considered.

One approach would be to require hard money appointments. To provide flexibility within institutions, it is worth separating individual and institutional levels of hard money support. A phased approach to introduce a hard money requirement might[66]: start in 2015, with a minimum average institutional hard money support level imposed at 2.5%, to be increased by 2.5% per year until 2031 when it reaches 40%. Additionally, starting in 2015, a minimum individual hard money support level might be imposed at 2% to be increased by 2% per year until 2030 when it reaches 30%. No acceleration of such a progression should be implemented without three years advanced notice.

An alternative approach would be to impose a hard money requirement only for newly hired researchers. Startup packages might be counted toward a hard money requirement for the first 5 years of a contract, if necessary.

Reductions in the maximum level of salary that NIH can support provide a third mechanism to reduce reliance on soft money, especially for more senior researchers. The recent reduction (in fiscal year 2012 the level is set at $20,000 less than the previous year) may provide information about how implementing this recommendation would affect different types of institutions.

Finally, one could tailor limits on soft money contributions for each institution by taking into account existing institutional costs and revenue streams by building faculty salary rate caps into typical indirect cost negotiations. Those negotiations are periodically required for all institutions that participate in federal grant programs and they already include factors that could help determine reasonable federal contributions to faculty salaries.

b. <u>Shift the balance of NIH resources among researchers at various career stages and at different funding levels</u>

Background: The average age of biomedical researchers and the share of older biomedical researchers have both increased, in part because of the elimination of mandatory retirement. At the same time the average age at which researchers receive their first R01 and tenure-track jobs have both increased. Although research shows that older researchers can be highly innovative, the aging of the biomedical research workforce ties up positions and funding that could assist young and mid-career researchers.

In addition, the distribution of resources at NIH is highly unequal. In general, 20% of the Principal Investigators (PIs) receive 50% of RPG funding. While it is socially optimal to allocate

[66] There was a diversity of opinion among the BMW-MSC members as to the appropriate numbers. Note that the proposal Bruce Alberts published in *Science* in September 2010 was more aggressive than that suggested here, suggesting a goal of 50% in 10 years.

more resources to the most productive researchers (who produce some of the most innovative and important research and best trainees), NIH allocations should equalize the research output produced by an additional investment in each researcher. Also, highly-funded researchers are likely to rely on research and administrative staff more heavily than less-funded researchers.

Impact: Gradual measures to redistribute some resources from late-stage to early- and mid-career researchers would complement other recommendations in this document designed to increase the attractiveness of the biomedical research career. Insofar as senior researchers have higher earnings and rely more heavily on research staff, this shift will also reduce costs and the need for research staff.

In addition, a moderate equalization of resources to less-well funded researchers would generate more positions for independent researchers both directly and by reducing reliance on research and administrative staff. Lower salaries among less-well funded researchers increase the impact of such equalization.

Implementation: NIH already has first-time investigator and early-career investigator initiatives. These appear to have at least reversed the previous declining trend of proportional support for more junior researchers. It will be important to evaluate the effect of these programs both on new investigators and on the resulting mid-career investigators as time progresses. NIH also might consider funding investigators at specific career stages for a specific period of time (e.g. 7 years) instead of funding specific projects, similar to the HHMI model.

Initiatives to review funding levels of investigators have been utilized or proposed by NIH. For example, NIGMS has a policy of additional scrutiny of awards to any principal investigator with existing funding of $750,000. The review is conducted by the NIGMS Advisory Council. In addition, in the FY 2013 President's Budget, NIH proposed to establish a similar process with a threshold of $1.5 million or more in NIH grants. It may make sense to institute a threshold level that evolves over time, adjusting as the cost of research increases.

c. <u>Gradually reduce the dependence on trainees to staff labs and develop a more permanent staffing model</u>

Background: The biomedical research enterprise requires a large corps of bench researchers. Currently this corps is largely populated by students and postdoctoral researchers, many of whom remain in training positions well beyond the period necessary for effective training. Most people feel that the duration of these experiences largely reflects an inadequate number of good opportunities for positions as independent researchers.

Impact: Creating a cadre of less temporary scientists would reduce the need to staff labs with graduate students and particularly postdoctoral researchers, allowing for clearer career paths. The cost implications of such scientists are unclear. On the one hand, such scientists likely will be paid more than postdoctoral researchers and would receive the normal employee benefits. On the other hand, staff scientists may be more experienced and productive than postdoctoral researchers and especially graduate students. Moreover, staffing labs with staff scientists may reduce training costs borne by NIH, institutions, and trainees if it reduces the number of students admitted to graduate school. These gains can be multiplied if the staff scientist position appeals to people who might otherwise leave the biomedical research enterprise. Such positions also will provide a better work-life balance and shorter lags between degree completion and a reasonably compensated career with benefits, all of which will likely improve retention.

Implementation: We note that permanent scientist positions currently are most viable in large labs. However, if funds are available, such scientists could be very effective in a small lab. The NIH could consider programs that would offset a portion of the costs of such employees to encourage the development of such scientist programs. It is possible that the marginal costs for such positions will be relatively small in comparison to postdoctoral positions and it is possible that such a program could have a limited duration. One possibility could be to allow those marginal costs and potentially transition funds for a scientist position to be built into research grant budgets. Thus if grant funding runs out on one grant there will be funds set aside to continue to pay the scientist for a short period.

d. <u>Push to stabilize science funding</u>

Background: Funding for NIH has grown rapidly, but in fits and starts. This episodic growth generates large fluctuations in entry (driven at least in part by staffing needs) and in construction of research facilities. Given that both training and construction are long, slow processes, the fluctuations in funding mean that when trainees and facilities are ready, the initial demand spurt has frequently passed.

Impact: A more stable funding stream would moderate boom-and-bust cycles that disadvantage trainees and destabilize institutions by encouraging building or remodeling of research facilities leading to increased pressure to generate proposals as funding growth declines. The cost in lost stimulus support would be made up by greater stability.

Implementation: The BMW-MSC recommends that NIH and the research community should push to have funding set as a percentage of GDP over the past 5 years.

3. Information about the biomedical research workforce

a. <u>Provide systematic information (“Prospectuses”) to trainees to improve decision making about biomedical careers</u>

Background: Investment firms are required to provide detailed prospectuses to investors and experiments on human subjects supported by NIH funds require institutional reviews and informed consent (or a waiver) from subjects. Yet, little systematic data on career outcomes are available to people contemplating careers in biomedical research or choosing between postdoctoral positions - even though both decisions represent extremely costly, long-term investments. Exacerbating this situation, support for training may be the easiest form of support that most biomedical researchers receive. The relatively easy access to support for training has the potential to attract people into graduate programs and postdoctoral positions but leave them with inaccurate perceptions about their future career prospects.

Impact: Providing systematic information to college students contemplating graduate programs and completing graduate students contemplating postdoctoral training would (1) provide clear information about typical prospects and (2) help them choose between programs. The availability of information also would provide an additional incentive for programs to place trainees well.

Implementation: NIH should require all supported institutions to provide basic demographic information on all students and postdoctoral researchers (including name, age, gender, race, ethnicity, nationality, and prior degrees) receiving NIH funding, as well as credible information of their employment and career paths over the first 10 years after completion of their training.

These data should be made available to the public in uniform, aggregated (and de-identified) form as well as provided to NIH for analysis.

These data, when combined with the data infrastructure recommended below, will allow NIH to generate statistical summaries of outcomes for trainees overall and for particular programs. Understanding this kind of information will permit the NIH to more easily identify training programs that work and to properly adjust its support for graduate and postdoctoral training, and also enable institutions to more effectively determine the optimal size of their biomedical training programs.

b. Establish an NIH-hosted job posting clearinghouse

Background: There is no single source of information on job openings for biomedical researchers as there are for researchers in many other fields.

Impact: A centralized job website would facilitate job searches and provide NIH and other policy makers with concrete, up-to-date information on labor market demand.

Implementation: As part of the analysis of the biomedical workforce the subcommittee is obtaining data from WANTED Technologies that collates job posting information from online resources including Science Careers and Chronicle Careers. NIH could find a way to collate such data on an ongoing basis. Alternatively, NIH could cross-list jobs from select vendors such as Science Careers. These data should be summarized on an annual basis to provide information about the types and locations of jobs.

c. Develop and securely distribute data infrastructure on the biomedical research enterprise

Background: Much of the data necessary for rigorous research on the biomedical research enterprise exist, but they are not integrated and are difficult for the research community to access. Additional data could be harvested from grant applications and/or required in reporting. Other data are either lacking or insufficiently reliable to support a comprehensive analysis of the enterprise. The lack of data limits our understanding of the biomedical research enterprise. It also hampers endeavors like that of the present Biomedical Research Workforce Taskforce, meaning that the modeling subcommittee is forced to quickly draw together a patchwork of data from multiple sources.

Impact: Developing and securely distributing large-scale data infrastructure on the biomedical research workforce will not only assist future efforts such as the present one but will also support research on biomedical research more broadly that can inform NIH policy.

Implementation: NIH should support the large-scale combination of its internal data (from grant applications, including biosketches) and their linkage to publicly available data and make these data available to the research community securely. One model is the nascent policy on access to internal NIH data for research purposes, which should be supported. Valuable components include data on: postdoctoral fellows; people trained outside of the US; numbers and support in academic positions; demand, especially outside of academia; and non-PhD MDs.

d. Support ongoing research on the biomedical research workforce and enterprise

Background: As a research agency, NIH routinely seeks evidence-based information to optimize and quantify its performance including, but not limited to, periodic studies of the biomedical research workforce, economic impact analyses, and evaluations of programs and initiatives. These efforts typically operate on a tight timeframe and in the face of the data fragmentation described above, limiting the analyses that are possible and greatly increasing the cost of such studies.

At the same time, the science of science and innovation is an increasingly dynamic field, meaning that the extramural research community has an ever-expanding ability to provide rigorous, research-backed answers to NIH's pressing policy questions. Unfortunately, NIH does not have a good mechanism for supporting such research – proposals submitted to standing study sections at the various institutes, for instance, are often viewed as not directly relevant to the interests of that institute even if they viewed as important for NIH as a whole.

Impact: An ongoing effort would ensure that future efforts such as the present one would have in place state-of-the -art infrastructure for more thorough analyses and simulations. It could assist the periodic outside assessments of the biomedical workforce mandated in current law, and would also be able to address the broader range of policy questions that NIH seeks to answer. It could also produce preliminary or "flash data" indicators of current conditions in the biomedical workforce, along the lines of such economic indicators routinely released by the BLS. The data obtained through such an ongoing effort also will be useful for implementing the recommendation to provide systematic information to people contemplating careers in biomedical research.

Implementation: NIH should provide a continuing flow of resources for research on the biomedical research enterprise as well as access to the necessary data (described above). This research could be guided by an entity in the office of the NIH Director, combining NIH staff with a small number of extramural advisors with expertise in labor economics supplemented by members of the biomedical research community who would work together to identify and implement projects that address NIHs policy needs using cutting-edge economic methods. One model for such an effort could be the President's Council of Economic Advisors.

F: Participants in June 21, 2012 meeting

Participants in June 21, 2012 meeting

- Cathee Johnson Phillips, M.A. - Executive Director and Zoe Fonseca-Kelly, Ph.D. - Chair, Board of Directors, National Postdoctoral Association
- Roger Chalkley, D.Phil, Chair, NRC *Study on Research Training and the Biomedical, Behavioral, and Clinical Research Sciences*, Senior Associate Dean for Biomedical Research Education and Training, Vanderbilt University Medical Center
- Phillip Pizzo, M.D., Dean, Stanford University School of Medicine
- Lawrence Brass, M.D. Ph.D., Professor of Medicine, Associate Dean, Combined Degree and Physician Scholars Program, Director, Penn MSTP, University of Pennsylvania
- Peter Henderson, Ph.D., Director, NRC *Report on Expanding Underrepresented Minority Participation, Director, National Research Council's Board on Higher Education and Workforce*
- Ann Bonham, Ph.D., Chief Scientific Officer, Association of American Medical Colleges
- Susan Amara, Ph.D., Detre Professor and Chair, Dept. of Neurobiology, University of Pittsburgh School of Medicine, and President, Society for Neuroscience
- Howard Garrison, Ph.D., Director of the Office of Public Affairs, Federation of American Societies for Experimental Biology
- Jennifer Poulakidas, Vice President, Congressional and Governmental Affairs, Association of Public and Land-grant Universities
- Carrie D. Wolinetz, Ph.D., Associate Vice President for Federal Relations, Association of American Universities

G: Report of Comments to Request For Information

NIH Request for Information: Future Biomedical Research Workforce

Summary of comments

January, 2012

This report covers the findings and conclusions of the comment analysis on the NIH Request for Information on the future of the biomedical workforce. The analysis was done by Ripple Effect Communications Inc. under contract # HHSN276200800275U.

Executive Summary

This report provides a summary of the comments received in response to the Request for Information (RFI): "Input into the Deliberations of the Advisory Committee to the NIH Director Working Group on the Future Biomedical Research Workforce" (NIH Guide Notice NOT-OD-11-106).

The RFI provided a list of eight issues that had been identified as important to consider when developing a model of the future biomedical research workforce. Information was requested in response to three questions related to the eight issues (or other unidentified issues).

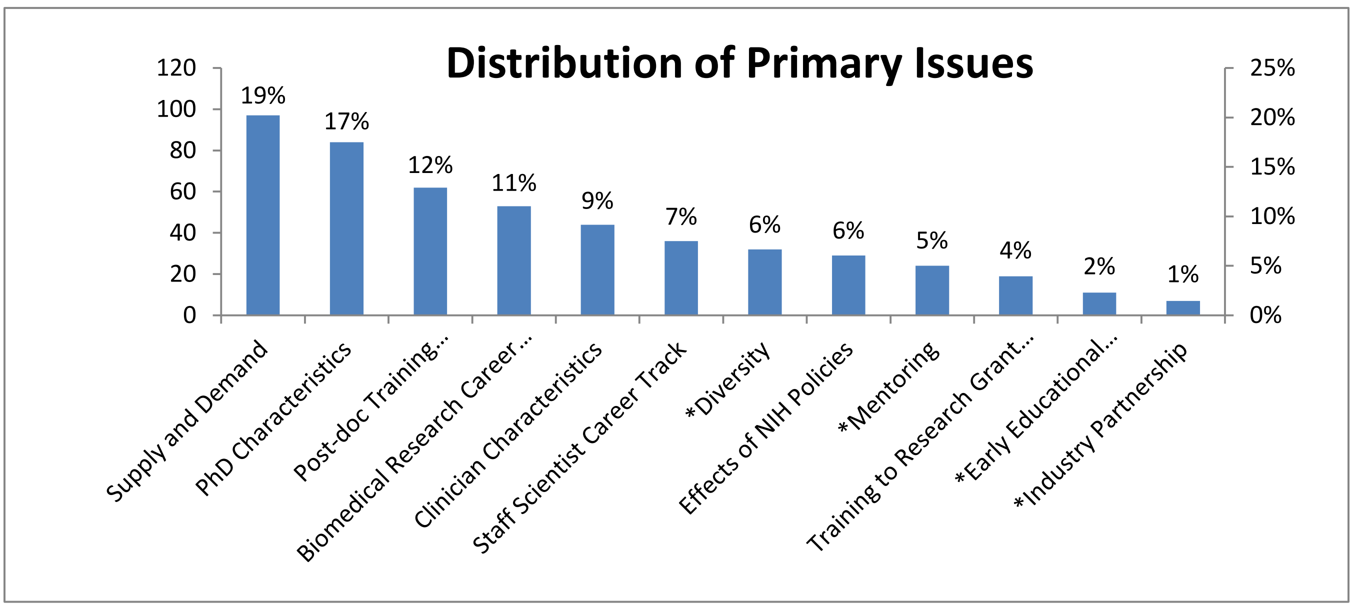
The comments received from 219 commenters were parsed into 498 "quotations" representing unique ideas, with an average of 2.3 quotations per commenter. Those quotations were key-word coded for sorting purposes.

Only 20% of the commenters replied on behalf of an organization, while 75% of the commenters provided personal input; the remaining 5% of the commenters were NIH staff. The organizations represented in the 20% were a broad cross section of NIH stakeholders, including NIH-funded investigators and research institutions.

Feedback was received on 1) how identified and unidentified issues affect institutions, scientists, or both; 2) what issue(s) are most important for the working group to address and why; and 3) how these issues should affect NIH policies or processes. The feedback was categorized into 12 primary issues, with 7 overlapping issues.

Primary Issues

The analysis process identified four primary issues in addition to the original eight primary issues included in the RFI. The distribution of primary issues, as cited by commenters, is shown in the graph.



**Issue not specified in the RFI but raised by commenters*

Overlapping (Secondary) Issues

Commenters found that most, if not all, of the primary issues were critical to the development of a sustainable biomedical workforce model. About two thirds of the comments included a secondary issue in addition to the primary issue. Therefore, we captured and analyzed the secondary issues mentioned by the commenters to help describe the overlapping and interlocking nature of the issues.

In cases where the primary and secondary issues are similar, the secondary issue covers only certain aspects of the primary issue. For example, the secondary issue of Career Appeal covers the specific issue of working conditions; whereas the primary issue of Biomedical Research Career Appeal encompasses all issues related to the attractiveness of biomedical research careers (e.g. salary, availability of research funding, working conditions).

The overlapping issues were as follows:

- **Funding.** Uncertainty and lack of funding, distribution of funding, restricted paylines, success rates, and excessive competition
- **Multi-disciplinary.** Need for multi/ inter/ trans-disciplinary research training to prepare individuals for a wide range of academic and non-academic career opportunities
- **Salary.** Inadequate compensation and benefits
- **Length of Training.** Amount of training time too long to be feasible for majority
- **Non-US Citizens.** Foreign students and post-doctoral fellows
- **Career appeal.** Working conditions (e.g. heavy workload, perception of being perceived as cheap labor, long work hours)
- **Mentoring.** Quality of career development and the need for pre-college preparation
- **Diversity.** Under-represented minority post-doctoral, fellows and junior faculty

The comments received are summarized within this report in a variety of ways to provide multiple options for the NIH ACD Working Group to review and utilize the information in their recommendations.

Contents

Background

In April 2011, the National Institutes of Health (NIH) Advisory Committee to the Director (ACD) formed a Working Group to examine issues related to the future of the biomedical research workforce in the United States and make recommendations to the ACD that would help promote a diverse and sustainable biomedical and behavioral research workforce. As part of the process, the Working Group was tasked with gathering input from the extramural community, including students, post-doctoral fellows, investigators, scientific societies, and grantee institutions to consider various aspects of the future workforce.

The Working Group identified eight (8) issues to consider in the development of the future biomedical research workforce model:

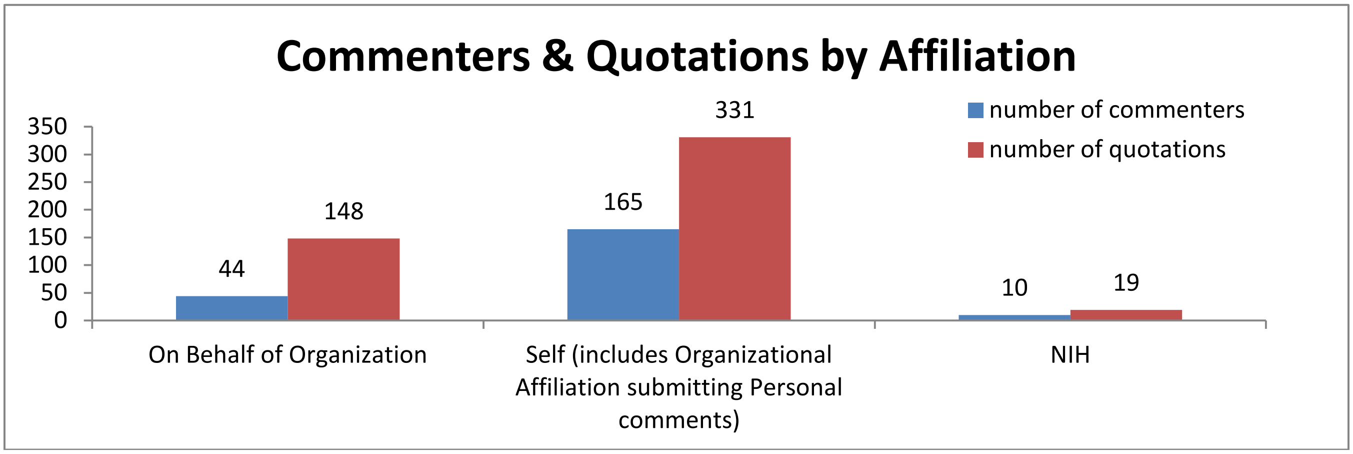
- The balance between supply, including the number of domestic and foreign trained PhDs and post-doctoral fellows, and demand, i.e. post-training career opportunities.
- Characteristics of PhD training in biomedical research, including issues such as
    - The length of the PhD training period.
    - Recommendations for changes to the PhD curriculum.
    - Training for multiple career paths (including bench and non-bench science).
- Characteristics of clinician-research training including issues such as
    - The balance between MDs and MD/PhDs
    - Career development of clinician-researchers.
    - Recommendations for changes to the curricula for training clinician-researchers.
- Length of Post-doctoral training.
- The ratio of PhD students and post-doctoral fellows on training grants to those supported by research grants.
- Possibilities for professional/staff scientist positions and the level of training required for such positions (e.g. PhD or MSc degrees).
- Issues related to the attractiveness of biomedical research careers (e.g. salary, working conditions, availability of research funding)
- The effect of changes in NIH policies on investigators, grantee institutions and the broader research enterprise.

NIH issued a Request for Information (RFI) to the community to provide input into the deliberations of the ACD Working Group. From August 17 through October 7, 2011 the extramural community submitted input to NIH on the identified issues (and other unidentified issues), the importance and effects of these issues on institutions and scientists, and how the issues should affect NIH policies and procedures.

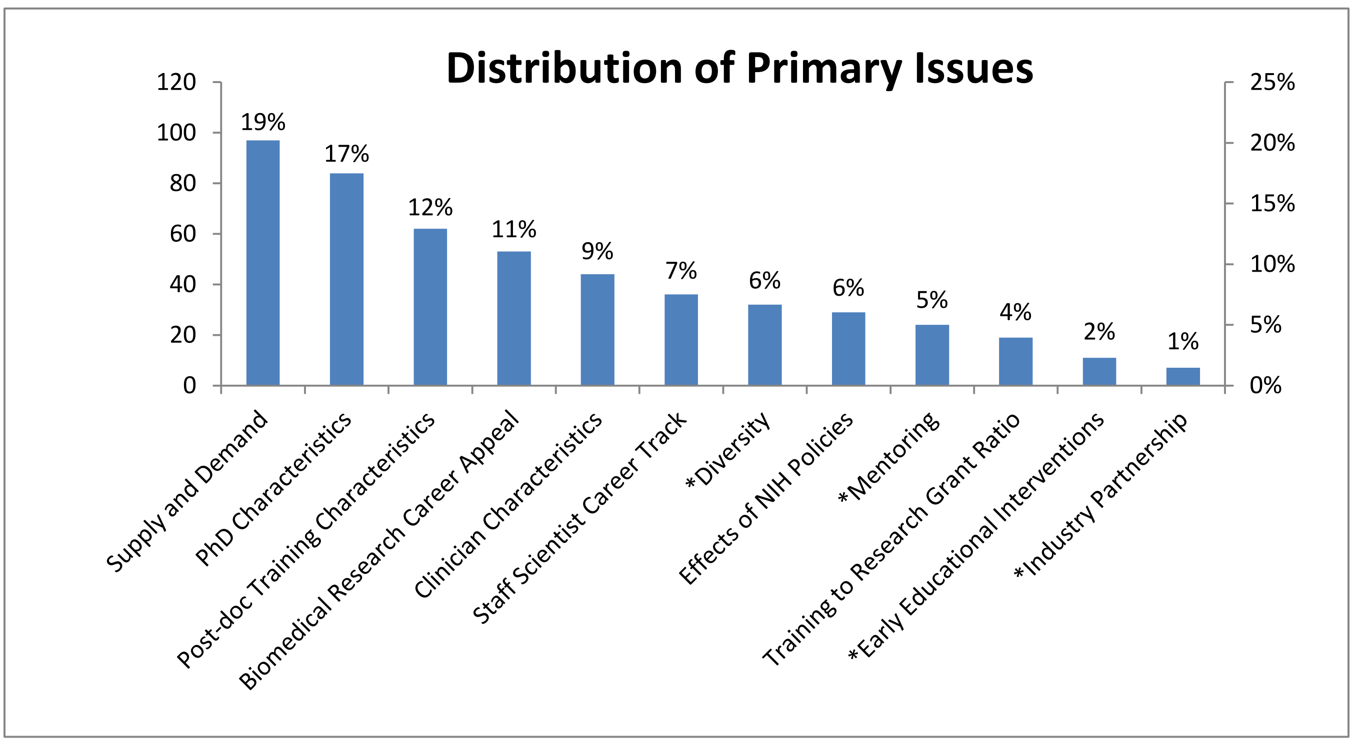
Methodology

About the Data

The primary type of submission was via an online form, but comments also were received via e-mail and postal mail. Responses from three commenters were received more than once; these duplicative comments were only analyzed once. There were a total of 219 commenters. Comments from the 219 commenters were parsed into 498 quotations, which correspond to an average of 2.3 quotations per commenter. Commenters responding on behalf of organizations provided an average of 3.4 quotations each, while commenters responding on behalf of themselves provided an average of 2.0 quotations each.



Each of the 498 quotations corresponded to one primary issue, according to the following distribution.



Issue not specified in the RFI but raised by commenters

Coding Scheme

The coding scheme evolved from the bottom up, by utilizing the eight issues identified in the RFI, and analyzing a sample of the responses to generate the scheme in an iterative fashion. Through this process, we identified four additional issues that were suggested by commenters. This bottom up approach was consistent with the key aspect of the RFI design which stated that all ideas and suggestions were welcome. The final issue categories and their descriptions are available in the Appendix).

The following is a list of the 12 primary issues (including 4 new* issues):

1. Supply and Demand
2. PhD Characteristics
3. Post-doc Training Characteristics
4. Biomedical Research Career Appeal
5. Clinician Characteristics
6. Diversity*
7. Staff Scientist Career Track
8. Mentoring*
9. Effects of NIH Policies
10. Training to Research Grant Ratio
11. Industry Partnership*
12. Early Educational Interventions*

Note that the issue "Post-doc Training Characteristics" is not identified as a new issue; however, it was broadened from the original primary issue, " Length of Post-doctoral Training," to be more inclusive of all the aspects of post-doctoral training that were identified by commenters.

During the coding process, we discovered that specific aspects of primary issues were appearing across all comments. To capture these "secondary" themes, overlapping issues were developed. For example, a comment on the primary issue of Supply and Demand may cite other interlocking issues such as Career Appeal or Funding.

The following is a list of the secondary issues and their descriptions:

- **Funding.** Uncertainty and lack of funding, distribution of funding, restricted paylines, success rates, indirect costs, excessive competition
- **Multi-disciplinary.** Need for multi/ inter/ trans-disciplinary research training to prepare trainees for a wide range of academic and non-academic career opportunities
- **Salary.** Inadequate compensation and benefits
- **Length of training.** Amount of training time too long to be feasible for majority
- **Non-US citizens. Foreign students and post-doctoral fellows**
- **Career appeal.** Working conditions, i.e. heavy workload, perception of being used as cheap labor, long work hours.
- **Mentoring.** Quality of career development and the need for pre-college preparation

- **Diversity.** Under-represented minority post-doctoral, fellows and junior faculty

Analysis Process

Both the primary and secondary issues were used as a starting point and expanded through successive analysis/coding iterations by a coding team. The following process was followed:

1) First, a random selection of comments was assigned to each team member to scan for meaningful quotations that addressed issues related to the future of the biomedical workforce;

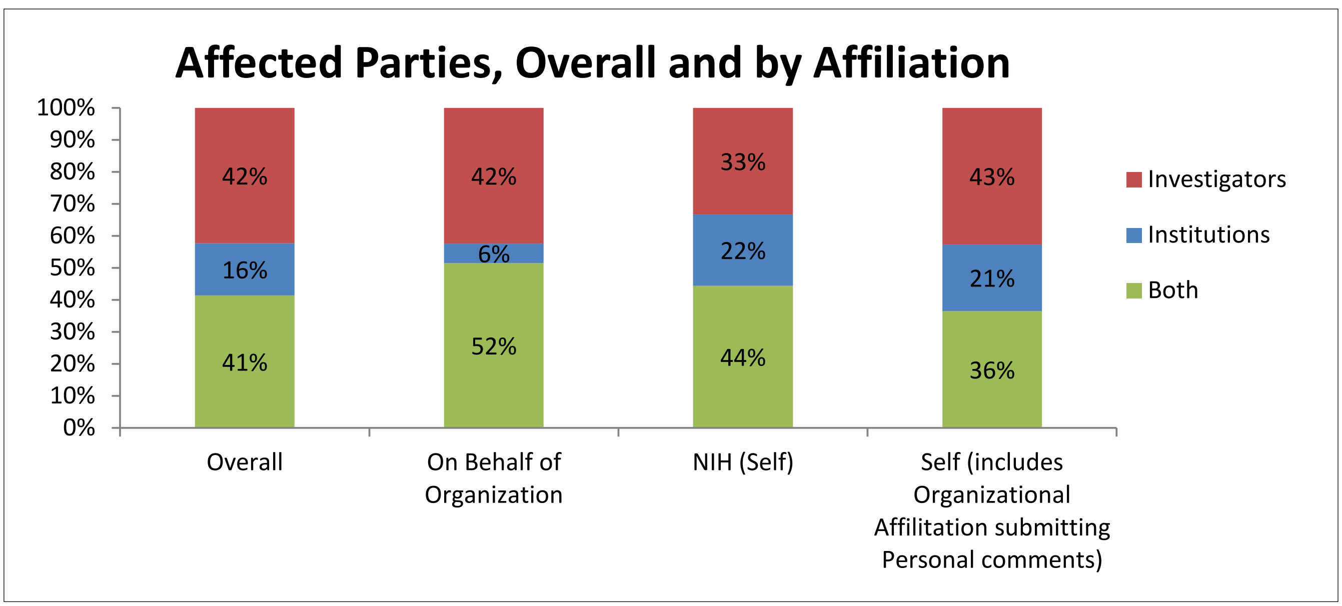
2) Team members analyzed the quotations to define the code categories (starting with the three questions identified by the RFI and the 8 issues identified by ACD) into which the quotation might belong (first cut);

3) Team members assigned the quotations into one of the existing issue code categories that best matched the quotation (second cut);

4) Finally, team members revised the code structure by creating new issues to categorize the quotations that did not fit existing issue categories.

Affected Parties

Each quotation was analyzed for affected party (investigators, institutions, or both), as cited by the commenter. Of the 498 quotations, only 319 (64%) were identified with an affected party. The distribution of affected party (for the overall data set and by affiliation) is shown in the graph below.



Priority Analysis

Commenters were asked to indicate the most important issue(s) for the working group to address. To capture and analyze responses to this question, cited issues for each commenter were given a ranking number[67]. For example, if a commenter mentioned three issues in her response, the first issue received rank 1, the second issue received rank 2, and the third issue received rank 3. The total count per issue was summed across all comments to determine the overall priority. This method allowed us to distribute the appropriate weight per issue, when commenters mentioned more than one issue. The theoretical maximum priority score for an issue was 219, and would have occurred if the issue received rank 1 from every commenter. Priority scores for each of the twelve issues, in descending order, are provided in the table below.

Issue	Priority Score
Supply and Demand	90
PhD Characteristics	85
Biomedical Research Career Appeal	67
Post-doc Training Characteristics	56
Clinician Characteristics	51
Diversity	34
Effects of NIH Policies	34
Staff Scientist Career Track	31
Mentoring	22
Training to Research Grant Ratio	15
Early Educational Interventions	9
Industry Partnership	7

As expected, the overall priority of issues followed a similar pattern to the frequency counts by issue.

[67] If issue priority was not explicitly stated by the commenter, it was assigned by the order in which the issue appeared within each comment.

Issue Priority

Commenters were asked to indicate the most important issue for the working group to address. To capture and analyze responses to this question, cited issues were given a ranking number[68] by commenter. The total count per issue was summed across all responses to determine overall priority.

As described above, the overall issue priority was similar to the overall frequency of issues. However, when considered by affiliation (self and organization), the pattern differed, as shown below.

Issue	Priority Score (Organization)
PhD Characteristics	29
Clinician Characteristics	21
Post-doc Training Characteristics	19
Supply and Demand	18
Biomedical Research Career Appeal	18
Staff Scientist Career Track	15
Diversity	12
Effects of NIH Policies	12
Training to Research Grant Ratio	12
Early Educational Interventions	2
Mentoring	1
Industry Partnership	1

Issue	Priority Score (Self)
Supply and Demand	68
PhD Characteristics	55
Biomedical Research Career Appeal	47
Post-doc Training Characteristics	36
Clinician Characteristics	30
Effects of NIH Policies	21
Diversity	20
Mentoring	18
Staff Scientist Career Track	13
Industry Partnership	6
Early Educational Interventions	5
Training to Research Grant Ratio	3

The order of issues as determined by frequency (below) is the same whether considering either the Organization or the Self perspective, but it does not correlate with the order of issues as determined by priority score for either Organization or Self.

Issue	Frequency (Organization)	Frequency (Self)
Supply and Demand	17%	20%
PhD Characteristics	15%	18%
Post-doc Training Characteristics	11%	13%
Biomedical Research Career Appeal	10%	10%
Clinician Characteristics	9%	9%
Staff Scientist Career Track	8%	6%
Diversity	7%	6%
Effects of NIH Policies	7%	5%
Mentoring	5%	5%
Training to Research Grant Ratio	5%	3%
Early Educational Interventions	3%	2%
Industry Partnerships	1%	2%

[68] Priority was assigned based on the order of issue appearance within each separate comment response.

Qualitative Analysis

The issues identified by the Working Group and commenters are discussed below in descending order by comment frequency, beginning with the issue that received the most comments, Supply and Demand.

Supply and Demand, 97 quotations [19%]

According to commenters, this was the most important issue because it affects all other issues. Commenters felt that the imbalance between supply and demand is so vast that excellent candidates cannot find work in academia. Generally, commenters agreed that NIH is training more scientists than the workforce can support; exceptions included certain specialties such as veterinary research, biostatistics, and medical informatics. Supply of research funds is largely viewed to be inadequate and, in the current environment, creates a demand for cheap labor to perform technician duties in laboratories.

Many solutions were proposed, some on the supply side, some on the demand side. Supply side remedies included reduction in trainees, and a branching career path. Demand side remedies included funding increases and revisions of funding structures. Institutions favored solutions that addressed funding distribution and increased flexibility in training outcomes. Individuals overwhelmingly called for a reduction in the number of post-doctoral fellows by various long-term measures, such as early identification of individuals who will not choose to perform a post-doctoral fellows and redirection to MS programs or non-research careers, or by limiting the long-term supply of post-doctoral fellows by various methods.

Oversupply. Some suggestions for addressing oversupply were class size reductions, raising graduate program entry requirements, and improving training for “alternative” careers. Several commenters suggested that the scientific community should return to using the Master’s degree for individuals not interested in becoming academic research PIs.

Pyramid scheme. Many commenters referred to the current structure of the research workforce as a “pyramid scheme” which utilizes the cheap labor of students and post-doctoral fellows in place of hiring mid-career level researchers. This structure has negative effects on both sides of the supply-demand problem. Suggestions to address this structure included addressing the tenure model, decreasing the number of funded trainees per PI, and increasing the use of staff scientists.

Funding contraction. Limited supply of research funds was cited by many commenters as creating funding barriers for ESIs and transitioning post-doctoral fellows due to decreased success rates. Suggestions to address this issue included increasing paylines, limiting the number of large grants a single PI can have, or funding ESIs at a higher percentile.

Non-US citizens. It was frequently suggested that, as domestic appeal wanes for research careers, the workforce is being infused with students and post-doctoral fellows from other countries who are willing to endure the struggles of academic research. Because this compounds the competition for future funding, many respondents called for restrictions on the number of foreigners who may enter the graduate and post-graduate training systems. Still, a majority of organizations and some individuals asserted that more foreign students and post-doctoral fellows should be encouraged to seek training in the U.S. and stay on to contribute to the U.S. economy, rather than return to their home countries.

SECONDARY ISSUES

Most (64%) of the quotations identified a secondary issue. Those with a secondary issue were categorized as follows:

Secondary Issues for Supply and Demand	
Non-US Citizens	35%
Funding	32%
Career Appeal	11%
Salary	10%
Multi-disciplinary	6%
Length of training	3%
Mentoring	2%

IMPACT

Almost half (43%) of the commenters felt that Supply and Demand was an issue for both institutions and investigators, while 34% felt that Supply and Demand was an investigator issue and 23% felt that Supply and Demand was an institutional issue.

SELECTED PUBLIC RECOMMENDATIONS FOR NIH ACTION

- Reduce the number of students and post-doctoral fellows supported, and improve awareness and understanding of the branching career path available to new scientists (supply-side).
- Increase total funding and revise current funding structures to promote wider distribution of funds (demand-side).

PhD Characteristics, 84 quotations [17%]

Commenters suggested that career development deficiencies and failure to train for a branching career pathway are contributing to bottlenecks at the senior post-doctoral fellow stage. Many commenters asserted that variability in mentoring and career development resources in different programs results in too much variation in the PhD experience; greater structure was cited as a solution to this problem.

The most popular proposed solutions were (1) Improved career development programs that integrate alternative career pathways, (2) Increased structure in the PhD experience, and (3) Funding mechanisms to support career development.

Training curriculum changes. Many commenters expressed that typical research training is insufficient for creating independent researchers. Greater career development training was suggested for skills such as lab management, teaching, and technical writing. Some concern was expressed that there is too much variability in standard expectations, such as publication requirements for thesis defense. As a result, some students are being held to higher standards than others, which can affect length of time to degree. Increased training for cross-disciplinary and translational research were also suggested as deficiencies in some programs.

Multiple career path training. The majority of respondents, both individuals and institutions, agreed that training focused on academic PI careers is no longer sufficient, given that only a small percentage of students and post-doctoral fellows will likely obtain these positions. Many respondents expressed a hope that the NIH would "redefine success" for training grant reviews to include non-academic appointments. Beyond a lack of information regarding non-academic careers, several noted that interest in such careers may actually be discouraged by faculty.

Length of training period. Only a few commenters suggested that PhD training was too long. Several warned that imposing a reduction or cap on length of training could have a negative effect on the quality of doctoral graduates.

SECONDARY ISSUES

A strong majority (81%) of the quotations identified a secondary issue. Those with a secondary issue were categorized as follows:

Secondary Issues for PhD Characteristics	
Multi-disciplinary	55%
Length of training	16%
Funding	14%
Salary	4%
Mentoring	4%
Career appeal	3%
Non-US Citizens	1%
Diversity	1%

IMPACT

Almost half (46%) of the commenters felt that PhD Characteristics was an investigator issue; slightly less (42%) felt that it was an issue for both institutions and investigators, and only 12% felt that PhD Characteristics was an institutional issue.

SELECTED PUBLIC RECOMMENDATIONS FOR NIH ACTION

- Evaluate and consider changing the structure in the NIH-supported PhD experience.
- Provide direct funding support and encourage career development programs that integrate alternative career pathways.
- Revise training grant review policies so that non-academic career choices for former trainees are not considered training failures.

Post-doctoral Fellow Training Characteristics, 62 quotations [12%]

This issue was broadened from the original issue, “Length of Post-doctoral Training”, since there were too many comments that could not be captured under the original, more specific issue. While there was some dissent, most agreed that post-doctoral training is too long and is largely the result of a bottleneck of individuals looking for faculty positions. Inadequate mentoring was another challenge cited by many as a possible cause for the lengthening of the training period. Some suggested that the inherent instability of a training position may affect the scientific work being done by these scientists.

Post-doctoral fellowship experiences seem to affect career appeal. The post-doctoral fellow lifestyle was viewed as untenable for many mid-30s professionals; this lack of appeal may result in a possible “brain drain” to industry jobs. The most popular solutions addressed salary, transition funding, and documentation of training progress.

Salary and benefits. Most commenters, both individuals and institutions, expressed concern that salary and benefits for post-doctoral fellows are insufficient and need to be increased. This issue was also one of the most common reasons cited for low career interest among students, since most students were aware that other careers would provide much better pay and benefits. Several commenters pointed to the family and retirement benefits provided to post-doctoral fellows at a life stage when these are critical needs.

Addressing the bottleneck. To alleviate the post-doctoral bottleneck, some commenters suggested increases and extensions in transition funding, while others maintained that greater use of staff scientists is the best approach. Some also expressed concern over the influx of foreign trainees at this career stage, which creates even greater competition for scarce faculty positions. The issue of a post-doctoral bottleneck seems to be a greater concern for individuals than for institutions/organizations.

Length of training. Both institutions and individuals generally agreed that the average post-doctoral fellowship has become too long. The greatest complaint noted in this issue was primarily in reference to the length and availability of transition awards, rather than on the length of the post-doctoral fellowship itself. Several commenters called for a lengthening of transition awards in today’s exceptionally competitive job market. Still, some institutions are enacting caps on the number of post-doctoral years in an effort to incentivize career development planning, a noted concern for poorly mentored post-doctoral fellows. A few respondents noted that the increasing post-doctoral fellowship length may be making candidates less desirable, not more.

Content of training. Some respondents called for more structure in the post-doctoral training experience. There was no consensus on what training ought to include or not include, but many expressed that post-doctoral fellows do not receive enough experience in non-research skills, such as teaching and grant writing. Many believed that a structured competencies-based approach, supported by NIH, would be preferable to a strict limitation on number of years.

Career development and mentoring. Most commenters seemed to agree that post-doctoral fellows do not engage in enough career development. This was especially true for post-doctoral fellows with non-academic or non-research career interests. A few commenters stressed the need for an increase in the training areas of lab management and teaching to create more self-sufficient researchers. Many others pointed out the mentoring challenges that PIs face in the current funding climate. With more time needed to write winning grants, PIs appeared to be neglecting their mentoring duties of new scientists. Overall, individual respondents felt that mentoring and career development was generally inadequate; a majority of institutions did not comment on this aspect of post-doctoral training.

Lifestyle of a post-doctoral fellow. Several commenters explained that the lifestyle of a post-doctoral fellow (hours worked, workload, and relationships with PIs) is not amenable to family life. Thus, many women of child-bearing age chose to place their career on hold at this stage or leave academia altogether. This issue appeared more often in comments from individuals than institutions.

SECONDARY ISSUES

A strong majority (82%) of the quotations identified a secondary issue. Those with a secondary issue were categorized as follows:

Secondary Issues for Post-doctoral Training Characteristics	
Length of training	27%
Funding	25%
Salary	20%
Multi-disciplinary	12%
Career appeal	8%
Mentoring	6%
Non-US Citizens	2%

IMPACT

More than half (54%) of the commenters felt that Post-doctoral Training Characteristics was an investigator issue; about one-third (36%) felt that it was an issue for both institutions and investigators, and just 10% felt that Post-doctoral Training Characteristics was an institutional issue.

SELECTED PUBLIC RECOMMENDATIONS FOR NIH ACTION

- Increase the availability and length of transition funding for senior post-doctoral fellows.
- Raise the NRSA post-doctoral stipend and mandate that all NIH-supported post-doctoral fellows (whether directly or indirectly supported) receive this amount.
- Require better documentation and monitoring of training progress and career planning.

Biomedical Research Career Appeal, 53 quotations [11%]

This issue is largely viewed as a downstream effect of the student and post-doctoral experience. Right now, students and post-doctoral fellows are largely unhappy due to the dismal economy and job outlook. Research careers are currently less appealing than careers in competing fields, including MD and MPH programs.

In general, commenters thought that the issue of career appeal is an important one and affects several other issues. Both institutions and individuals agreed that a career in biomedical research is less appealing today as a result of lower starting salaries for graduates and the increasing competition for limited research funding. Individuals seemed more concerned than institutions with career aspects such as family-friendly work environments, long hours, high stress, and benefits packages. By comparison, institutions expressed greater concern with regulatory burdens placed on current investigators. Many individuals viewed long-term institutional commitment unfavorably, citing the erosion of tenure positions and the increasing burden to fund one's own salary.

Some commenters pointed out that misinformation about graduate degrees and career opportunities led many to be dissatisfied with their career in biomedical research. What information students are given on potential graduate degree programs and career opportunities and how that information was conveyed were thought to be critical.

Improved mentoring and career development, as well as anything that addresses the supply and demand imbalance, were perceived as the best solutions.

Salary. Commenters felt that compensation is inadequate; suggesting that most faculty PhD positions start from the low to high $30,000s. A main contributing factor to the issue of low pay was attributed to students and post-doctoral fellows being utilized as technicians in labs. Institutions are utilizing NIH NRSA program salary levels as de facto guidelines – in spite of NIH clarification that the NRSA salary levels are for that program specifically.

Funding availability. Commenters deemed the availability of funding as the most critical aspect for the recruitment and retention of young and talented individuals in biomedical research. Commenters strongly felt that funding for science research must increase; suggestions to increase funding included shifting funding priorities to investigator-initiated grants (e.g. R01 grants) and basic science research, reducing and/or limiting overhead, and limiting the number or dollar amount of grants awarded to a single investigator. Other suggestions included the provision of dedicated funding mechanisms for multi-disciplinary training programs.

SECONDARY ISSUES

More than three-quarters (79%) of the quotations identified a secondary issue. Those with a secondary issue were categorized as follows:

Secondary Issues for Biomedical Research Career Appeal	
Funding	48%
Salary	40%
Length of training	7%
Multi-disciplinary	2%
Non-US Citizens	2%

IMPACT

Almost half (46%) of the commenters felt that Biomedical Research Career Appeal was an issue for both institutions and investigators, while 33% felt that it was an investigator issue and 21% felt that it was an institutional issue.

SELECTED PUBLIC RECOMMENDATIONS FOR NIH ACTION

- Encourage improved mentoring and career development.
- Establish salary standards/ guidance for non-NRSA supported postdoctoral fellows, and increase the NRSA stipend levels.
- **Increase overall funding or change funding distributions that favor higher success rates, especially for transitioning and new investigators.**

Clinician Characteristics, 44 quotations [9%]

Overall, individual commenters cited the pressure to increase clinic time as the main reason why the clinician researcher path is less attractive and attainable. Commenters felt that the time required to conduct research is often not adequately compensated by the institution (in terms of pay, recognition or career advancement). This makes it difficult for many MD recipients, especially for those with medical school loans to repay, to justify beginning or continuing down this career path. Both individuals and institutions suggested funding support from NIH to provide clinicians with protected time to maintain research activities.

Institutions and individuals agreed that a broader approach to training was needed and clinical/translational training should begin sooner – in medical and undergraduate school.

Balance between MDs and MD/PhDs. Commenters believed that MD/PhD degrees are valuable, but that the increasing cost of medical school, requirements and length of training, and the limited opportunities in academia make the MD/PhD career path less attractive.

Career development. Commenters felt that there is a decline in the number of MD recipients conducting clinical research in academia. Many commenters agreed that this decline is due to the pressures they face to be profitable in clinical practice (e.g. see more patients, bill more, etc.). Commenters suggested that funding support is needed to provide clinician scientists with protected time to conduct competitive research.

Training curriculum changes. Few recommendations were made with regard to curriculum changes. Commenters believed that MD and PhD recipients should be cross-trained and equally versed in translational research and quantitative studies such as physics, mathematics, engineering and informatics. Commenters cited a need for clinical research training to begin at the graduate and/or undergraduate level. Some commenters suggested that NIH funding could provide support for medical schools to offer clinical relevant courses such as statistics, epidemiology and genomics.

SECONDARY ISSUES

Slightly more than half (57%) of the quotations identified a secondary issue. Those with a secondary issue were categorized as follows:

Secondary Issues for Clinician Characteristics	
Funding	36%

Multi-disciplinary	32%
Salary	16%
Length of training	8%
Career appeal	8%

IMPACT

More than half (53%) of the commenters felt that Clinician Characteristics was an issue for both institutions and investigators, while 33% felt that it was an investigator issue and 13% felt that it was an institutional issue.

SELECTED PUBLIC RECOMMENDATIONS FOR NIH ACTION

- Provide mechanisms to support protected time for clinician research.

Staff Scientist Career Track, 36 quotations [7%]

There was much support among individual commenters to create permanent career staff scientists positions. They saw this as a way for all parties to reap the benefits of training support provided by NIH. Institution commenters where divided, some taking a cautious approach to the idea of utilizing staff scientist in the lab, citing possible adverse effects including potential loss of innovative ideas (currently provided by graduates) and the reduction in project budgets to cover the salaries for these positions.

Career level of staff scientists. Some opined that the staff scientist position should remain at the PhD level, while others believed that over-supply of graduates could be addressed by opening this new field to Master's recipients. There was some divergence about whether staff scientist positions would be viewed as career-terminal or if they could be an additional step towards independent faculty positions.

Staff scientists vs. post-doc labor. Some commenters noted that staff scientists have different incentives and productivity profiles than post-doctoral fellows. Specifically, commenters felt that if PIs employed staff scientists instead of post-doctoral fellows, the amount of productivity received per NIH dollar would likely decrease; therefore, many expressed that NIH must fully support the move to use the more expensive staff scientists. Without this backing, PIs will continue to use student and post-doctoral fellow labor to keep budget proposals low.

SECONDARY ISSUES

Only 36% of the Staff Scientist Career Track quotations identified a secondary issue. Those with a secondary issue were categorized as follows:

Secondary Issues for Staff Scientist Career Track	
Funding	46%
Multi-disciplinary	15%
Length of training	15%
Salary	15%
Career appeal	8%

IMPACT

Half (50%) of the commenters felt that Staff Scientist Career Track was an issue for both institutions and investigators, while 44% felt that it was an investigator issue and only 6% felt that it was an institutional issue.

SELECTED PUBLIC RECOMMENDATIONS FOR NIH ACTION

- Provide grant mechanisms and change the funding policy to increase project budgets to support the costs associated with permanent staff.

Diversity, 32 quotations [6%]

Commenters believed that the issues of the biomedical workforce cannot be addressed without addressing the need for diversity. There was much fear that the current economy and funding climate will gravely affect the diversity of the workforce. Little difference was evident between individual and institutional/organizational responses to this issue. Most agreed that diversity should remain a priority in any proposed policy changes.

Most commenters that addressed this issue delivered a general call to action with few specifics on recommendations. The few that provided specific requests focused on reviewing and addressing policies within grant funding and training that adversely affect these groups. One commenter acknowledged the importance of diversity as an issue but warned NIH not to sacrifice competitiveness for diversity.

Women. Many commenters felt that there is a significant loss of women from the academic research workforce; most believe this loss is due to the negative effect that raising a family can have on a woman's career. Others proposed that the loss is caused by the disproportional size of the average lab headed by women when compared to men; smaller labs cannot compete with larger ones in terms of experimental productivity. Another issue raised by commenters was the problem of "career pacing", which occurs when individuals (usually females) take time away from research that can then reduce their eligibility for certain programs and affect competitiveness for funding later in their careers. Commenters recommended that the existing NIH family-friendly policies and NIH-ORWH Reentry program be reviewed and revised to create a mechanism for scientists who take a part-time rather than a full-time leave of absence.

Ethnic and racial minority groups. Commenters felt strongly that the low success rate among ethnic and racial minority groups was an issue that needs to be addressed. Many cited a recent *Science* article (Ginther, et. al) as a cause for great concern within the scientific community. Specific barriers to success were not provided for these groups as they were for women; instead, most comments assumed that these barriers were well-known. Commenters proposed a diverse list of recommendations to resolve this issue including pre-college mentoring, use of social media tools to mentor, recruitment and tracking of candidates, and support of diversity specific mechanisms.

SECONDARY ISSUES

Less than half (44%) of the quotations identified a secondary issue. Those with a secondary issue were categorized as follows:

Secondary Issues for Diversity	
Funding	50%
Career appeal	21%
Non-US Citizens	14%
Multi-disciplinary	7%
Length of training	7%

IMPACT

A plurality (40%) of commenters felt that Diversity was an institutional issue; about one third (35%) felt that Diversity was an investigator issue, and only 25% felt that it was an issue for both institutions and investigators.

NIH Action Recommendations

- Expansion of targeted funding opportunities for underrepresented groups, such as loan repayment programs that will benefit minorities, who are likely to have heavier loan burdens.
- Review and modification of family friendly policies, such as family leave for trainees, and funding restrictions/preferences based on career pacing to better address issues that disproportionately occur for females.

Effects of NIH Policies, 29 quotations [6%]

The issue of NIH polices appeared throughout the responses. Commenters cited NIH policies and practices that positively and negatively affected the workforce, and offered possible solutions. Comments responding to this issue were disparate. Only two themes received attention from multiple commenters: adverse funding policies and the dissolution of the National Center for Research Resources (NCRR).

Commenters addressing the issue of funding policies expressed a range of reasons for being dissatisfied with the current funding review system. The predominant reason, for both institutions and individuals, was that securing funding has become increasingly difficult, particularly for new investigators.

Adverse funding policies for new investigators. Overall, commenters believed that established investigators are receiving an undue proportion of available funding. Some commenters acknowledged the efforts that the NIH has made to improve success rates for Early Stage Investigators (ESI). However, most felt that current efforts are not enough to continue to draw new talent to the field. Several commenters noted that the shift away from R21 funding and the new limitation on resubmissions are especially detrimental for new investigators.

NCRR dissolution. Several commenters submitted similar responses, which expressed concern that funding and extramural support for animal-model biomedical research would be reduced with the dissolution of NCRR. These commenters urged the NIH to ensure that NCRR's commitment to animal-model research would continue following this reorganization.

Institution affiliation. Currently, scientists must be associated with an institution or hold a certain job title to apply for certain types of funding at NIH. One commenter felt that this policy was counterproductive in the current economic climate, especially for unemployed scientists who are trying to re-enter to the workforce. This policy could also be a burden for post-doctoral applicants who are unable to get institutional support.

SECONDARY ISSUES

More than half (59%) of the quotations identified a secondary issue. Those with a secondary issue were categorized as follows:

Secondary Issues for Effects of NIH Policies	
Funding	88%
Salary	6%
Career appeal	6%

IMPACT

A majority (61%) of the commenters felt that Effects of NIH Policies was an investigator issue, while 26% felt that it was an issue for both institutions and investigators, and only 13% felt that it was an institutional issue.

SELECTED PUBLIC RECOMMENDATIONS FOR NIH ACTION

- Increase funding opportunities for various grant mechanisms and research areas.
- Consider the short and long-term implications of proposed models and gather additional input from the extramural community prior to implementation.
- Restrict the amount of funding and/or number of grants one investigator may be awarded.

Mentoring, 24 quotations [5%]

As reported by commenters, the quality of mentoring varies immensely, and it has a significant effect on mentee's perspectives and career paths. Institutional commitment to career development resources was also reported to vary, which could present greater challenges for some graduates. Mentoring can improve or compound other issues such as diversity, length of training, and biomedical research career appeal.

Institutions and individuals both describe conflicts of time and interest for PIs when mentoring students and post-doctoral fellows. PIs are spending more time in the office to obtain funding and less time doing research and mentoring new scientists. Anything that would improve current funding success rates could address this conflict. Individuals criticized the academic bias present in much of the mentoring.

Mentoring plan documentation. Many commenters suggested that all NIH-funded students and post-doctoral fellows should have documented individual development plans (IDPs), created and approved by both the mentor and mentee. The progress of such plans should be included in the annual reports to NIH for funded trainees.

Conflict interest for mentors. An additional concern for many commenters was the conflict of interest that mentors experience. Funding systems, such as the NIH, and academic promotion structures reward discovery and publications, metrics which are largely fueled by student and post-doctoral fellow productivity. This reliance on student and post-doctoral labor creates an environment where productivity is prioritized over career development, especially when pursued outside of the lab. Because mentoring is an uncompensated activity, several commenters suggested that making mentoring a part of funding reviews might provide the incentive needed to address these conflicts.

Funds for institutional program management staff. Several commenters recommended that training grants provide support for program management of the training grants, including salary support for program directors, staff, and significant faculty. Also requested on training grants were funds for purchasing training technologies.

Non-academic mentoring. Of commenters addressing non-academic career paths, most agreed that training for these paths is inadequate. Given that most current mentors were "raised" on the academic, tenure-track path, commenters expressed an absence of mentoring for non-academic careers, which has a downstream effect on the supply and demand issue.

SECONDARY ISSUES

More than half (54%) of the quotations identified a secondary issue. Those with a secondary issue were categorized as follows:

Secondary Issues for Mentoring	
Multi-disciplinary	43%
Funding	36%
Length of training	7%
Salary	7%

IMPACT

A strong majority (73%) of the commenters felt that Mentoring was an investigator issue and none (0%) felt that it was an institutional issue. The remaining 27% felt that Mentoring was an issue for both institutions and investigators.

SELECTED PUBLIC RECOMMENDATIONS FOR NIH ACTION

- Encourage a more structured mentoring experience and develop career/mentorship plans and guidelines.
- Permit training grant budgets to support the salary of mentors and support staff (e.g. training director).
- Uncouple career/mentorship from financial support and access to career development resources.

Training to Research Grant Ratio, 19 quotations [4%]

Few respondents commented on this issue; those that did respond to this issue felt that there was a need for more training grants because their flexibility allows for better career development of funded trainees. This belief was held by institutions as well as individuals.

Institutions requested an in-depth evaluation be conducted to understand the potential impact of moving students and post-doctoral fellow support off of research grants and onto training grants.

Training funds versus research funds. In terms of training goals, most commenters agreed that training funds are better at training than research funds. Training grants were described as being more flexible, more amenable to career development, and easier to track. However, commenters warned that a migration away from research funds for training purposes could have unintended consequences for institutions and for foreign students who are currently ineligible for most training grants.

Value to institutions. Commenters indicated that the funding provided by training grants is declining as the grant review requirements are on the rise. As a result, training grants are perceived as not being worth the trouble since many institutions can no longer afford to subsidize the salary shortfalls these grants contain.

Direct to trainee awards. A few individual commenters suggested that more portable awards, granted directly to the trainee, might foster independence among new trainees, enabling them to move to a new lab/institution if this would better suit their training goals.

SECONDARY ISSUES

More than half (58%) of the quotations identified a secondary issue. Those with a secondary issue were categorized over a broad group of the following secondary issues:

Secondary Issues for Training to Research Grant Ratio	
Funding	42%
Mentoring	17%
Salary	8%
Career appeal	8%
Multi-disciplinary	8%
Non-US Citizens	8%
Diversity	8%

IMPACT

Commenters were equally split (40% each) between those that felt Training to Research Grant Ratio was an investigator issue versus an issue for both institutions and investigators; only 20% felt that it was an institutional issue.

SELECTED PUBLIC RECOMMENDATIONS FOR NIH ACTION

- **Conduct a thorough analysis of the benefits and drawbacks of each type of funding before instituting a change to the current ratio.**
- **Increase training mandates and trainee monitoring on research grants.**
- **Increase the use of training funds or administrative supplements that allow more time and effort for career development.**

Early Educational Interventions, 11 quotations [2%]

Commenters suggested that some of the primary issues may have roots as early as K-12 education. Intervention programs prior to graduate school will likely have downstream effects on issues such as Biomedical Research Career Appeal, Diversity, and Supply and Demand. Suggestions generally called for an increase in funds devoted to programs that would affect the K-12, undergraduate, and post-baccalaureate student populations.

K-12 interventions. The ability to draw in new talent, especially underrepresented groups, may be best addressed in early education and mentoring. One commenter suggested that the NIH may wish to encourage its funded researchers to increase their community engagement as a way to increase awareness about science careers.

Undergraduate curriculum changes. Rather than lengthening or adding to the requirements for PhD degrees, it may be more appropriate to broaden or deepen undergraduate training. Additionally, commenters suggested that training for non-academic career paths could occur at the undergraduate level. Additionally, commenters suggested that training may be improved by the development and institution of competencies that would provide common metrics for PhD programs considering new applicants.

Expansion of post-baccalaureate programs. Many applicants to PhD programs may not be aware of the realities of a career in research, such as the length of the training period and investigator struggles to maintain funding levels. Without this experience, student expectations upon entering graduate school may be unrealistic. Inflated expectations may contribute to a sudden drop in motivation during the training period; expanding post-baccalaureate and pre-doctoral programs could expose potential applicants to graduate school to the realities of a research career at an earlier time point.

SECONDARY ISSUES

Most (64%) of the quotations identified a secondary issue. Those with a secondary issue were categorized as follows:

Secondary Issues for Early Educational Interventions	
Funding	43%
Mentoring	29%
Multi-disciplinary	14%
Length of training	14%

IMPACT

A strong majority (67%) of the commenters felt that Early Educational Interventions was an issue for both institutions and investigators; the remaining 34% were equally split (17% each) as to whether they felt Early Educational Interventions was an investigator issue or an institutional issue.

SELECTED PUBLIC RECOMMENDATIONS FOR NIH ACTION

- Increase funding for internship experiences, for undergrads and post-bac/pre-doc students.
- Develop undergraduate competencies that may be used as pre-requisites for PhD program applications.
- Increase overall funding for post-baccalaureate and pre-doctoral programs.

Industry Partnership, 7 quotations [1%]

Industrial research corporations can be valuable partners in the mission to improve human health. However, many viewed the relationship between industry and academia as imbalanced in terms of benefits and burdens. Specifically, industry was thought to share more of the benefits and academia was thought to share more of the burdens. Many felt that a change in partnership structure might be warranted. Although fewer than ten commenters made specific reference to partnerships between academia and industry, we've made this a primary issue since so many individuals felt that industry was a vital part of the branching career pipeline for biomedical workers. Individuals submitted all but one of the comments on this issue.

Industry capitalizing on academic efforts. Several commenters asserted that industry research capitalizes on the efforts of academia at every stage. Students trained in the academic setting often leave academia for a job in industry research, particularly in the current job market.

Industry as a training partner. One way in which industry could provide a return on the human capital it receives from academia is to create partnerships for the purpose of training students in non-academic careers. Such efforts could benefit everyone by reducing over-supply issues in academia and improving mentoring of students and post-doctoral fellows who are interested in careers in industry research. Structured fellowships for students and post-doctoral fellows within industry might also alleviate the mentoring burdens currently being experienced by academic PIs who may not be well-equipped to mentor post-doctoral fellows with non-academic aspirations. One commenter pointed out that the reason so few academic PIs have industry experience is that it is nearly impossible to break into academia after a successful career in industry.

SECONDARY ISSUES

Only two of the quotations (29%) identified a secondary issue. In both cases, the secondary issue was Mentoring.

IMPACT

Three quarters (75%) of the commenters felt that Industry Partnership was an issue for both institutions and investigators, while 25% felt that it was an investigator issue; none (0%) classified it as an institutional issue.

SELECTED PUBLIC RECOMMENDATIONS FOR NIH ACTION:

- Set up or encourage partnership agreements between private industry and individual scientists; partnerships would define focus of academic partner (discovery) and focus of industry (commercialization).
- Adopt a ”net-benefit policy” in which institutions receiving NIH funds must secure a commitment from private US employers to hire an equal or greater number of scientists than those supported by the NIH monies.
- Promote partnership programs for post-doctoral fellows to provide them with a better understanding of how science is carried out in industry, which would help prepare them for career paths outside of academia.

Appendix

Additional Data

Comment Coding Status

				Counts
TOTAL COMMENTS RECEIVED	**224**	Duplicates:	3	
		Non-Responsive:	2	
Unique and Responsive Comments Received:				219
Quotations Coded To Date:				498
Mean Quotations Per Submission:				2.3

Submission Method

	Count	Percent
Web Form:	213	96%
Email:	7	3%
Postal Mail:	1	1%
Fax:	0	0%

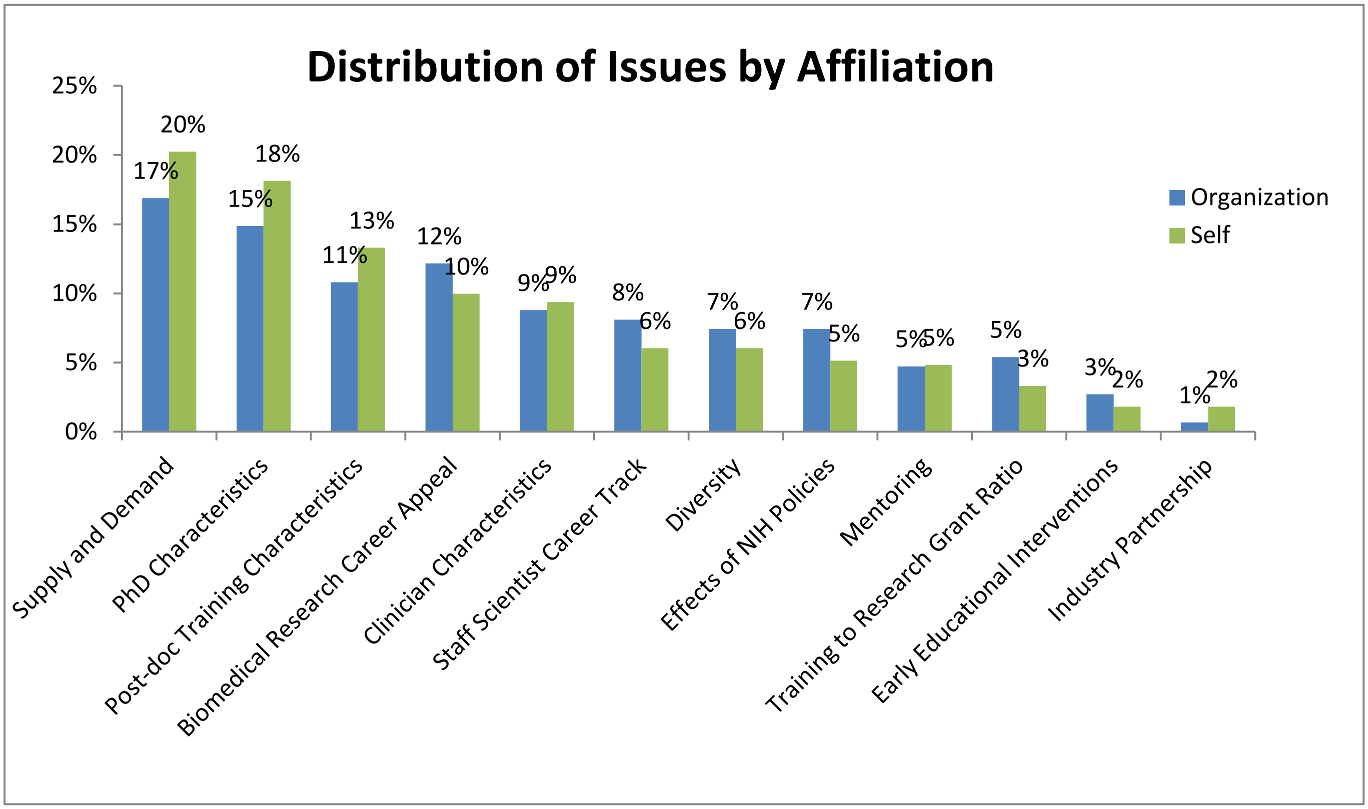
Affiliation Catergory

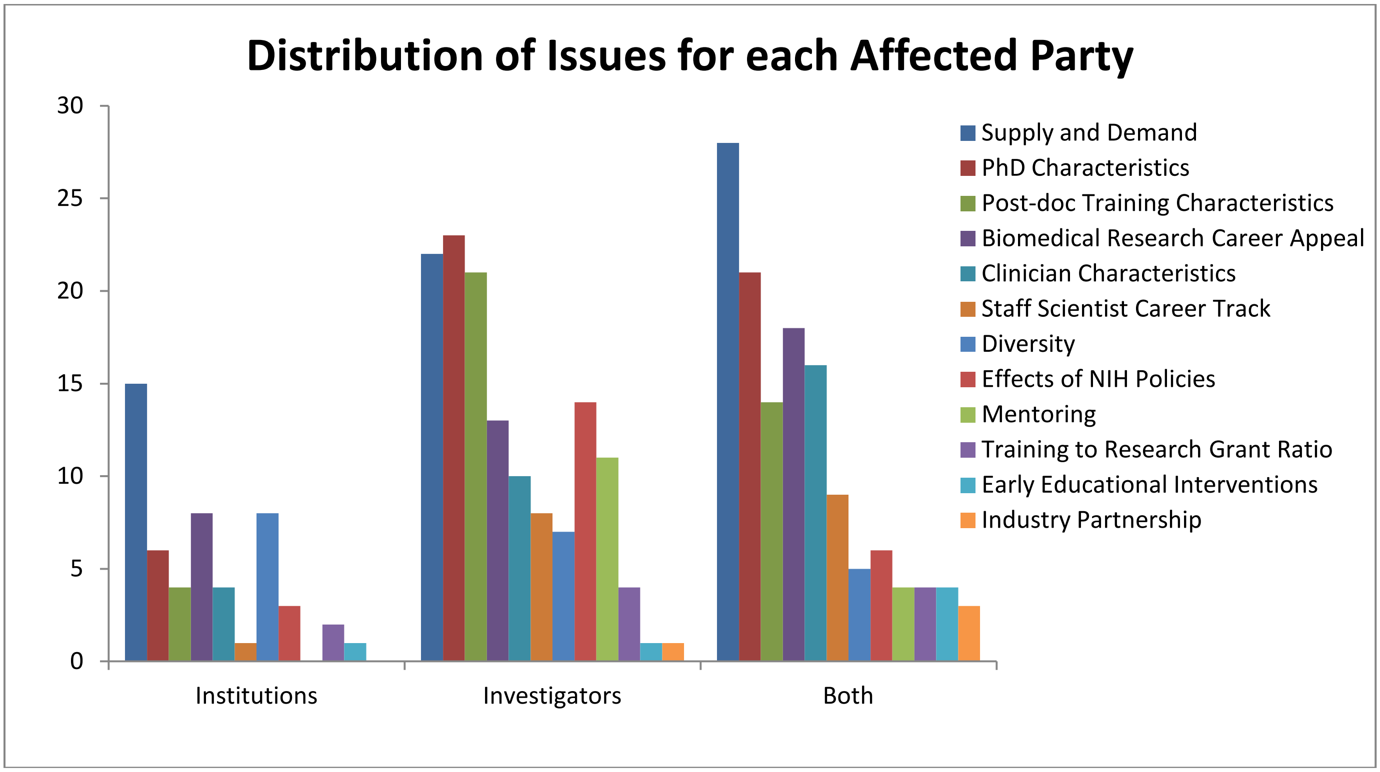
	Count	Percent
Self (Private Citizen)	165	75%
Organization	44	20%
NIH Staff	10	5%

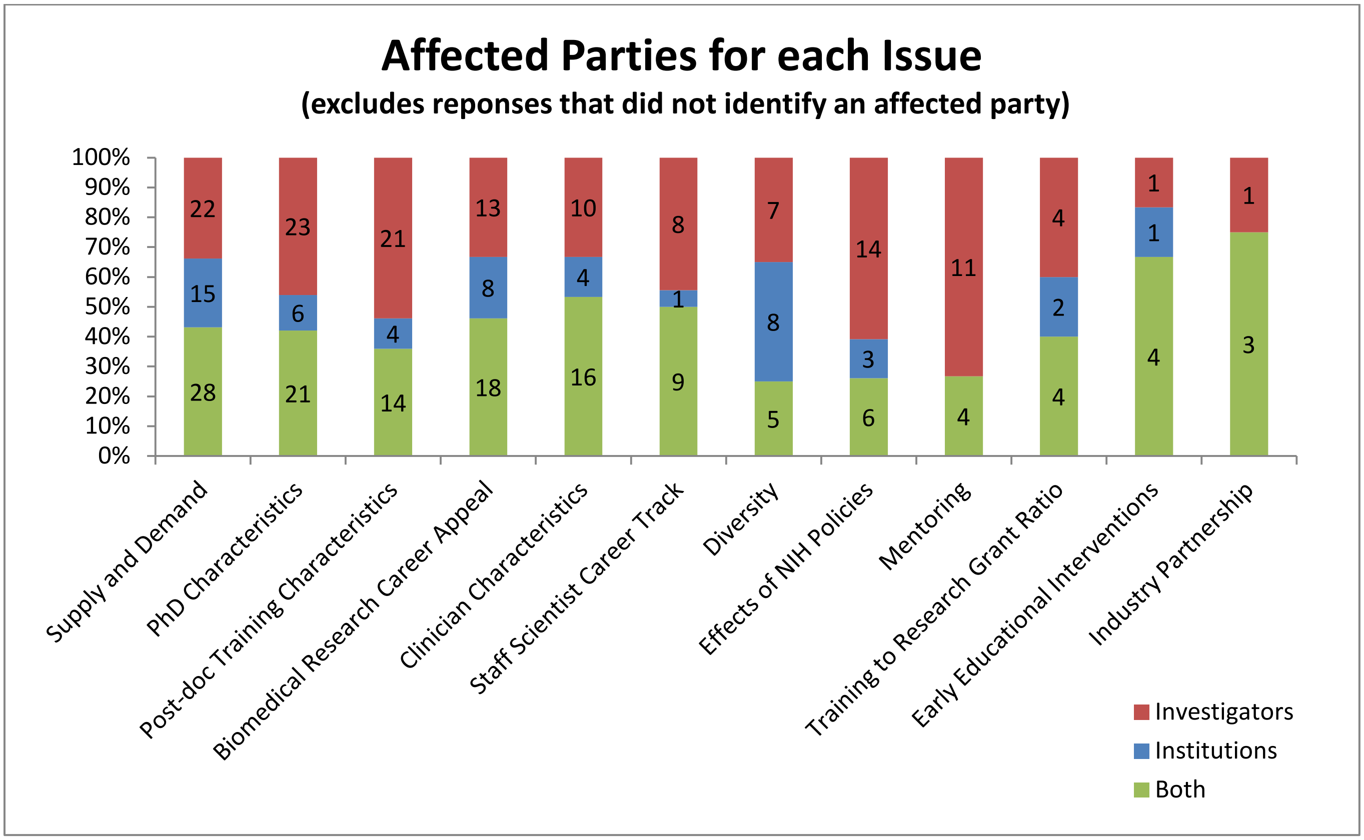
Comment Catergories (By Frequency)

	Count	Percent
Supply and Demand	97	19%
PhD Characteristics	84	17%
Post-doc Training Characteristics	62	12%
Biomedical Research Career Appeal	53	11%
Clinician Characteristics	44	9%
Staff Scientist Career Track	36	7%
Diversity	32	6%
Effects of NIH Policies	29	6%
Mentoring	24	5%
Training to Research Grant Ratio	19	4%
Early Educational Interventions	11	2%
Industry Partnership	7	1%

Issues by Affiliation




Distribution of Issues for each Affected Party
30
25
20
15
10
5
0
Institutions
Investigators
Both
Supply and Demand
PhD Characteristics
Post-doc Training Characteristics
Biomedical Research Career Appeal
Clinician Characteristics
Staff Scientist Career Track
Diversity
Effects of NIH Policies
Mentoring
Training to Research Grant Ratio
Early Educational Interventions
Industry Partnership


Affected Parties for each Issue
(excludes reponses that did not identify an affected party)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Supply and Demand
PhD Characteristics
Post-doc Training Characteristics
Biomedical Research Career Appeal
Clinician Characteristics
Staff Scientist Career Track
Diversity
Effects of NIH Policies
Mentoring
Training to Research Grant Ratio
Early Educational Interventions
Industry Partnership
22 15 28
23 6 21
21 4 14
13 8 18
10 4 16
8 1 9
7 8 5
14 3 6
11 4
4 2 4
1 1 4
1 3
Investigators
Institutions
Both

Primary Issues and Descriptions

Issue	Description
Biomedical Research Career Appeal	Issues related to the attractiveness of biomedical research careers (e.g. salary, working conditions, availability of research funding)
Clinician Characteristics	Characteristics of clinician-research training including issues such as: • The balance between MDs and MD/PhDs • Career development of clinician-researchers. • Recommendations for changes to the curricula for training clinician-researchers.
Diversity	Under-represented minority post-doctoral, fellows and junior faculty.
Early Educational Interventions	Need for interventions prior to graduate-level training, including: • K-12 science interventions • Undergrad interventions • Post-bac/Pre-doc programs
Effects of NIH Policies	The effect of changes in NIH policies on investigators, grantee institutions and the broader research enterprise.
Industry Partnership	Problems related to relationships between academic research and commercial industry research. Examples are: • industry use of academic discovery • difficulty of industry scientists returning to academia • partnering with industry to train new scientists
Mentoring	The need to improve the quality of career development at institutions. Guidelines and monitoring of mentorships is needed as there is a lack of non-research science skills being taught.
PhD Characteristics	Characteristics of PhD training in biomedical research, including issues such as: • The length of the PhD training period. • Recommendations for changes to the PhD curriculum. • Training for multiple career paths (including bench and non-bench science).
Post-doc Training Characteristics	Length of Post-doctoral training.
Staff Scientist Career Track	Possibilities for professional/staff scientist positions and the level of training required for such positions (e.g. PhD or MSc degrees).
Supply and Demand	The balance between supply, including the number of domestic and foreign trained PhDs and post-doctoral fellows, and demand, i.e. post-training career opportunities.
Training to Research Grant Ratio	The ratio of PhD students and post-doctoral fellows on training grants to those supported by research grants.

Secondary Issues and Descriptions

Overlapping	Descriptions
Funding	Uncertainty and lack of funding, distribution of funding, restricted paylines, success rates, indirect costs, excessive competition
Multi-disciplinary	Need for multi/ inter/ trans-disciplinary research training to prepare trainees for a wide range of academic and non-academic career opportunities
Salary	Inadequate compensation and benefits
Length of Training	Amount of training time too long to be feasible for majority
Non-US Citizens	Foreign students and post-doctoral fellows
Career appeal	Working conditions (e.g. heavy workload, perception of being used as cheap labor, long work hours)
Mentoring	Quality of career development and the need for pre-college preparation
Diversity	Under-represented minority post-doctoral, fellows and junior faculty

H: Report of NIH/TAC Workforce Committee (NTW)

NIH/TAC Workforce (NTW) Committee

Report to the Biomedical Workforce[69] Working Group on NTW Deliberations

December 6, 2011

[69] The Biomedical Workforce (BMW) Working Group is a subcommittee of the NIH Advisory Committee to the Director (ACD)

Introduction

The NTW Committee[70] explored different scenarios for NIH's role in the support of training the future biomedical research workforce (biomedical, unless otherwise noted, includes the biomedical, behavioral, social and clinical sciences). The scenarios developed in this document are intended to provide a framework for discussion about how NIH supports research training and possible avenues for change. The biomedical research workforce comprises not only independent research scientists, but also a much larger component, the trainees themselves. This obvious point is made to emphasize that any scenario that results in a reduction in the size of the trainee pool also reduces the size of a vital component of the workforce, with significant financial consequences.

NIH support of research training and education is focused at the predoctoral, postdoctoral, and early career stages of a biomedical scientist's career. NIH also supports diversity-promoting programs at all these career stages, as well as at the high school and undergraduate levels. Although the committee did not explore possible changes to these diversity programs, it did consider the impact of these scenarios on NIH's diversity efforts. NIH also supports short-term and science outreach and education programs that encompass the K - 12 grade levels. Although rigorous science education at these early grades is absolutely essential to creating a well-prepared pipeline of individuals for NIH's programs at the graduate level and beyond, NIH activities at the K - 12 stage generally provide for short-term interventions and thus constitute a smaller contribution to science education at these earlier grade levels.

A recurring theme throughout these scenarios is the importance and effectiveness of NIH formal research training programs (namely, institutional training, fellowship and career development awards) versus training supported by research grants. The formal training programs are peer reviewed not only for the excellence of the science proposed, but also for the excellence of the proposed training and the training potential. Formal training awards can also be targeted to emerging scientific disciplines and to areas of national need. Of particular note, formal training programs have played a vital role in creating incentives for increasing the diversity of the workforce pipeline. Research grants play little, if any, such role in developing a more diverse biomedical workforce. Given the important role that formal training programs play in research training, it is a concern that less than half of the individuals earning a research doctorate in the biomedical sciences in 2009 were ever supported by an NIH formal training mechanism.[71]

The committee made NO distinctions among the careers of individuals engaged in biomedical research in academia, industry, government, or any other sector; these were NOT considered 'non-traditional' or 'alternative' careers. The committee felt it was important not to confuse these careers with truly alternative or non-traditional careers, such as science policy, law, finance, and teaching at K-12 levels or at institutions where there is little or no research activity.

The committee made the distinction between the career paths of the majority of biomedical research scientists, namely PhD recipients, and the much smaller population of clinician scientists (individuals holding the MD, DO, DDS, DVM, DN, or equivalent clinical doctorate degrees who are research scientists). Clinician scientists generally do not receive support from the NIH for their clinical training, except for those enrolled in formal combined degree programs. The committee also notes the

[70] Background and membership of the NTW Committee is in the Appendix.
[71]NIH Supported Ph.D. Recipients in the NIH Data Book, at: http://report.nih.gov/NIHDatabook/Charts/Default.aspx?showm=Y&chartId=268&catId=21

differences in immediate career options for clinicians, who may fall back on clinical practice for their livelihoods, and PhD researchers, whose options are more limited. On the other hand, clinician scientists face demands on their time for research activities that are not generally encountered by PhD scientists.

The committee did not take a position on whether we are producing too many or too few scientists, although the number of PhD graduates in the biomedical sciences (excluding behavioral, social and clinical sciences) increased by nearly 40% in the past decade (to well over 7,000 in 2010). It is difficult to argue that during this same period opportunities for research doctorate scientists in the biomedical workforce grew at this pace. Many argue that this is not a major concern because the individuals who were trained acquired skills that can be of utility in a broad range of careers. Others argue that, although true, many of these non-traditional careers don't necessarily require a research doctorate in science, nor the requisite investment of time in training. Thus, the committee essentially developed scenarios from two opposing positions:

A) NIH should support primarily the training of independent research scientists; or

B) NIH should support training for a wide range of research and non-traditional careers.

The committee proposed policy changes that could be considered consistent with Position A or B.

Relevant to Position B, the recent paper by Furhmann[72] et al. provides insight into what sorts of careers current graduate students at a top tier graduate institution are actually considering, and at what point during their training they are making such choices. These choices are being made relatively early in their graduate training, and include science education, science policy, the business of science, law-related occupations, and science writing, among others. The NTW committee developed several scenarios based on these findings.

The biomedical sciences workforce pipeline is a continuum, but the focus of the scenarios in this report is on three distinct training and career stages of biomedical scientists, namely:

A) **Predoctoral training**
B) **Postdoctoral training**
C) **Early career development**

There are more policy options and leverage at the beginning of the career continuum, since changes made early in the training stages have greater potential to align the numbers of individuals in training to existing opportunities, especially in the long term. Conversely, policy and programmatic changes later in the training pipeline offer fewer opportunities for realignment; in addition, they cannot easily address the current population of individuals already at the Early Career stage. In the Early Career stage, the committee struggled with how to retain highly trained individuals in the research workforce without impacting the research grant budget. For this reason, the committee chose not to reduce the large postdoctoral pool directly but to make changes earlier in the training pipeline and allow workforce supply and demand to self-correct.

The scenarios in each career stage represent moderate to significant policy changes required of the NIH, depending on the desired outcome. There were varying levels of support for the different scenarios from the full NTW committee; however, most disagreement was manifested in the scenarios for the Early Career stage, for the reasons mentioned above. In addition, committee members noted that

[72] Improving Graduate Education to Support a Branching Career Pipeline: Recommendations Based on a Survey of Doctoral Students in the Basic Biomedical Sciences. (Fuhrmann, et al, CBE—Life Sciences Education, Vol. 10, 239–249, Fall 2011) http://www.lifescied.org/content/10/3/239.full

solutions that work for one biomedical discipline may not work for another, and that particular NIH Institutes and Centers might have unique issues. Finally, for all scenarios, there was concern that some of the policy changes could impact efforts to create a more diverse workforce, but there was agreement that adjustments in policies were possible to minimize or eliminate these effects.

Predoctoral Career Stage

We considered three scenarios for NIH's role in supporting research training at the predoctoral level.

The first scenario (1A) assumes that the NIH should support only the training of independent research scientists. This scenario focuses on the selection (at the time of graduate school admission) of those students most likely to pursue careers as research scientists. It incentivizes graduate schools to be more selective in their admissions process, making them more financially responsible for supporting students who do not successfully compete for formal training awards and restricting the use of NIH research grants for such support. The advantage of this scenario, if pursued, is that the overall quality of graduate students would improve over time; implementation of this scenario would also significantly reduce the number of graduate students in the biomedical workforce.

The second scenario (1B) acknowledges the large number of students who enroll in biomedical science graduate programs but moves them into 'non-traditional' career training tracks that do not require a biomedical research doctorate degree. This scenario accepts the current graduate admissions process, but requires institutions receiving NIH support for research or formal training to track the career intentions of supported students. Formal NIH training support would be reserved for those students exhibiting clear plans to engage in research careers. Students who intend 'non-traditional' careers, although ineligible for formal NIH training programs, could be hired as research assistants on research grants to help support their training for careers other than research science. Alternatively, students who intend 'non-traditional' careers but wish to pursue the research doctorate could earn multiple degrees (for example, both the PhD and MBA). The advantage of this scenario is that it would allow students to enter into a career trajectory that matches their career intentions much sooner than most do now. It would be difficult to implement this scenario since students may be reluctant to self-identify their intention to pursue a 'non-traditional' career. This scenario, like the scenario above, would also significantly reduce the number of graduate students in the biomedical workforce.

The third scenario (1C) also acknowledges a broader range of career outcomes, but retains students in the research doctorate track. Institutions would be required to provide broader training within the research doctorate program that would prepare all students for both research and 'non-traditional' careers. This broader training would take place while students pursued their research doctorate degrees.

1A: Training Graduate Students Exclusively for Research Careers

Change from Current

Significant change

Assumptions

- The NIH currently supports the graduate research training of many more individuals than there are opportunities for independent investigators in academia, industry, and government.
- Most NIH support for graduate students is provided by research grants rather than by formal training. This approach affords the NIH little control over the number of students trained, their fields of study, the quality of research training, or the diversity of the trainees.
- The imbalance in the supply and demand of research scientists has led to longer periods ‘in training’ beyond the receipt of the PhD degree, as individuals wait for opportunities to materialize.
- This situation is discouraging some of the most talented college graduates from pursuing a biomedical research career. Graduate school admissions decisions are driven by incentives other than future workforce needs, including demand for graduate researchers and teaching assistants and the availability of extramural research funds for their support.
- Institutions are responsible for a small fraction of a graduate student’s financial support; the balance comes from research grants and, to a lesser extent, from training grants and individual fellowships.

Scenario Overview

- Significantly increase the proportion of PhD recipients that move into careers as independent research scientists, and significantly reduce the number of biomedical graduate students.

- Maintain the number and quality of NIH predoctoral institutional training programs and individual fellowships, encouraging their use in emerging, multidisciplinary, or interdisciplinary fields, as future needs dictate.
- Incentivize institutions to admit fewer (and more promising) students by holding them responsible for an increasing proportion of their total funding. This new paradigm could be phased in relatively quickly for maximal impact or over a number of years for less disruption to the current system, and might involve:
  - Requiring institutions to be more selective in choosing graduate students or to pay a larger proportion of graduate student support out of their own funds.
  - Restricting the use of research grant support for graduate students to those who have been previously supported by NIH formal training programs.
  - Limiting the total number of years of research grant support for graduate students.

Intended Outcome

Prepare the most talented students for careers as independent research scientists in numbers that are more aligned with current and projected demand.

Supporting Data

- Total graduate enrollment and first-time, full-time enrollment (NIH Data Book) http://report.nih.gov/NIHDatabook/Charts/Default.aspx?showm=Y&chartId=227&catId=19
- Primary mechanisms of graduate support (NIH Data Book) http://report.nih.gov/NIHDatabook/Charts/Default.aspx?showm=Y&chartId=235&catId=19
- Career Outcomes of NRSA Trainees/Fellows vs. Other Biomedical PhDs (National Research Council. 2011. Research Training in the Biomedical, Behavioral, and Clinical Research Sciences. Washington, DC: The National Academies Press.) http://grants.nih.gov/training/Research_Training_Biomedical.pdf

Type of individuals	Number of Years Followed	% receiving an NIH RPG
NRSA trainees and fellows	15	24.9%
Non-NRSA-supported individuals receiving PhDs from institutions with NRSA training grants	15	7.0%
Non-NRSA-supported individuals receiving PhDs from institutions without NRSA training grants	15	2.7%

- Comparison of PhD graduates to NIH awardees (Survey of NIH Support of Physician Scientists Post-Graduate Years to First Major Research Project Grant – A Report to the NIH Deputy Director for Extramural Research, September 20, 2011)
  - 8,021 individuals graduated with PhDs in biological/biomedical sciences in 2009
  - 2,214 (27.6%) of the PhD graduates had received NIH training grant or fellowship support during the course of their training
  - Only 650 Early-Stage Investigators (ESIs) with PhD degrees received R01 research awards in FY2010
- Expected funding growth and projected workforce size (National Research Council. 2011. Research Training in the Biomedical, Behavioral, and Clinical Research Sciences. Washington, DC: The National Academies Press.) (http://grants.nih.gov/training/Research_Training_Biomedical.pdf)
  - "For 2006, total U.S. biomedical research funding, from government, industry, and foundations, was $93.4 billion, or $262,000 per scientist . . . Real growth in funding, from 2003 to 2007, was 3.4 percent annually. If the growth rate stays at this level (or declines because of recession), funding growth will be slower than the projected growth of the . . . workforce."
- Life sciences doctorate holders that ever held a postdoctoral position (NSF Science and Engineering Indicators 2010, Chapter 3) http://www.nsf.gov/statistics/seind10/pdf/c03.pdf
  - The percentage of life sciences doctorate holders that ever held a postdoctoral position has increased from 46% (for those who received their doctorate before 1976) to 60% (for those receiving their doctorate in 2002-2005)

Analysis of the Scenario

Pros	Cons
• Incentivizes graduate schools to be more selective in their admissions and admit fewer, but more qualified, students • Allows for some NIH influence on the number of students trained, their fields of study, and the quality of their research training • Maintains incentives for diversity recruitment and retention on NIH formal training programs • Encourages students unlikely to become independent or lead investigators to seek other career paths earlier in their lives • Aligns the number of graduate students more closely with the number of positions for independent research scientists in academia, industry, and government • May benefit universities if it encourages the development of more tuition-generating graduate programs • Use of Professional Science Masters (PSM) programs increases the attractiveness of biomedical research careers by reducing the oversupply of research scientists and the number of trained research doctorates entering ‘non-traditional’ careers	• Significantly impacts the biomedical workforce by reducing the size of the least expensive component of the research workforce • Further increases the demand for postdoctoral research associates unless other limits are placed on their numbers • May increase research costs, if the cost for alternative staff exceeds that for graduate research assistants • May significantly decrease opportunities for foreign graduate students to study in the US, unless they bring their own funds • May limit the opportunities of institutions without NIH training grants • May result in an insufficient supply of PhD scientists prepared to serve as independent research scientists, if future workforce needs suddenly and significantly increase • Limits eligibility on formal training awards to US citizens and permanent residents (unless a broad definition of “NIH training programs ” is used)

1B: Tracking Graduate Students into Research or Non-Traditional Careers

Change from Current

Significant Change

Assumptions

- The number of graduate students pursuing PhD degrees in the biomedical sciences continues to increase, although opportunities for these individuals to pursue doctoral-level research in academia, industry, academia, and government do not.
- Graduate students play an important role in the biomedical research workforce, regardless of whether they ultimately pursue research careers.
- In many instances, graduate students make decisions about 'non-traditional' careers early in their PhD training.
- Doctoral education in the biomedical sciences provides important and transferable skills that can be applied to a broad range of research and 'non-traditional' careers.
- Despite their high-level skills, students in the biomedical sciences often feel that they are trained too narrowly to readily enter the workforce and transition to 'non-traditional' careers.

Scenario Overview

- Incentivize graduate school programs to monitor the career intentions of students in their early years of graduate study, and to be responsible for supporting students that have interests in 'non-traditional' careers.

- Maintain the number and quality of NIH predoctoral institutional research training programs and individual fellowships, restricting trainee appointees to students focused on a research career.
- Require institutions with NIH support for training or research to track biomedical graduate students' career intentions throughout their graduate career.
- Implement one of the following options to provide students with access to career pathways that do not require a research doctorate in biomedical science.
  - Option 1: require institutions to provide alternative educational opportunities to students who don't intend to pursue research careers after three or four years of graduate school. This could be accomplished by requiring or encouraging training program directors to develop agreements with other professional schools at their institution to ensure the matriculation of trainee appointees with 'non-traditional' career interests.
  - Option 2: require institutions to move students who don't intend to pursue research careers into more appropriate training in other professional schools/divisions within their university. In this case, students would no longer be eligible for NIH formal training support.
- Enforce all NIH formal training award requirements, including the expectation that appointed trainees or awarded fellows intend careers as research scientists.
- Allow all students, including those with research or 'non-traditional' career intentions, to continue to be supported on NIH research grants as employees.

Intended Outcome

Provide the opportunity for individuals early in their graduate school training to select a career option other than biomedical research.

Supporting Data

- Graduate enrollment in the biomedical sciences, by citizenship (NIH Data Book) http://report.nih.gov/NIHDatabook/Charts/Default.aspx?showm=Y&chartId=252&catId=19
- National Research Council. 2011. Research Training in the Biomedical, Behavioral, and Clinical Research Sciences. Washington, DC: The National Academies Press.) http://grants.nih.gov/training/Research_Training_Biomedical.pdf
- Improving Graduate Education to Support a Branching Career Pipeline: Recommendations Based on a Survey of Doctoral Students in the Basic Biomedical Sciences. (Fuhrmann, et al, CBE—Life Sciences Education, Vol. 10, 239–249, Fall 2011) http://www.lifescied.org/content/10/3/local/complete-issue.pdf

Analysis of the Scenario

Pros	Cons
• Moves students to training tracks that align with their career aspirations more quickly • Brings large numbers of students into the pipeline early and increases chances of more talent eventually being directed to biomedical research careers • Maintains opportunities for foreign graduate students to study in the U.S. • Could make graduate school a more attractive option to talented college graduates by recognizing a broader range of career outcomes • Increases the technical skills and overall scientific literacy of the U.S. workforce • May increase income for graduate schools by transferring more students into alternative tuition-generating programs • Maintains current predoctoral biomedical workforce levels at no increase in costs by allowing students to be research assistants as employees	• Would be very difficult to support those students tracking into training not involving biomedical research doctorate degree • Creates disincentive for students to identify themselves as not aspiring to a career as a research scientist, unless support for alternative tracks is available • May impact the cost of doing research • Reduces the number of postdocs if many predocs are tracked out of research this early, thus increasing the cost of doing research • Requires institutions to acquire outside funding to support student movement to other programs or schools

1C: Training Graduate Students for a Wider Range of Science-Related Careers

Change From Current

Moderate Change

Assumptions

- The number of graduate students pursuing PhD degrees in the biomedical sciences continues to increase, although opportunities for these individuals to pursue doctoral level research science in industry, academia and government do not.
- Foreign students now constitute close to 30% of graduate school enrollment in the biomedical sciences.
- Graduate students play an important role in biomedical research, in part by providing a low-cost workforce, regardless of whether they ultimately pursue research careers.
- Doctoral education in the biomedical sciences provides skills that can be applied to a broad range of careers.
- Despite their high-level skills, students in the biomedical sciences often feel that they are trained too narrowly to readily transition to non-research careers.

Scenario Overview

- Align biomedical graduate school training and educational experience with the reality that students will pursue a range of career outcomes aside from research science, and provide them with a broader set of skills to prepare for such careers.

- Maintain current number of predoctoral positions in NIH formal training programs, but require these programs to develop skills beyond biomedical research to ensure flexibility in career choices.
- Require institutions with support for training or research to prepare students for a wider range of science careers by providing them with training in areas such as written and oral communications, collaboration, management, teaching, business culture, science policy, regulatory policy, etc) , as they match both the institution's resources and the career choices of its graduate students.
- Extend these expectations to all graduate students supported by NIH research grants.

Intended Outcome

Students would earn research doctorate degrees in biomedical sciences, but would be better prepared to embark on careers related to science.

Supporting Data

- Total graduate enrollment and first-time, full-time enrollment (NIH Data Book)
  http://report.nih.gov/NIHDatabook/Charts/Default.aspx?showm=Y&chartId=227&catId=19

- Improving Graduate Education to Support a Branching Career Pipeline: Recommendations Based on a Survey of Doctoral Students in the Basic Biomedical Sciences. (Fuhrmann, et al, CBE—Life Sciences Education, Vol. 10, 239–249, Fall 2011) http://www.lifescied.org/content/10/3/local/complete-issue.pdf

- National Research Council. 2011. Research Training in the Biomedical, Behavioral, and Clinical Research Sciences. Washington, DC:The National Academies Press. http://grants.nih.gov/training/Research_Training_Biomedical.pdf

Analysis of the Scenario

Pros	Cons
• Fulfills research workforce needs at low cost • Students benefit by having their education expenses paid • Benefits graduate students by providing enhanced training and mentoring for wide variety of career options related to science • Brings large numbers of students into the pipeline early and increases chances of more talent eventually being directed to biomedical research careers • Requires few policy changes (aside from those related to RPGs) in NIH-funded research and training • Maintains opportunities for foreign graduate students to study in the U.S. • May make graduate school a more attractive option to talented college graduates by recognizing a broader range of career outcomes • Increases the technical skills and overall scientific literacy of the U.S. workforce	• Unlikely to increase the proportion of graduate students becoming independent research scientists • Could add to the length of PhD training by adding a wider range of training activities to prepare students for various careers • Prepares large numbers of individuals for career roles that support a research enterprise that is not itself growing • Debatable that a PhD degree, and the attendant lengthy training period, are essential for all non-traditional career outcomes • Difficult to justify NIH research training dollars being used to support individuals pursuing careers that may only be tangentially related to science

Postdoctoral Career Stage

Two scenarios were developed for the postdoctoral career stage.

The first scenario (2A) limits NIH formal training support to individuals most likely to continue in careers as research scientists, with greater emphasis on high quality career development experiences. If this scenario were implemented, the number of postdoctoral positions on research grants would be significantly limited. An advantage of this scenario is that postdoctoral scientists would be better prepared to become independent research scientists because they would receive higher quality research experiences with an emphasis on mentoring. A disadvantage of this scenario is that the numbers of postdoctoral scientists in the workforce would be significantly reduced.

The second scenario (2B) would align the postdoctoral experience to the reality that not all individuals will move on to careers as independent research scientists. NIH formal training programs would be changed to include a broadening of training experiences beyond laboratory research. The breadth of these experiences would be determined by the historical outcomes of postdoctoral scientists and the resources available at the host institution. Support of postdoctoral scientists on research grants would continue to be allowed, but additional requirements would be instituted so that they would receive the same level and type of training no matter their funding source (research awards, fellowships, or training grants). The overall advantage of this scenario is that it would preserve the pool of postdoctoral scientists as a large and important component of the biomedical workforce, while at the same time ensuring that postdoctoral scientists are better prepared to move on to careers other than research science. The disadvantage of this scenario would be that postdoctoral productivity would likely decrease, as postdoctoral scientists invest more time in broader training and less time in research.

Both scenarios call for maintaining the NIH career development award programs for those postdoctoral scientists most likely to become independent or lead scientists, with a shift toward more support of transition to independence programs.

2A: Training Postdoctoral Fellows Exclusively for Research Careers

Change from Current

Significant Change

Assumptions

- The NIH is currently supporting the postdoctoral training of more individuals than there are opportunities for independent research scientists in academia, government, and industry.
- Retention of a very large pool of scientists 'in training' for a prolonged time makes biomedical research a less attractive career choice to the best and brightest domestic students .
- The numbers of postdoctoral scientists are dependent on the rate of U.S. PhD production and, to a larger extent, the recruitment of foreign postdoctoral scientists who, because of cultural and language differences, may not be fully contributing to or benefiting from the intellectual environment.
- The time of postdoctoral training is indefinite and can be as long as, or even longer than, the predoctoral training.
- The compensation of biomedical postdoctoral scientists does not reflect their years of professional training and experience, and lags behind the compensation of postdocs in other science areas.

Scenario Overview

- Target NIH formal training support to individuals most likely to continue in careers as research scientists with the emphasis on high quality career development experiences

- Shift the balance in Kirschstein-NRSA postdoctoral training so that a greater proportion of PhD training occurs through fellowships rather than training grants

- Reduce the current NIH guidance on the appropriate length of the postdoctoral period from 5 years to 4 years.

- For Kirschstein-NRSA and Career Development Programs:
    - Limit the number of formal institutional training positions for postdoctoral scientists, encouraging their use in emerging, specialty, multidisciplinary, or interdisciplinary fields and shifting other postdoctoral training positions to individual postdoctoral fellowships.
    - Increase the starting postdoctoral trainee and fellowship stipend to levels comparable to those provided to postdoctoral researchers in other science fields.
    - Expand the use of transitional career development awards for advanced postdoctoral fellows.

- For research grants:
    - Require that postdoctoral scientists supported by research grants are within five years of receipt of their terminal doctoral degree.

- Limit the support of postdoctoral scientists on research grants by adopting one or more of the following policies:
  - Require individual development plans of all postdocs supported by NIH funding.
  - Mandate full employee benefits for all individuals supported on research grants that are at or above the postdoctoral level.
  - Reduce the indirect cost rate to 8% for postdoctoral positions on research grants.

Intended Outcome

With an emphasis on high quality research experiences, provide for the professional development of postdoctoral individuals so that they are fully prepared for research careers.

Supporting Data

- Postdoctoral Population in the US in Biomedical Sciences (NIH Data Book) http://report.nih.gov/NIHDatabook/Charts/Default.aspx?showm=Y&chartId=255&catId=20
- Funding success of Early-Stage Investigators with PhD Degrees. (Survey of NIH Support of Physician Scientists Post-Graduate Years to First Major Research Project Grant – A Report to the NIH Deputy Director for Extramural Research, September 20, 2011, Data from IMPAC II)
  - 650 Early-Stage Investigators with PhD Degrees received R01 funding in FY2010.
- Expected funding growth and projected workforce size (National Research Council. 2011. Research Training in the Biomedical, Behavioral, and Clinical Research Sciences. Washington, DC:The National Academies Press.) http://grants.nih.gov/training/Research_Training_Biomedical.pdf
  - "For 2006, total U.S. biomedical research funding, from government, industry, and foundations, was $93.4 billion, or $262,000 per scientist . . . Real growth in funding, from 2003 to 2007, was 3.4 percent annually. If the growth rate stays at this level (or declines because of recession), funding growth will be slower than the projected growth of the . . . workforce."
- Starting Postdoctoral Stipends in 2009 (Doctorate Recipients from U.S. Universities: 2009, NSF) http://www.nsf.gov/statistics/nsf11306/data_table.cfm#44
  - Note: Kirschstein-NRSA Stipend, 2009: $37,368 (NOT-OD-09-075)

Field	Starting Salary
Biological/biomedical sciences	$37,500
Chemistry	$37,500
Psychology	$37,500
Physics and astronomy	$45,000
Earth, atmospheric, and ocean sciences	$45,000
Economics	$55,000

- Career Outcomes of Kirschstein-NRSA Postdoctoral Fellows Compared to Kirschstein-NRSA Postdoctoral Trainees (http://grants.nih.gov/training/NRSA_report_5_16_06-2.doc)

	Kirschstein-NRSA postdoctoral fellows	Kirschstein-NRSA postdoctoral trainees
Application rate for a subsequent R01 research award	48.3%	32.5%
Funding rate for subsequent R01 research award	63.3%	50.0%
Average time to receive subsequent R01 research award	5.3 years	6.5 years

Analysis of the Scenario

Pros	Cons
• Aligns the number of postdocs more closely with the number of positions as independent investigators in academia, industry, and government • Benefits postdocs by providing stipends more consistent with their professional qualifications • Accelerates the development of independent investigators, and shortens the time to research independence • Encourages individuals to seek other career paths sooner if they are unlikely to, or uninterested in, becoming independent research scientists • Could lead to an increase in "career staff scientist" positions at institutions • Could increase the attractiveness of biomedical research careers in the long term • Shifts the emphasis of the post doc experience away from workforce needs and towards professional development	• Substantially reduces the size of a major component of the biomedical workforce • Could limit opportunities for foreign PhDs to obtain postdoctoral training in the US and limit their contributions to US science • Could increase the demand for graduate students to fill workforce needs, if no limits are placed on their supply • Could increase research costs if the cost of alternative staff exceeds that of postdocs

2B: Training Postdoctoral Fellows for a Wider Range of Careers

Change from Current

Significant Change

Assumptions

- There are more postdoctoral individuals in training than there are opportunities for employment as research scientists.
- These numbers are directly dependent on the rate of U.S. PhD production, and the recruitment of foreign postdocs.
- As evidenced by their large numbers, postdocs fill an important need in the biomedical research workforce, although their compensation does not align with their level of training and experience.
- A small proportion of postdocs will become research scientists; transition awards facilitate their transition to independence.
- Many postdocs will not become independent or lead scientists, but may play valuable roles in the support of the research establishment, either directly as research staff scientists, or in careers that relate to or support the biomedical research enterprise.
- Postdoc experiences should align with this broad range of possible career options.

Scenario Overview

- Align the postdoctoral experience to the reality that not all individuals will move on to careers as independent research scientists

- Maintain the current level of postdoctoral positions in NIH formal training programs but change requirements to include a broadening of training experiences beyond laboratory research, determined by the historical outcomes of postdoctoral fellows at that institution, and utilizing the resources available at the host institution.
- Shift more support to transitional career development award programs for postdoctoral fellows most likely to become independent research scientists.
- Continue to allow support of postdoctoral fellows on research grants, but with identical requirements of NIH formal training programs.
- Increase the starting postdoctoral trainee and fellowship stipend to levels comparable to those provided to postdoctoral researchers in other science fields.

Intended Outcome

Preserve postdoctoral fellows as a large and important component of the biomedical workforce, but ensure that they are better prepared to move on to both research and 'non-traditional' careers.

Supporting Data

- Postdoctoral Population in the US in Biomedical Sciences (NIH Data Book) http://report.nih.gov/NIHDatabook/Charts/Default.aspx?showm=Y&chartId=255&catId=20
- Funding success of Early-Stage Investigators with PhD Degrees. (Survey of NIH Support of Physician Scientists Post-Graduate Years to First Major Research Project Grant – A Report to the NIH Deputy Director for Extramural Research, September 20, 2011, Data from IMPAC II)
  - 650 Early-Stage Investigators with PhD Degrees received R01 funding in FY2010.
- Expected funding growth and projected workforce size (National Research Council. 2011. Research Training in the Biomedical, Behavioral, and Clinical Research Sciences. Washington, DC:The National Academies Press.) http://grants.nih.gov/training/Research_Training_Biomedical.pdf
  - "For 2006, total U.S. biomedical research funding, from government, industry, and foundations, was $93.4 billion, or $262,000 per scientist . . . Real growth in funding, from 2003 to 2007, was 3.4 percent annually. If the growth rate stays at this level (or declines because of recession), funding growth will be slower than the projected growth of the . . . workforce."
- Starting Postdoctoral Stipends in 2009 (Doctorate Recipients from U.S. Universities: 2009, NSF) (http://www.nsf.gov/statistics/nsf11306/data_table.cfm#44)
  - Note: Kirschstein-NRSA Stipend, 2009: $37,368 (NOT-OD-09-075)

Field	Starting Salary
Biological/biomedical sciences	$37,500
Chemistry	$37,500
Psychology	$37,500
Physics and astronomy	$45,000
Earth, atmospheric, and ocean sciences	$45,000
Economics	$55,000

Analysis of the Scenario

Pros	Cons
• Maintains a vital component of the biomedical research workforce • Prepares postdocs for the wide range of careers they will enter • Maintains the current open-door policy for foreign postdocs which potentially brings a wide array of talent to the US biomedical research enterprise • Increases the technical skills and overall scientific literacy of the U.S. workforce	• Maintains the current number of postdoctoral fellows without addressing the disparity between supply and biomedical workforce demand • Trains postdocs for science-related careers that likely do not require extensive postdoc laboratory research experience • Will reduces research productivity if training for non-traditional careers is expected for all postdocs • Does not mitigate opportunity costs being

Pros	Cons
	incurred by postdocs who are undergoing protracted 'training' that limits their long-term earning power • Does not address the unattractive career outlook for postdocs (i.e., no retirement fund, health benefits, etc.) when compared to other professionals at comparable career stages • Fails to increase the chances for postdocs to become independent or lead investigators unless there are substantial limits placed on the number of PhDs awarded • Increasing stipends will raise overall research costs

Early Career Stage

At this career stage, the committee felt that there were no major policy changes that NIH could implement to alleviate the current situation of large numbers of senior postdoctoral scientists seeking a limited number of job opportunities as research scientists. Nevertheless, the committee did develop two scenarios to describe possible NIH action.

One scenario (3A), for which there was modest enthusiasm, was the creation of a 'lifeline' award to keep early career scientists in the biomedical workforce so that they could eventually compete for full research grant support. The award would allow senior postdoctorates to initiate independent research projects. This scenario is unique in that the award program would be counter-cyclical; when academic, industrial and government research scientist openings are abundant, NIH would limit the number of awards. Likewise, when these openings are very limited, NIH would increase the funding of this program. Although we include this scenario for BMW consideration, we note that the committee was not very enthusiastic. Implementation of the scenario would drain dollars from regular research grants, and would simply postpone resolving disparities between supply and demand.

The second scenario (3B) proposes a program to support staff scientists as part of a team of individuals providing core services to laboratories with NIH research grant support. Unlike the first scenario, these individuals would not be expected to become independent research scientists. Rather, they would bring new technical competencies to the institution and provide intellectual input to the supported laboratories. The purpose of this program would be to provide an NIH supported career pathway for highly trained research doctorates who might otherwise leave the workforce, while at the same time perhaps creating a more efficient research infrastructure. Some NIH Institutes currently offer such an award, but it is not clear if there is a strong enough demand for such an award on a trans-NIH basis.

3A: Supporting Research Scientists after Postdoctoral Training during Difficult Economic Periods

Change from Current

Significant Change

Assumptions

- A large proportion of the work on research grants is currently carried out by graduate students and postdoctoral fellows, who are sources of inexpensive temporary labor.
- External factors, such as the state of the economy and the amount of public support for research, currently drive career opportunities for postdoctoral researchers.
- At the moment, a sizeable group of very strong researchers are trapped in a career stage just beyond the postdoctoral pool.
- The nation cannot afford a "lost generation" of researchers. NIH needs to provide the opportunity to allow the best and brightest of the postdoc pool to advance.

Scenario Overview

- Create a research scientist career award mechanism aimed at recent postdoctoral individuals with the intention to provide a large fraction of the resources needed for institutions to establish a faculty appointment:
  - The award would be renewable, if the recipient has obtained independent research support by the time of renewal.
  - Provides a way to move postdoctoral researchers into positions where they can direct their own research.
- The concept is counter-cyclical; therefore, when faculty openings are abundant, NIH would limit the number of awards. When faculty openings are very limited, NIH would increase the funding of this program.

- Cost shift of funds that support postdocs on research awards to this award that allows them to work on research that is already funded on NIH research grants.
- Use an 8% overhead rate rather than the full overhead rate currently used for postdocs supported on research awards.

Intended Outcome

This award mechanism would help to retain highly trained research scientists in the biomedical workforce during difficult budget periods by moving them to awards with lower indirect costs, thereby reducing the number (and cost) of postdoctoral employees supported by research grants.

Supporting Data

AAMC Data Book (https://www.aamc.org/data/databook/)

Analysis of the Scenario

Pros	Cons
• Provides a way to move researchers into positions where they can direct their own research • Provides a way to manage resources that reflects the broader economic environment • Removes recent post-docs from research grants and replaces them with research scientists • Reduces overhead costs by using a lower indirect cost allowance • Provides a method to retain individuals who might otherwise be shifted out of science careers	• Redirects NIH dollars that might otherwise go to fund research awards or highly meritorious career development awards • Redirects funds away from the current model of using inexpensive student labor, which is a cost efficient way of accomplishing research • Is only a temporary solution; these individuals would need to either become permanently employed research scientists, or leave research science • Might support individuals that are in a "holding pattern" with their institution, and the institution may not be interested in providing a faculty position for such a person

3B: Supporting Career Staff Scientists

Change from Current

Incremental

Assumptions

- There is a cadre of highly-trained scientists emerging from post-doctoral training experiences that have exquisitely-developed technical skills and a scientific conceptual framework and depth that could play an invaluable role as career staff scientists and creative team members, beyond the capabilities of the best trained technicians.
- Career staff scientists make very substantive contributions to the biomedical research enterprise, generally serving more than one research project grant or subprojects of center grants.
- Career staff scientists are generally not suitable or competitive as Principal Investigators on their own research grant applications.
- Several NIH Institutes utilize the Research Core Center grant mechanism, i.e. P30, P50, P60, which typically support one or more research-serving cores providing centralized research resources, services and facilities to an aggregate of funded research grants with common technical needs.

Scenario Overview

- Support the hiring of staff scientists in core services laboratories with NIH research grant support. The career staff scientists will bring new technical competencies and scientific conceptual thinking to investigative teams that will promote the "cutting-edge" capabilities and productivity of individual projects.

- Creation and evaluation of pilot supplement program:
    - A limited number of such "career staff scientist cores" would be funded for a three-year experimental period to determine the Nation's pool of such individuals, the need, and the viability of the supplement to support such individuals.
- With the renewal of the center/core grant, the career staff scientist core position also could be renewed (without limitation of renewal periods).

Intended Outcome

Provide an NIH-supported, viable career pathway for individuals who might otherwise leave the biomedical workforce.

Analysis of the Scenario

Pros – for this Model	Cons – against this Model
• Provides increased opportunities for otherwise valuable scientists that are not suitable or competitive as Principal Investigators leading their own full-scale research grants. • Recovers some return on investment for the	• Core grant awards are not currently offered by all Institutes and Centers • Requires further justification since the need for these types of positions has not been clearly demonstrated

Pros – for this Model	Cons – against this Model
NIH funds already invested in training these individuals • Improves the quality of research done in core-supported labs since it will encourage the utilization of career staff scientists that have capabilities beyond those of the best trained technicians	• Would increase the "center" budget line and might be an unattractive option to some ICs

Clinician Scientists

The situation regarding research careers for clinician scientists[73] is very different than the situation discussed for research doctorates in the previous scenarios. While there are many PhD holders seeking limited research jobs (the domestic plus foreign postdoctoral pool is estimated to be more than 35,000[74] and growing), the number of clinician scientists at the postdoctoral level (post-residency) is much smaller. Additionally, only a small fraction of medical students express interest in careers as independent research scientists. This committee concentrated on the challenges to becoming a clinician scientist and considered the critical need for a comprehensive workforce infrastructure to support clinical-translational research as beyond the scope of this exercise.

The clinician scenario includes actions that NIH could take to support the careers of clinician scientists at three career stages: medical school, residency, and early career. For medical students, NIH could support more programs for short-term research experiences during medical school, and create more awards for 'year out' programs. At the residency level, NIH could create awards that support 'fast-tracking' in residency programs, thereby allowing clinicians to begin research careers sooner. At the early career stage, the NIH Loan Repayment Program could be extended to more clinicians by broadening the eligibility criteria. Finally, the NIH could create incentives for more team approaches to research that involve collaborations between clinician scientists and PhDs. Combined, or in part, these measures could contribute to increasing the numbers of clinicians who become scientific leaders by making careers more attractive and attainable.

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[3]For the sake of clarity, we use the term 'clinician scientist.' This could be any clinical doctorate (physician, DN, DDS, DVM, etc.) who also performs scientific research, including bench science, epidemiological work, outcomes research, etc. However, most of the available data pertain to MD degree holders and those who hold both MD and PhD degrees.

[74] Postdoctorates, by citizenship and gender (NIH Data Book) http://report.nih.gov/NIHDatabook/Charts/Default.aspx?showm=Y&chartId=255&catId=20

4A: Making Research Careers More Attractive for Clinician Scientists

Change from Current

Significant Change

Background Information

The group was instructed to place some boundaries around what issues would be addressed regarding clinician (or equivalent degree holders) scientists' involvement in biomedical and clinical research. While it was acknowledged that the clinical-translational research workforce encompasses a wide array of disciplines and skill sets, this group will concern itself with a more narrowly defined group: the scientific leaders in the clinical-translational research workforce, whether in industry, private research foundations, academia, or government.

With the data at hand, it is difficult to determine if we are preparing a sufficient number of clinicians as independent scientists for the biomedical workforce of the future. There is abundant anecdotal evidence of shortages in specific fields. Unlike the situation with the PhD pool of scientists, where the supply of research doctorates exceeds the demand, the number of clinician scientists (and certainly the legendary 'triple threat' individual: clinic; bench; classroom) has been declining over the past several decades. The 'demand' for these individuals is in fact driven primarily by NIH research dollars, as 'positions' on medical school faculty are only created when an individual can demonstrate the ability to successfully compete for extramural research dollars. Thus, given the current system's dependence on NIH research support of clinicians to pursue research programs, this group intends to steer clear of the debate about too many versus too few, and instead concentrate on how such research careers can be made more attractive to the most capable individuals.

Assumptions

- MDs, MD/PhDs and PhDs have similar success rates when applying for NIH research grants, with MD/PhDs holding a slight advantage. This has remained unchanged for a number of years.
- In this respect, MD/PhD programs have been very successful in seeing a much greater proportion of their graduates being successful at earning independent research support than PhD programs.
- While the number of MDs applying for NIH research grants has remained fairly constant over several decades, the number of PhDs applying continues to increase.
- The perception, and perhaps the reality, is that there are insufficient numbers of clinician scientists on NIH review panels that review applications from clinician scientists.
- Salary and lifestyle issues play a significant role in clinicians opting out of a career in research. Lifestyle issues especially impact the decisions of women to pursue careers as clinician scientists. This is important as the proportion of women medical students has steadily increased over the years.
- It is worth repeating that 'bedside-to-bench' is as important as 'bench-to-bedside', and that the isolation noted above threatens both, but especially the former. Both scientists and clinician scientists are becoming increasingly isolated from the clinicians who interact with patients at academic medical centers.
- Possible career stages at which the NIH policies/programs could influence clinicians' interest in and preparation for a career in research include **medical school**, **residency**, and **post-residency career stages.**

- Recent evaluations of NIH's K awards to early career clinician (MD and MD/PhD) scientists (post-residency stages) show a significant positive impact on their ability to obtain independent research support.
- There remains insufficient data on academic medical center faculty appointments that actually provide the opportunity to develop a career as a clinician scientist. These seem to be essentially derivative; the absolute number of these positions is dependent on continued success at acquiring NIH research grant (or other major grant) support, and thus ultimately dependent on the NIH research grant budget.
- The economic pressures on the academic medical centers push them to rely increasingly on 'soft' money from the NIH or other funding organizations for the support of their research enterprises.

Scenario Overview

- Enhance existing NIH programs directed at medical students, residents and early career clinician scientists

- Expand Loan Repayment Programs to clinicians that are engaged in translational and bench research, to encourage more bedside-to-bench investigations.
- Increase opportunities for medical students to engage in research experiences that could improve perception of clinician scientist career tracks.
- Promote/encourage the idea of "fast-tracking" for a clinician scientist, compared to clinician requirements.

The following considerations led to the policy changes recommended.

- The Loan Repayment Programs restrict the areas of research and lead to the exclusion of clinician scientists pursuing more fundamental areas of biomedical science. This is unfortunate as it excludes a group of scientists who could serve as links between the basic and clinical sciences.
- There is a demand for more support for 'year out' programs for medical students. These programs attract very talented medical students to research activities, and in many cases to research careers. These could be designed to restrict support to a stipend and health insurance costs, with no tuition reimbursement. Should NIH ICs offer more of these? Should NCATS fund these programs?
- The T35 short term research experiences for medical students are also quite popular, although not offered by all ICs, and suffer from the limitation that one medical school may not be able to enroll sufficient numbers of students in a specific IC mission-oriented scientific area. Should NCATS support these programs?
- Although NIH support of faculty salaries may require downward adjustment, should NIH's career awards policies be more flexible with salary reimbursement for these early career clinicians?
- Should NIH consider more dual degree individual fellowships for those medical students who develop a strong interest in earning a research degree to complement their clinical degree?

- Should the limit on the number of years of support from an NIH career award be relaxed so as to provide more protected time to be in a position to successfully compete for independent research support?
- The notion of fast-tracking a resident to a research career should be seriously considered, although this would involve decisions beyond the NIH, namely the buy-in of residency programs and professional accrediting organizations. Select residency programs still value the presence of research-oriented clinicians in their classes. In fact, select residency programs continue use the presence of research-oriented physicians as a recruitment incentive to attract the best of the medical graduating classes to their specialty.
- The usual issues of procedure-intensive specialties precluding sufficient time to establish a research career came up, with the usual alternatives: relax effort requirements on career awards and/or extend the length of career awards to clinicians, although many thought this was not a promising way to get sufficient research experience and prove one's independence. For individuals in those specialties, some ventured that if one is to have a research career, less time needs to be spent staying proficient in procedures, and more time must be spent engaging in research.

Intended Outcome

Increase the number of clinicians who become scientific leaders by making clinician-research careers more attractive and attainable.

Supporting Data

- *The Vanishing Physician Scientist?* Andrew I. Schafer, ed. Cornell University Press, 2009.
- AAMC Faculty Databases
- Funding success of Early-Stage Investigators in FY2010. (Survey of NIH Support of Physician Scientists Post-Graduate Years to First Major Research Project Grant – A Report to the NIH Deputy Director for Extramural Research, September 20, 2011, Data from IMPAC II)
    - PhD degrees: 650
    - MD degrees: 132
    - MD/PhD degrees: 115
- AAMC Survey of Medical Students
- NIH Individual Career Development Awards Program-Evaluation 2011: http://grants.nih.gov/training/K_Awards_Evaluation_FinalReport_20110901.pdf

Appendix: NTW Committee

Background:

In April 2011, the National Institutes of Health (NIH) Advisory Committee to the Director (ACD) formed the Biomedical Workforce (BMW) Working Group to examine issues related to the future of the biomedical research workforce in the United States. The Working Group was tasked with making recommendations to the ACD that would help ensure a diverse and sustainable biomedical and behavioral research workforce. As part of the process, the Working Group asked for input from NIH staff. The NIH Training Advisory Committee (TAC) took a lead role in this process - the NIH/TAC Workforce (NTW) was formed and met several times to develop the scenarios contained within this document.

Co-chairs:

- **Rod Ulane, OD** Director, Division of Scientific Programs, Office of Extramural Programs, Office of Extramural Research
- **Richard Baird, NIBIB** Director, Division of Interdisciplinary Training, NIBIB

Full Membership:

Name and IC	**Title/Position**
Amy Adams, NIDCR	Director, Office of Science Policy & Analysis
David Armstrong, NIMH	Chief, Scientific Review Branch
Robin Barr, NIA	Director, Office of Extramural Activities
Ken Bridbord, FIC	Director, Division of International Training and Research
Alison Cole, NIGMS	Assistant Director for Research Training
Sandra Colombini-Hatch, NHLBI	Medical Officer
Nancy Desmond, NIMH	Associate Director, Division of Neuroscience & Basic Behavioral Science
Irene Eckstrand, NIGMS	Supervisory Health Scientist Administrator
Katrin Eichelberg, NIAID	Scientific Review Officer
Robert Finkelstein, NINDS	Associate Director for Extramural Research
Valerie Florance, NLM	Director, Division of Extramural Programs
Greg Germino, NIDDK	Deputy Director, NIDDK
Mimi Ghim, NDA	Deputy Coordinator for Research Training
Ann Graham, CSR	Program Analyst
Lindsey Grandison, NIAAA	Project Director
Anthony Hayward, NCRR	Director, National CTSA Program
Milton Hernandez, DLR	Director, Loan Repayment Program

Name and IC	**Title/Position**
Henry Khachaturian, OD	Extramural Program Policy Officer
Ming Lei, NCI	Branch Chief, Cancer Training
Anne Menkens, NCI	Molecular Imaging BRR
Carol Merchant, NCRR	Medical Officer
Marie Mancini, NCI	Health Scientist Administrator
Sharon Milgram, OD	Director, Office of Intramural Training and Education
Sherry Mills, OD	Director, Office of Extramural Programs
Helena Mishoe, NHLBI	Director, Office of Research Training and Minority Health
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James Onken, OD	Special Assistant to the NIH Deputy Director for Extramural Research
Jennifer Pohlhaus, OD	Project Director of OER Support (Contractor, Ripple Effect Communications)
Tracy Rankin, NIDDK	Career Development and Training Program Director
Walter Schaffer, OD	Senior Scientific Advisor for Extramural Research
Carol Shreffler, NIEHS	Chief, Cellular, Organ and Systems Pathobiology Branch
Shiva Singh, NIGMS	Chief, MORE Special Initiatives Branch and Program Director
Daniel Sklare, NIDCD	Program Director, Assessment and Management of Hearing and Balance Disorders
Jennifer Sutton, OD	Extramural Policy and Program Evaluation Officer
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Anil Wali, NCI	Program Director
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Dorit Zuk, OD	Science Policy Advisor