

National Institute of General Medical Sciences



Strategic Plan for Training and Career Development

OCTOBER 14, 2010

Analysis of Responses
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Executive Summary

In Fall 2009, the National Institute of General Medical Sciences (NIGMS) began a strategic planning process to examine existing activities and articulate strategies to help build and sustain the workforce that the nation needs for improving health and global competitiveness. NIGMS made several observations that prompted this effort to prepare a Strategic Plan for Training and Career Development. These observations included:

- Trainee support has been constant over the past three decades, but more and more individuals are being supported through “research assistantships” – i.e., as researchers on their PI’s grant.
- There has been a decline in academic positions and an increase in industry positions available to biomedical researchers.
- Students and postdoctoral researchers (postdocs) are spending increasingly longer periods of time in trainee positions.
- The biomedical workforce is not representative of American diversity.

Historically, NIGMS has been a leader at the National Institutes of Health (NIH) in research training, especially with the development of several novel programs over the years. Ideally, improvements that originate in NIGMS as a result of this strategic planning process will be considered pilot programs and spread to NIH as a whole.

Role of Ripple Effect Communications, Inc.

Ripple Effect Communications, Inc., was engaged by NIGMS to perform a detailed analysis of the responses received from stakeholders in the NIGMS strategic planning process. Ripple Effect was established in 2006 to provide “Intelligent Project Management”™ to the Federal government, and is often called upon to provide support in one or more of the following areas: Communications, Program & Policy, Technology, Training and Conference Management, and Workforce Development. We assess, plan, manage and execute projects that aid the government (with the current focus on increasing transparency) in transforming into a “people-centric, results driven and forward thinking” organization.

Analysis of Comments

This report provides an analysis of stakeholder comments that were received as part of the NIGMS strategic plan for training and career development process. The data collected were rich and plentiful. The issues facing NIGMS are complex, and Ripple Effect recognizes that changes to the current system will impact individual lives, the output of biomedical research, and the image of science in this country. Ripple Effect employed both quantitative and qualitative data analysis techniques to provide a comprehensive analysis and a holistic approach to telling the story of the data.

NIGMS received a total of 1,653 responses to six specific research questions, one open ended question, and three supplemental questions asked to a subset of respondents. The amount of qualitative data collected as part of the public input period was immense.

In the deductive quantitative approach, categories for grouping responses were created after preliminary data analysis, input from NIGMS, and subsequent analysis. In the inductive qualitative approach, the analysis was open to the data and was driven by the content of the data regardless of the research question. Three major themes emerged from the qualitative analysis: (1) workforce needs and the scientific enterprise, (2) guidelines for individual and institutional success, and (3) attracting bright minds. In addition, we identified the following key issues, which either are focused on concerns specific to NIGMS and NIH, or are relevant to the greater scientific community.

Issues Relevant to NIGMS Training and Career Development

- Supporting Non-Academic Careers
- Fostering Successful Training Programs
- Providing Structure to the Postdoctoral Research Position
- Bolstering NIGMS Data Collection and Analysis

NIGMS and Broad Issues Facing the Greater Scientific Community

- Improving the Public Image of the Scientific Enterprise
- Ensuring Continued Research Funding in the Modern Fiscal Environment
- Preventing the Indentured Use of Trainees

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Chapter 1: Introduction

Overview

In Fall 2009, the National Institute of General Medical Sciences (NIGMS) began a strategic planning process to examine existing activities and articulate strategies to help build and sustain the workforce that the nation needs for improving health and ensuring global competitiveness. This report provides an analysis of stakeholder comments that were received as part of this process, with the goal of informing the development of the NIGMS Strategic Plan for Training and Career Development, which is expected to be completed by early 2011.

Research Training and Career Development at NIH

The mission of the National Institutes of Health (NIH) is to seek fundamental knowledge about the nature and behavior of living systems and the application of that knowledge to enhance health, lengthen life, and reduce the burdens of illness and disability¹. Inherent in the mission is the need for well-prepared scientists to perform biomedical research.

NIH has a long history of support for biomedical workforce development, extending back to the establishment of the National Institute of Health (then singular) in 1930 and the concurrent establishment of fellowships for biomedical research². By 1948, with the incorporation of several institutes, NIH became the National Institutes of Health and supported both fellowship opportunities and training programs in specific research areas. NIGMS was established in 1962 in response to Public Law 87-838, which documented the need for an institute to conduct and support research and research training in the general or basic medical sciences and in related natural or behavioral sciences that have significance for two or more other institutes of NIH, or that lie outside the general areas of responsibility of any other institute. Thus, from its establishment, research training support was paramount for NIGMS.

Research Award Programs

Most of the NIH budget (\$20.8 of \$30.5 billion in 2009³) is used to fund research grants in the extramural

¹ <http://www.nih.gov/about/mission.htm>

² National Academies: Advancing the Nation's Health Needs

³ <http://report.nih.gov/FileLink.aspx?rid=575>

community; about half (\$10.3 billion in 2009⁴) of the research funding is distributed through R01 awards. By design, the R01 award supports a discrete, specified, circumscribed project to be performed by the named investigator(s) in an area representing the Primary Investigator's (PI) specific interest and competencies⁵. Part of the allowed expenses on such a research award is salary support for the research team, which regularly includes the PI and one or more researchers (at various career stages) who are part of the PI's research team (e.g., students, postdoctoral researchers (postdocs) and research technicians).

In contrast to research programs, which are focused toward meeting the goal of the research question, NIH supports workforce development by providing support to early-career investigators through research training and career development awards. These awards are designed with the goal of ensuring that a diverse pool of highly trained scientists is available in appropriate scientific disciplines to address the Nation's biomedical, behavioral and clinical research needs.

Research Training Award Programs

The National Research Service Award (NRSA) program was established in 1974 to ensure that highly trained scientists would be available in adequate numbers and in appropriate research areas to carry out the Nation's biomedical and behavioral research agenda. It has been modified several times since then to expand the research fields covered under the award, and it was renamed in 2002 as the Ruth L. Kirschstein-NRSA program to honor the former NIGMS Director and her efforts to support biomedical workforce development.

Under the congressional authority of the Kirschstein-NRSA program, NIH supports research training through both institutional training grants (T awards) and individual fellowships (F awards). NIH also funds a small percentage of T and F awards under authorities separate from the Kirschstein-NRSA program. In recent years, NIH research training grants and fellowships were funded at a level of \$800 million per year, with 90% of these funds awarded through the NRSA program⁶.

NIH has several institutional award programs that support research training for individuals interested in pursuing careers in biomedical, behavioral and clinical research. In the T series, awards are made to the institution to develop a training program to which trainees apply. The T34 Ruth L. Kirschstein National Research Service Award (NRSA) funding mechanism supports undergraduate research training to help ensure that a diverse and highly trained workforce is available to assume leadership roles in research. Beyond the baccalaureate degree, the primary means of supporting predoctoral and postdoctoral

⁴ <http://report.nih.gov/FileLink.aspx?rid=536>

⁵ http://grants.nih.gov/grants/funding/ac_search_results.htm?text_curr=r01&Search.x=0&Search.y=0&Search_Type=Activity

⁶ <http://report.nih.gov/NIHDatabook/Charts/Default.aspx?showm=Y&chartId=49&catId=17>

research training is through the T32 Ruth L. Kirschstein NRSA Institutional Training Grant program.

In the F series, awards are made directly to the fellows rather than through the institution as in the T series. The F30 and F31 awards include several Ruth L. Kirschstein NRSA Predoctoral Programs, while the F32 awards support postdoctoral researchers. There is also an F33 award that supports experienced investigators making changes in the direction of their research careers.

Career Development Award Programs

In contrast to the research training award programs, which prepare students and postdoctoral researchers for a career in research, research career development (K) awards are designed to assist researchers in establishing their independent research careers.

Since the K award mechanism was developed in the 1950s⁷, there have been more than 20 variations on the types of K awards provided. NIH-wide, there were 13 K award programs accepting applications in 2010, and recent years have seen total funding for K awards range from \$650 to 700 million per year⁸.

Many K awards target researchers at their first independent career stage, Assistant Professor; these awards require a mentored approach toward career development and support individuals that have accepted or are ready for a faculty position. There are also several awards specific to fields of research; for example, the K08 Mentored Clinical Scientist Award for clinical research that does not involve human subjects, and the K23 Mentored Patient-Oriented Research Career Development Award for clinical research that does, and the K25 Mentored Quantitative Research Development Award for quantitative science and engineering research.

Another type of mentored K award is the “transition” K award, such as the K99/R00 award that provides both a mentored phase and an independent phase of support during the early years of a faculty position.

Finally, there is the Institutional Career Development Award (K12), which provides for the development of independent clinical scientists. The scientists are referred to as “Scholars” while they are supported on this institutional award and mentored by senior scientists who direct the program. NIGMS uses a K12 mechanism to support an Institutional Research and Academic Career Development Award (IRACDA) that combines a traditional postdoctoral training with more career development activities including a service to a minority serving institution.

⁷ <http://grants.nih.gov/training/CareerDevelopmentAwardsReport010207R.doc>

⁸ <http://report.nih.gov/NIHDatabook/Charts/Default.aspx?showm=Y&chartId=65&catId=16>

Diversity Awards

The recruitment and retention of researchers who collectively bring diversity to the pool of NIH-supported researchers has been a long-supported activity at NIH. Diversity programs began at NIH in 1972 with the establishment of two programs: the Minority Schools Biomedical Support program was developed at the Division of Research Resources (now National Center for Research Resources) and the Minority Access to Research Careers (MARC) Visiting Scientist and Faculty Fellowship program was developed at NIGMS. Over the years, the Minority Schools Biomedical Support program evolved into the Minority Biological Research Support (MBRS) program and transferred to NIGMS in 1989, and the MARC program expanded to include several subprograms. In addition to these NIGMS programs, other NIH Institutes and Centers release various funding opportunity announcements to increase diversity in the scientific workforce.

An NIH-wide program, Research Supplements to Promote Diversity in Health-Related Research, which was established in 1989, also supports diversity in the biomedical workforce. The supplement program provides support to already-funded NIH investigators to fund researchers from groups that are traditionally and currently underrepresented in research, including various racial and ethnic groups, individuals with disabilities, and individuals from disadvantaged backgrounds.

Special Research Award Programs

In addition to the research training and career development that may be occurring as part of research awards (described above), NIH maintains the R25 funding mechanism, which is a research award by type, but designed to support training and education programs. NIH Institutes and Centers use this funding mechanism to provide support for institutions to educate and train researchers, particularly those from underrepresented groups. There are many R25 programs supported by NIH; NIGMS currently has six: the MBRS Research Initiative for Scientific Enhancement (RISE), the Initiative for Maximizing Student Development (IMSD), and Short Courses on Mathematical, Statistical, and Computational Tools for Studying Biological Systems.

Two other aspects of the research award program are designed to help the careers of new or early stage investigators by transitioning them into independently-funded NIH investigators. First, the New Investigator (NI) and Early Stage Investigator (ESI) policy assures that NIs and ESIs, collectively, have success rates equivalent to experienced investigators for new R01 applications. This policy is designed to “accelerate the transition to an independent scientific career with substantive NIH research grant

support.”⁹ Similarly, the NIH Director’s New Innovator Award is designed to support promising new investigators, especially those who have innovative research ideas, but not the preliminary data to fare well in the R01 review process. This award is for investigators who are within ten years of having completed their terminal degree, but it only supports a small number of researchers each year.

Role of NIGMS in NIH Research Training and Career Development

Historically, NIGMS has been a leader in the development of several novel programs, including the dual M.D./Ph.D. degree program, programs to increase diversity, and training in interdisciplinary research.

Support of the Dual M.D./Ph.D. Degree Program

NIGMS established the Medical Scientist Training Program (MSTP) in the 1960s to support predoctoral trainees enrolled in a joint M.D./Ph.D. program. It was modified into its modern rendition in 1974, along with the NRSA program. Since this time, the program has grown, and it currently has 933 trainees at 45 degree-granting institutions. The pioneering role of NIGMS can be observed in the fact that dual-degree training support is provided not only by NRSA funds but also by private and institutional sources, and that support has been expanded to dual programs beyond the traditional combination of M.D./Ph.D. (e.g., D.D.S./Ph.D.).

Support of Programs to Encourage Diversity in the Workforce

NIH support of programs to encourage diversity in the workforce also began with NIGMS, as described above. Unique among NIH even today, NIGMS has an entire division devoted to increasing the representation of minority biomedical and behavioral scientists. The Division of Minority Opportunities in Research (MORE) is composed of three branches: Minority Access to Research Careers (MARC), Minority Biomedical Research Support (MBRS), and MORE Special Initiatives (SI).

Support of Training in Interdisciplinary Research

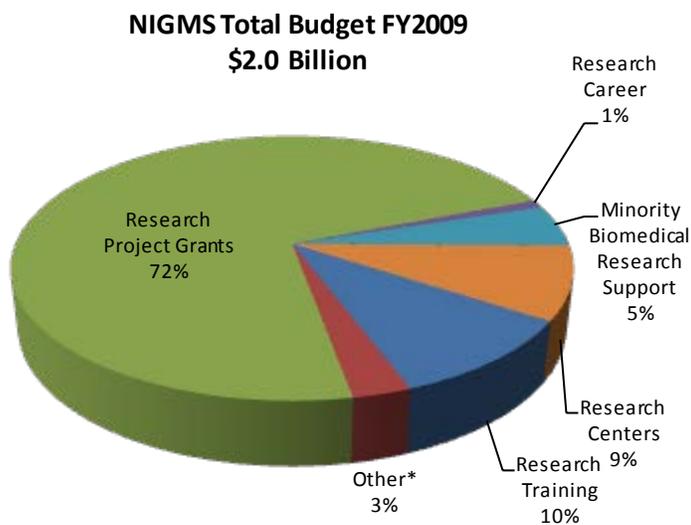
NIGMS has been a leader in supporting research training in multidisciplinary and interdisciplinary fields, beginning with its first NRSA research training awards. Since then, promotion of interdisciplinary research has flourished in the biomedical community, both with the development of new support programs from NIH and other funders, and also with the majority of research institutions now offering

⁹ <http://grants.nih.gov/grants/guide/notice-files/NOT-OD-09-013.html>

education programs that cut across research boundaries.

NIGMS Today

NIGMS is the fourth-largest Institute at NIH, with \$2.05 billion appropriated in FY2010 (representing 7% of the NIH budget)¹⁰, and is a leader in providing research training and career development support for the extramural community. NIGMS is considered “the ‘training institute’ by virtue of the number, breadth and forward-thinking features of its programs.”¹¹



*Other includes Other Research Grants, R&D Contracts, Intramural, and Research Management/Support

Of its \$2.0 billion FY 2009 budget, NIGMS spent \$1.4 billion on research projects (supporting 3939 grants) and \$174 million on research centers (supporting 49 grants).

There were 89 research career awards representing \$19 million and 319 Minority Biomedical Research Support awards representing \$99 million. Finally, within the \$196 million spent on research training awards, NIGMS supported 4,321 full-time training positions: 3,826 through institutional T awards and 495 through individual F awards¹².

In 2009, NIGMS was the largest NIH funder of research training, providing funding for 4,321 (26%) of the 16,430 full-time training positions under Kirschstein-NRSA training grants and fellowships. The distribution between trainees (supported on institutional T awards) and fellows (supported on individual F awards), as well as the difference between predoctoral versus postdoctoral, is shown below, along with a comparison to the career development awards.

¹⁰ <http://officeofbudget.od.nih.gov/pdfs/FY11/FY%202010%20Enacted%20Appropriations.pdf>

¹¹ <http://www.nigms.nih.gov/Training/ruthkirschstein.htm>

¹² <http://www.nigms.nih.gov/About/Budget/Mechanism.htm>

	Predoctoral Trainees	Postdoctoral Trainees	Total Trainees	Predoctoral Fellows	Postdoctoral Fellows	Total Fellows	Career Development Awardees
NIGMS	3,668	158	3,826	129	366	495	89
Total NIH	7,954	5,477	13,431	1,655	1,344	2,999	4,189
% NIGMS supported	46%	3%	28%	8%	27%	17%	2%
	Predoctoral: 3,797 NIGMS		9,609 NIH				
	Postdoctoral: 524 NIGMS		6,821 NIH				

Of the total positions supported by NIH in FY2009, NIGMS supported 40% of predoctoral positions (3,797 of 9,609), 8% of postdoctoral positions (524 of 6,821), and 2% of K awards, which, at the individual level, were mostly distributed to researchers at the assistant professor level. This distribution is consistent with the NIGMS mission, which is to support individuals at earlier stages in their careers who are less likely to have determined a specific biomedical specialty.

NIGMS Strategic Plan for Training and Career Development

NIGMS noted several observations that prompted this effort to prepare a Strategic Plan for Training and Career Development:

Training of students and postdocs has evolved over time to include not only formal training received through NIH supports, such as the F and T grants, but also training-related activities that occur as part of NIH-supported research grants, as investigators support research personnel (including students and postdocs) in their labs. The number of U.S. graduate students supported by any kind of traineeship, fellowship or teaching assistantship has been fairly constant since 1990, but the number of graduate students supported by research assistantships (on PIs'

research grants) has greatly increased¹³.

The percentage of Ph.D. recipients employed in academia has declined over the past 30 years, while the percentage employed in industry has increased. In turn, individuals that are trained with NIH funds may pursue many different career paths, including government, industry, and nonprofit sectors.

Students and postdocs are spending increasingly longer periods of time in trainee positions. The median time spent in a postdoctoral position for a life science doctorate recipient is longer than all other science and engineering fields¹⁴. The average new PI on an NIGMS research award has spent 6.7 years getting from B.S. to Ph.D., 5.0 years from Ph.D. to Assistant Professor, and 3.6 years beyond that before receiving their first R01 award (a total of 15.3 years).

The biomedical workforce is not representative of American diversity. Although faculty are less diverse than students and postdocs, even students and postdocs are more likely to be White or Asian, and less likely than the U.S. population to be Black or Hispanic.

Given these observations, NIGMS engaged in this strategic planning exercise to ensure both that its programs and activities effectively meet current needs, and that it is anticipating emerging opportunities.

NIGMS solicited input from stakeholders, including faculty members, administrators, current and former predoctoral and postdoctoral trainees, industry representatives, representatives of professional and scientific organizations, and other interested parties, in several different venues. The venues included:

- An online questionnaire (open March 2 to April 21)
- Four regional stakeholder meetings:
 - Thursday, April 29, in Philadelphia, PA
 - Wednesday, May 12, in San Francisco, CA
 - Tuesday, May 25, in Chicago, IL
 - Friday, June 4, in Atlanta, GA
- An online webinar discussion on Friday, June 11, from 1:00 – 4:00PM

In all venues, responses to the following seven research questions were requested:

¹³ <http://www.faseb.org/Policy-and-Government-Affairs/Data-Compilations/Education-and-Employment-of-Scientists.aspx>

¹⁴ Postdoc Participation of Science, Engineering, and Health Doctorate Recipients, NSF 08-307

1. What constitutes "success" in biomedical research training from the perspectives of an individual trainee, an institution, and society?
2. What can NIGMS do to encourage an optimal balance of breadth and depth in research training?
3. What can NIGMS do to encourage an appropriate balance between research productivity and successful outcomes for the mentor's trainees?
4. What can NIGMS do through its training programs to promote and encourage greater diversity in the biomedical research workforce?
5. Recognizing that students have different career goals and interests, should NIGMS encourage greater flexibility in training, and if so, how?
6. What should NIGMS do to ensure that institutions monitor, measure, and continuously improve the quality of their training efforts?
7. Do you have other comments or recommendations regarding NIGMS-sponsored training?

In three of the regional stakeholder meetings, the following questions were also asked:

8. How should NIGMS manage the alignment between training efforts and emerging fields?
9. How should NIGMS manage training resource allocation within and across institutions?
10. Should NIGMS help develop support mechanisms for additional research career tracks?

Ripple Effect Communications attended all of the stakeholder meetings and the webinar, and has independently read and verified all of the comments received through the online questionnaire, the stakeholder meetings, and the webinar. We offer this report as a summary of our analysis.

Methods for Analysis

We engaged both quantitative and qualitative data analysis techniques to provide a comprehensive analysis. The quantitative portion of our analysis provides a general overview of the types of responses each research question elicited, while the qualitative portion gives a detailed account of specific ideas that became recurring themes. Using both methods added value to our analysis; it allowed us to take a holistic approach to telling the story of the data. A detailed account of our methodological process is provided.

About the Data

In total, the NIGMS Strategic Plan for Training and Career Development successfully received a total of 1,653 responses to six specific research questions, one open ended question, and three supplemental questions asked to a subset of respondents. Comments were received primarily from academia (e.g., administrators, faculty, individuals holding joint administrative and faculty positions, postdocs, and students), and professional societies.

Role Type	Total Responses	PERCENT
Faculty	582	35%
Postdoctoral Trainee	257	16%
Administration	212	13%
Student	208	13%
Professional Society	166	10%
Joint Faculty & Administration	120	7%
Industry	41	2%
All Other (includes Government)	67	4%
Total Responses	1653	100%

As will be reported in Chapter 2, each research question has a different number of total responses. This is an artifact of the data collection process and our methodological decision for managing and coding the data. The number of responses per question does not reflect the number of people who responded, but captures the number of times they responded to that particular question. Responses from the online questionnaire were straightforward; each participant responded just once to each question. However, stakeholder and webinar participants often responded multiple times to the same research question. When one person offered more than one response, we chose to count each response individually because it was the most efficient way to accurately capture all of the ideas presented in the data. Another reason for the mismatch between the number of responses per question and the number of participants is due to the lack of responses; some participants chose to respond to some of the questions, but not to all. The no-response category created to code these instances is not included as part of the analysis in Chapter 2.

Quantitative Analysis

Our deductive quantitative approach involved dividing the research questions into broad categories specific to each question, and then assigning each response to the appropriate category. For each question, a code “alternative response” was available and covered responses that did not fit into any of the other codes. The details of the alternative response code emerged as part of the qualitative analysis process, described below.

Qualitative Analysis

We used a grounded theory approach¹⁵ for our qualitative analysis. This inductive method offers analytical guidelines that begin with the data and systematically raise the conceptual level of analysis

¹⁵ Charmaz, K. (2006). *Constructing grounded theory: A practical guide through qualitative analysis*. Sage: Thousand Oaks.

while maintaining a strong foundation in the data. We began analyzing the online questionnaire by studying the data and engaging in line-by-line coding, which involves defining the data. After initial line-by-line coding, we moved onto focused coding, which means sorting, integrating and synthesizing initial codes and identifying major coding categories. To assist in the analysis of this large amount of qualitative data, we crafted outlines of the relevant codes for each of the research questions. Developing outlines revealed codes and coding categories that applied across research questions, an important step in understanding and naming emergent themes. This iterative process of line-by-line, focused coding, and developing outlines continued until we completed the analysis for the online questionnaire data. Our next step involved axial coding where we identified major themes and sub-themes, thus lifting the data up another conceptual level into a coherent whole. As part of the analysis process, we constantly generated analytical memos that captured insights about the data, elaborated coding categories and themes, and defined connections between categories. A non-linear process, we continued to engage our coding scheme and major themes and sub-themes as we completed our analysis of the stakeholder meetings and the webinar. The final coding scheme consisted of 6 coding categories and 63 codes that directly relate to, and inform, the 3 major themes and 8 major sub-themes. It was beyond the scope of our ability to provide quantitative tallies for our coding scheme and major themes and sub-themes.

Caveats and Limitations

The input collected through the NIGMS Strategic Plan for Training and Career Development amounted to a vast pool of suggestions and opinions. There are two limitations identified as part of this analysis process. First, due to the size of the data and the time constraints, we were unable to quantify our detailed coding scheme (i.e., the analysis provided in Chapter 4 is qualitative only). While it would have been advantageous to have provided both qualitative and quantitative analysis on the coding scheme we developed, we rely on the quantification by research question (i.e., the data provided in Chapter 3) to give NIGMS a general flavor for how widely general ideas received support. Second, we note the lack of responses received from industry (n=16); the data collected as part of this process came primarily from the academic community. Based on the workforce issues identified as part of the analysis process, receiving greater input from industry would have been preferable.

Chapter 2: Quantitative Analysis

To capture and demonstrate group trends in response to each research question posed by NIGMS, a deductive qualitative analysis approach was applied. Categories for grouping responses were created after preliminary data analysis, input from NIGMS, and subsequent analysis. When the same suggestions recurred frequently within each question, the relevant category was broken down into subsequent categories to capture and reflect the scope of the more detailed responses. The category “Alternative Response” was available for each research question, and it captured responses that were outside of the scope of the specific research question posed. The alternative responses were analyzed as part of the inductive qualitative analysis in Chapter 3.

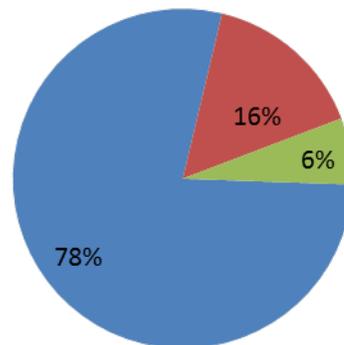
In this chapter, we present each research question, the number of responses to that research question, the categories used to code responses (and their associated tallies), a graph to visually display the outcome of our coding process, and a brief explanation describing the nature of the category. When appropriate, we use specific suggestions from the data to help illustrate the category, but these suggestions are not an exhaustive list. Question seven (Do you have other comments or recommendations regarding NIGMS-sponsored training?) was of a different nature than the other questions, in that the responses to question seven could be categorized, in many cases, as being responsive to one of the other research questions. Therefore, responses to question seven were incorporated into the responses to the related questions (as appropriate), and included in the analysis of each research question, below. At the end of the chapter, we include a more detailed summary of the responses to each research question, showing the number of responses by Role Type (Administration, Faculty, Joint Faculty & Administration, Postdoctoral Trainee, Student, Industry, Professional Society, and All Other).

Question One

What constitutes "success" in biomedical research training from the perspectives of an individual trainee, an institution, and society?

Responses (284):

- Broaden definition of success (222) ■
- Continue with traditional definition (44) ■
- Alternative response (18) ■



Broadening the definition of success:

This category was most relevant to the issue of individual success, defined broadly as individual employment and the acquisition of skills relevant for career success. The majority of respondents voiced support for moving away from defining individual success as a career in academia; the general sentiment was in favor of viewing any career trajectory as successful if the individual is able to apply their skills and knowledge for the betterment of the human condition. A successful institution was one that produced those individuals. Oftentimes, respondents named traditional metrics for defining individual success, (e.g., number of publications and presentations), as long as those elements were relevant for the individual's chosen career path. In addition to those measures, respondents suggested that success would be better defined by also including elements not traditionally defined and not easily measured (e.g., the ability to manage personnel or teach).

Continue with traditional definition:

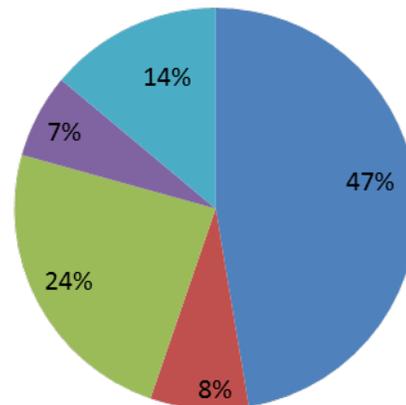
These respondents voiced support for continuing to define success in terms of traditional measures, such as publications, presentations and an academic career for individual success, and metrics such as attrition rates and grant acquisitions for institutional success. Respondents coded this way did not suggest a need to broaden how success is defined.

Question Two

What can NIGMS do to encourage an optimal balance of breadth and depth in research training?

Responses (266):

- Encourage breadth (126) ■
- Suggestions for how to balance breadth and depth
 - Balance-expand funding (21) ■
 - Balance-other (64) ■
- Keep status quo or encourage depth (18) ■
- Alternative response (37) ■



Encourage breadth:

Oftentimes, respondents simply stated support for this effort, while others made specific suggestions for encouraging breadth. Suggestions ranged from co-mentorship to broadening eligibility for training funds so that a broader range of biomedically relevant disciplines are invited into programs, thus enhancing interdisciplinary interactions.

Suggestions for how to balance breadth and depth:

We divided this category into two to distinguish between those who requested more funding to achieve this goal, and those with suggestions that did not specifically include a request for funding.

Balance-expand funding: This category captured the sentiment that NIGMS funding either needed to be more flexible, which meant providing funding directly to the student for their entire educational career, or stipulating time for student development outside the bounds of the PI's project, or the sentiment that NIGMS needed to increase research funding for PIs, which they believed would loosen up demands on the PI's time, thus allowing them more time for mentoring.

Balance-other: Suggestions in this category to balance breadth and depth were void of specific requests for funding; however, respondents believed NIGMS had a role to play. Requests for resources from NIGMS included guidelines and evaluations; other requests involved NIGMS encouragement or requirements for institutions to provide broader curriculum, increase student and postdoc attendance at meetings, workshops or symposiums, improve mentoring, and provide flexible programs.

Keep status quo or encourage depth:

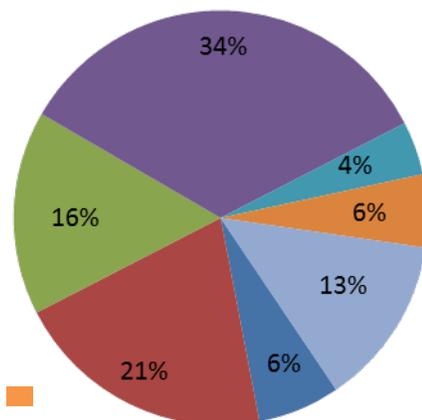
Some of these respondents voiced concern that increasing breadth would result in sacrificed depth of research training and were not in favor of moving in this direction. Others felt NIGMS already did an ample job of encouraging breadth and felt no movement necessary in either direction. Others simply stated that individual programs should determine adequate breadth and depth independent of NIGMS.

Question Three

What can NIGMS do to encourage an appropriate balance between research productivity and successful outcomes for the mentor's trainees?

Responses (264):

- Encourage successful outcomes
 - Hold mentors accountable (17) ■
 - Recognize, encourage, reward, allow time for mentoring (54) ■
 - Encourage flexible definitions of success (42) ■
 - Other (90) ■
- They are one in the same (11) ■
- Do not sacrifice research productivity for outcomes (15) ■
- Alternative response (35) ■



Encourage successful outcomes:

There was overwhelming support for NIGMS to ensure that both trainees and their mentors achieve meaningful outcomes as part of their work together. An individual development plan, or some mechanism for monitoring the targeted outcomes for each student, was suggested across the sub-categories below.

Hold mentors accountable: This was a straightforward request that PIs be held accountable for their training efforts through some kind of requirement for a training plan as part of the funding process, and that they provide evidence of training as part of progress reports.

Recognize/encourage/reward/allow time for mentoring: Among this group, there was broad consensus that mentorship determined the quality of outcomes for trainees. These respondents suggested mentoring be recognized, encouraged or rewarded as a means for making mentoring a respected and expected component of the research process.

Encourage flexible definitions of success: For this group, there was a sense that successful outcomes involved more than research productivity. Effective mentoring was mentioned frequently, but these respondents related their comments to question one and suggested NIGMS needs to broaden what it encourages as successful outcomes and allow greater flexibility toward trainee self-determination.

Other: Several suggestions were captured within this category, including providing more course work, encouraging alternative training opportunities and expanded funding for those experiences (e.g., teaching and travel to conferences), placing greater value on academic performance, limiting time to degree, and encouraging publication format for thesis/dissertation.

They are one in the same:

These respondents did not perceive a need to balance research productivity with successful trainee outcomes. Their perception was that when all of the necessary elements were working correctly, a PI's research productivity and trainee outcomes were the same. One postdoc commended the protected time for research that he received as part of his NIGMS funding.

Do not sacrifice research productivity for outcomes:

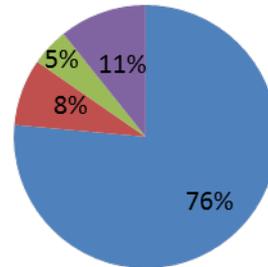
Dovetailing on the previous category, these respondents did not like the question. They pointed out that trainees are evaluated based on their research productivity as a means of gaining future employment. Respondents voiced concern that any time taken away from training directly related to research would compromise the quality of the trainee's skills as a researcher.

Question Four

What can NIGMS do through its training programs to promote and encourage greater diversity in the biomedical research workforce?

Responses (280):

- Suggestions to further promote diversity (214) ■
- Maintain current diversity efforts (23) ■
- Do not promote diversity (13) ■
- Alternative response (30) ■



Suggestions to further promote diversity:

A rainbow of ideas to promote diversity emerged within this category. From requests for best practices to expanding funds for current programs to facilitating relationships between institutions, respondents were in full support of NIGMS continuing and expanding efforts to attract diverse students to the field of biomedical research.

Maintain Current Diversity Efforts:

Respondents in this category felt that NIGMS efforts were working well, and they did not perceive a need for NIGMS to make any changes or enhancements to current programs.

Do Not Promote Diversity:

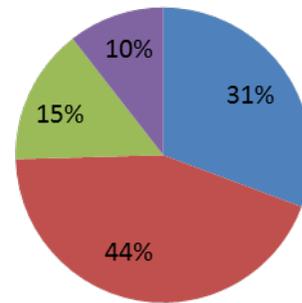
Some respondents were unclear about whether or not promoting diversity was necessary, while others in this group took exception to NIGMS efforts to encourage diversity. These respondents opposed the idea that any trainee should be offered special treatment, calling it inverse racism against the majority. These respondents felt all individuals should be treated equally. A few respondents suggested the only issue of diversity that should matter is the diversity of ideas.

Question Five

Recognizing that students have different career goals and interests, should NIGMS encourage greater flexibility in training, and if so, how?

Responses (228):

- Encourage greater flexibility
 - Encourage greater flexibility through funding support (70) ■
 - Encourage greater flexibility in other ways (100) ■
- Do not encourage greater flexibility/status quo (34) ■
- Alternative response (24) ■



Encourage greater flexibility with funding support:

For the respondents in this group, suggestions were tied to changes in the funding structure, or increased funding that would allow for new training structures and/or additional program content as noted in the category below (encourage greater flexibility in other ways).

Encourage greater flexibility in other ways:

Respondents in this category voiced continued support for, and suggestions to encourage, interdisciplinary and cross-disciplinary training. Respondents want to see trainees given the opportunity to learn about and practice writing, to present and share research, teach, and receive career guidance. The idea to add new program elements in support of skill development for a non-academic career was prevalent, as were requests for best practices to support program flexibility. The idea of an Individual Development Plan (IDP) was visible.

Do not encourage greater flexibility/status quo:

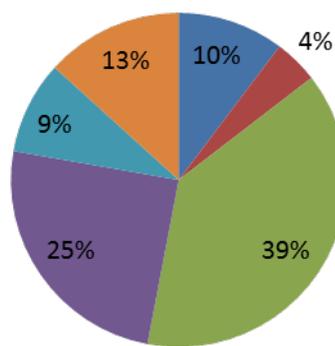
This group did not support flexibility or the idea of adding any new programs aimed at training for specific career tracks outside of academia. In terms of flexibility at the individual level, there was the perception that this would add paperwork to an already overburdened system or would result in NIGMS micro-managing programs. Associated with the idea of new career tracks, respondents believed that trained scientists were valuable regardless of their ultimate career, and that NIGMS should either maintain the status quo, or head in the opposite direction and focus on encouraging training in basic science.

Question Six

What should NIGMS do to ensure that institutions monitor, measure, and continuously improve the quality of their training efforts?

Responses (234):

- NIGMS should provide support for institutions to achieve this goal (90) ■
- NIGMS should be monitoring and evaluating programs
 - Add new elements to broaden evaluation criteria (24) ■
 - Use existing data and review process more effectively (10) ■
- Require increased rigor (58) ■
- No oversight necessary (21) ■
- Alternative response (31) ■



NIGMS should provide support for institutions to achieve this goal:

Respondents categorized here requested more support from NIGMS, which included requests for more funding (e.g., to provide protected time and hire external evaluators), site visits, and best practices. One of the difficulties that arose in coding these responses was the nature of what should be monitored. Short-term or long-term indicators of success often drove respondents to suggest who should be doing the monitoring, but that was not always the case. Monitoring long-term career outcomes was consistently pointed to as one of the most important measures for assessing student success, but there was no consensus about who should be doing this.

NIGMS should be monitoring and evaluating programs:

These respondents resisted the notion that institutions needed to be doing more and turned the direction of the question back to NIGMS with suggestions about what NIGMS should be doing.

Add new elements to broaden evaluation criteria: NIGMS should get involved in the process and conduct anonymous interviews with trainees and mentors or provide anonymous surveys as part of required reporting.

Use existing data and review process more effectively: NIGMS should be making better use of documents already produced as part of the existing funding structures (e.g., grant applications and progress reports).

Require increased rigor:

Almost all respondents were mindful about the potentially negative implications of increasing rigor for monitoring efforts at the institutional level, but recognition of the importance of this component for continued program improvement was pervasive. Ideas for increasing rigor included enforcement of existing requirements, that NIGMS recommend and accept material created through pre-existing institutional review processes, and that new elements be added to the current reporting process (e.g., input from trainees and/or mentors or an open-ended accountability question). Some respondents suggested these efforts be tied to funding.

No oversight necessary:

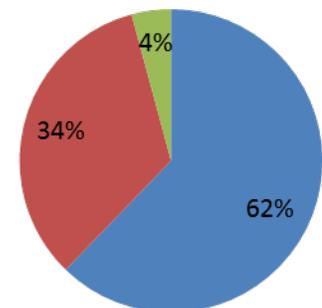
The concern that more oversight would place additional burden on an already over-taxed system prompted some respondents to state that institutions should manage this effort independent of NIGMS oversight.

Question Seven

Do you have other comments or recommendations regarding NIGMS-sponsored training?

143 total responses (54 responses that were not included in analysis of other questions):

- Response fits into the scope of other research questions (89) ■
- Response is outside the scope of research questions (48) ■
- Response is outside of the scope of NIGMS research training (6) ■



Response fits into the scope of other research questions:

89 responses were received that were related to other research questions; these responses are included in the analysis and the total count of the other questions.

Response is outside the scope of research questions:

These responses were not related to a particular research question. They were incorporated in the qualitative analysis provided as part of Chapter 3.

Response is outside of the scope of NIGMS research training:

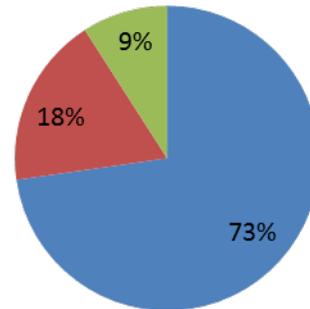
Six responses were outside the scope of NIGMS research training.

Question Eight

How should NIGMS manage the alignment between training efforts and emerging fields?

Responses (11):

- Suggestion for new programs (8) ■
- Do not need more programs (2) ■
- Alternative response (1) ■



Suggestion for new programs:

One respondent called this a slippery slope and would support new programs in core knowledge base areas such as informatics, or biostatistics, but not in areas such as translational science or cancer cells. The other suggested support for “umbrella programs” that focused on integrative types of programs that cover more than one area.

Do not need more programs:

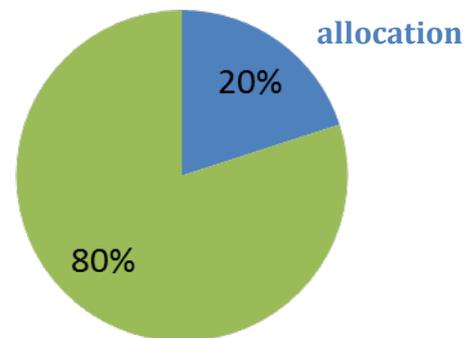
Three respondents did not support this idea, suggesting that (a) this would result in “shoehorning some innovative ideas or associations into categories that are overly constrained,” (b) that it would be too difficult to decide the appropriate number of training slots for specific programs, and (c) that the more logical and efficient way to proceed was for NIGMS to ensure trainees are well equipped to advance ideas.

Question Nine

How should NIGMS manage training resource within and across institutions?

Responses (5):

- Facilitate collaboration (1) ■
- No change (0)
- Alternative response (4) ■



Facilitate Collaboration:

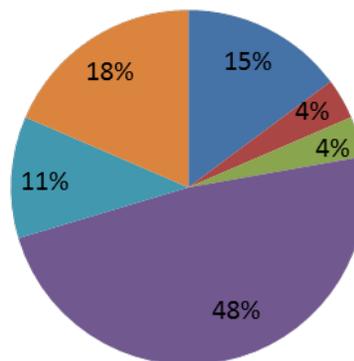
A suggestion related to facilitating collaborations across institutions was to provide a platform for web-based collaboration. Suggestions coded as alternative response were related to resource allocation but did not simply recommend facilitation of collaboration.

Question Ten

Should NIGMS help develop support mechanisms for additional research career tracks?

Responses (27):

- Develop mechanisms for additional tracks
 - Master's Degree Programs (4) ■
 - Re-entry Programs (1) ■
 - Technician Career Track (1) ■
 - Other Career Tracks (13) ■
- Do not develop mechanisms for additional tracks (3) ■
- Alternative Response (5) ■



Develop mechanisms for additional tracks:

Respondents were in favor of exploring this option, but considered it a bit of a slippery slope.

Master's Degree Programs: Support was expressed for NIGMS to create funding opportunities that would provide support for master's degrees. Note: Support for this idea was broadly expressed as part of the online questionnaire, but was coded according to the appropriate research question, which is why the numbers are low here.

Re-entry Programs: A straightforward suggestion was related to the difficulty for women to re-enter after a period of leave for family obligations.

Technician Career Track: Support was expressed for the idea to keep well-trained scientists unable to attain tenure-track positions contributing to the field.

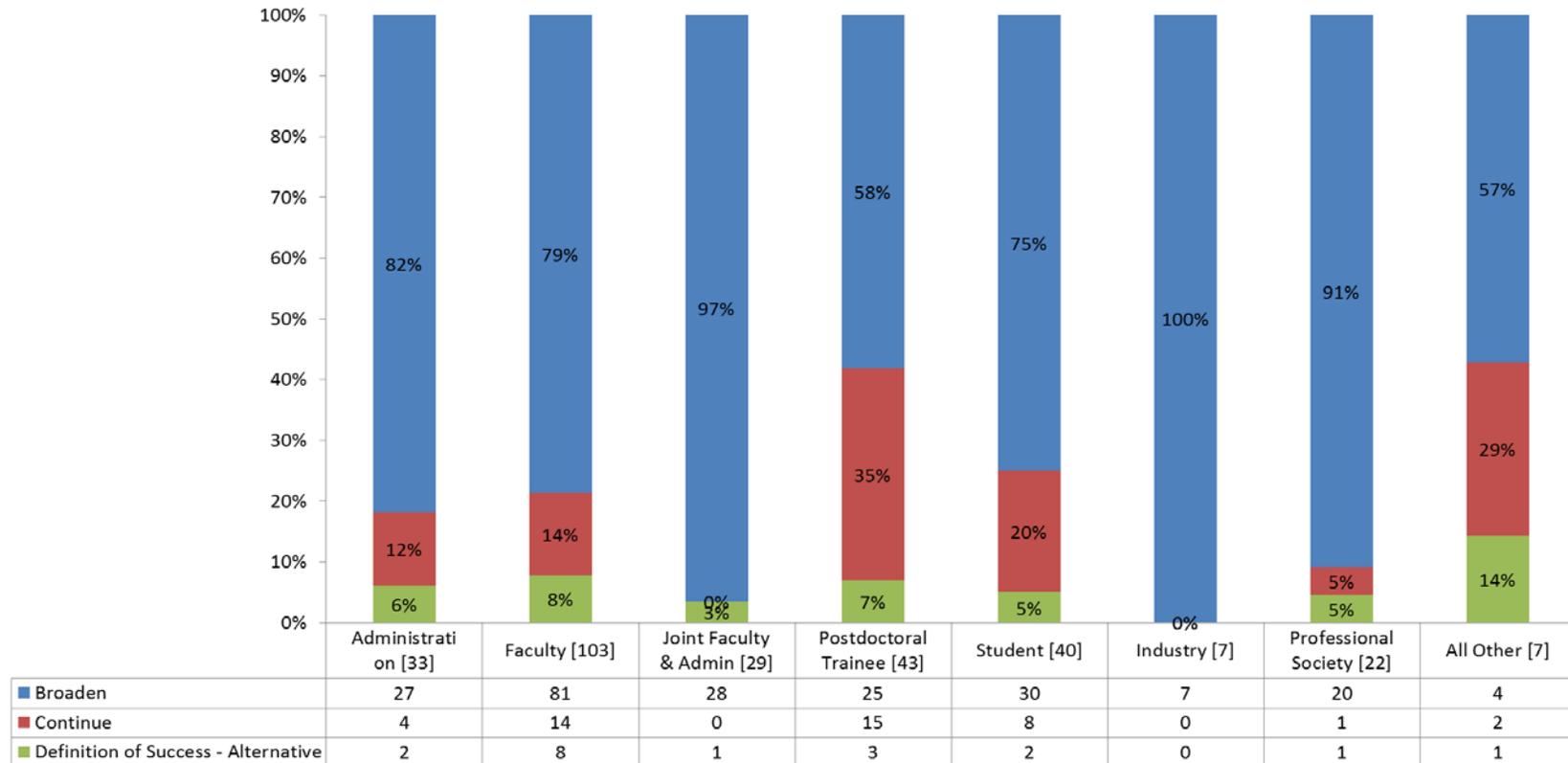
Other Career Tracks: Related to the previous code, but broader. Respondents supported the idea of creating a stable position for someone to serve as a senior research scientist, and also with the goal to keep well-trained scientists unable to attain tenure-track positions contributing to the field, but beyond a "technician" position to one that would allow the individual to mentor, as well as conduct research. Respondents noted the value of postdocs currently in this kind of situation.

Do not develop mechanisms for additional tracks:

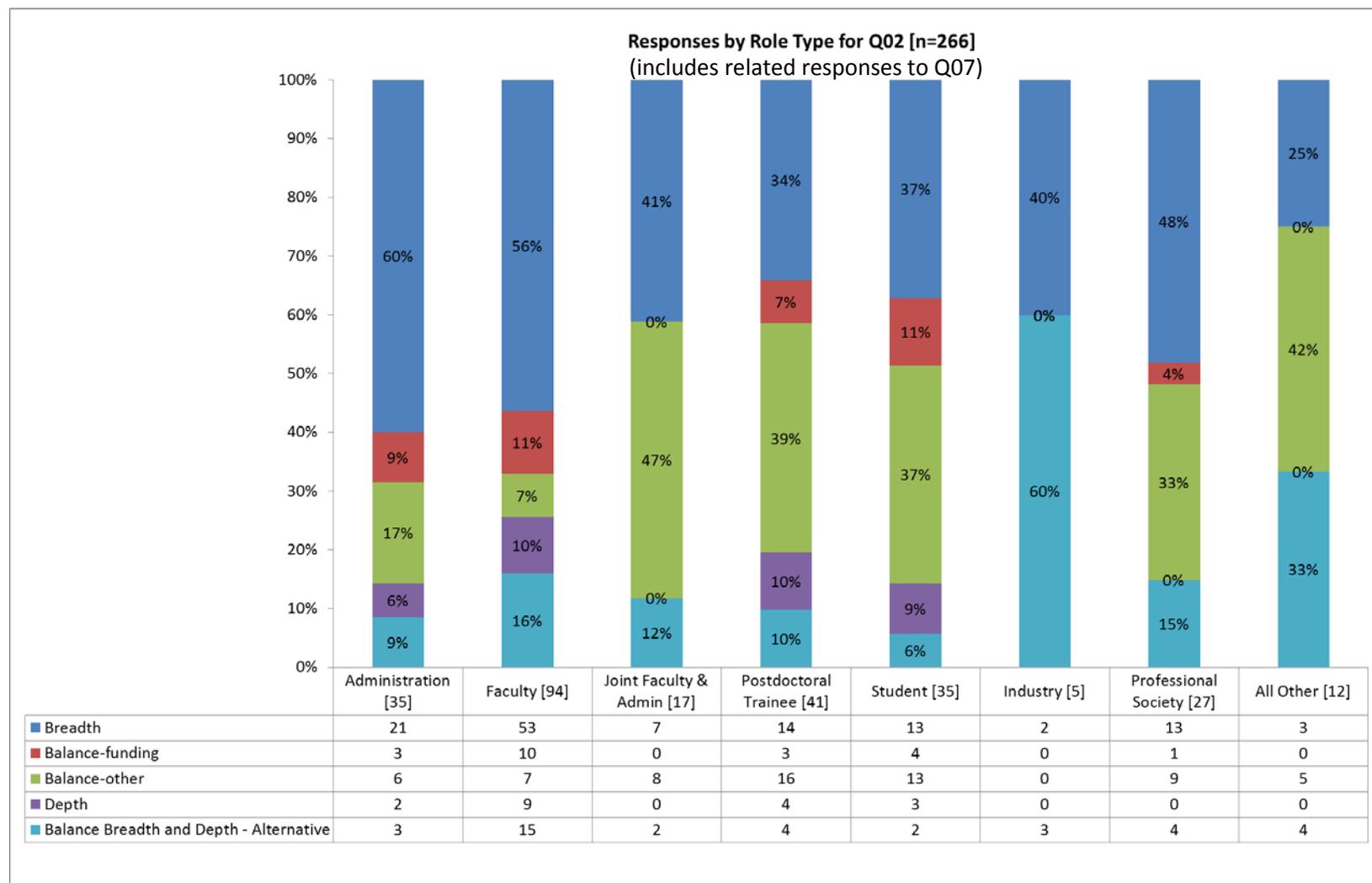
Respondents expressed fear about a reduction in the amount of R01 funding as a means for creating alternative career tracks; the belief that NIGMS is in the business of training, not job creation; and displeasure with the idea of Master's programs (too little time with the student; not worth the PI's time).

Question One: What constitutes "success" in biomedical research training from the perspectives of an individual trainee, an institution, and society? (includes related responses to Question Seven)

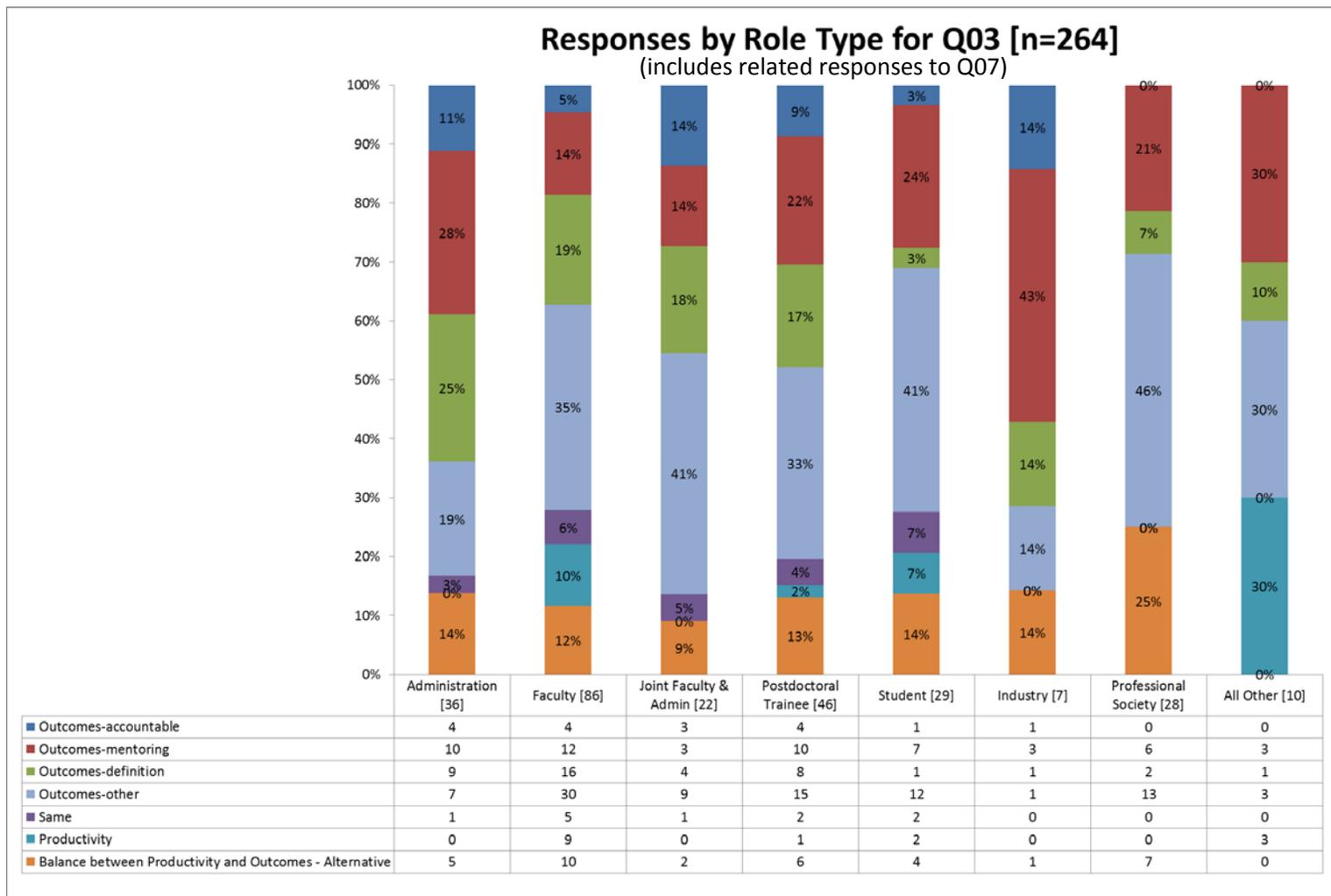
Responses by Role Type for Q01 [n=284]
(includes related responses to Q07)



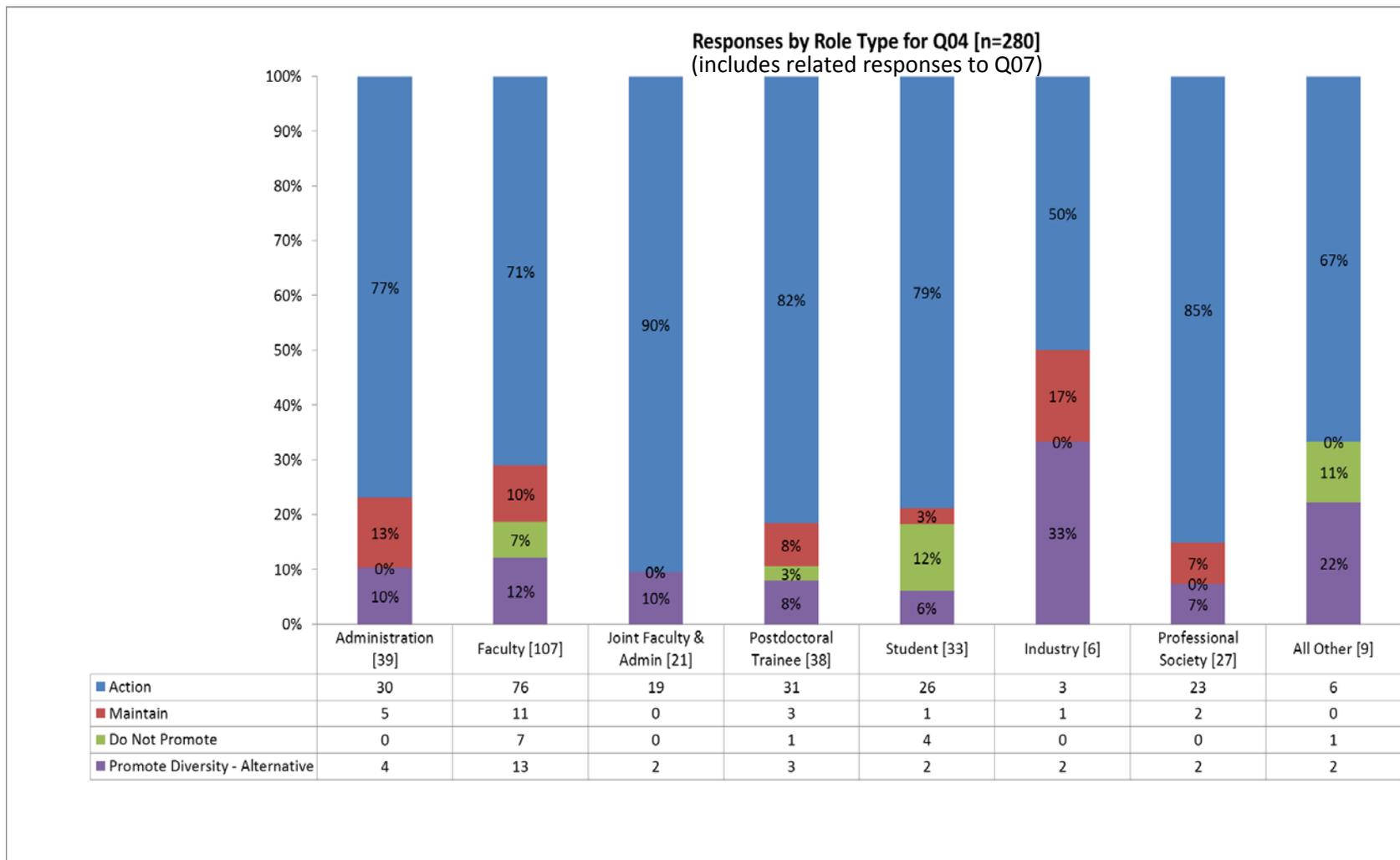
**Question Two: What can NIGMS do to encourage an optimal balance of breadth and depth in research training?
(includes related responses to Question Seven)**



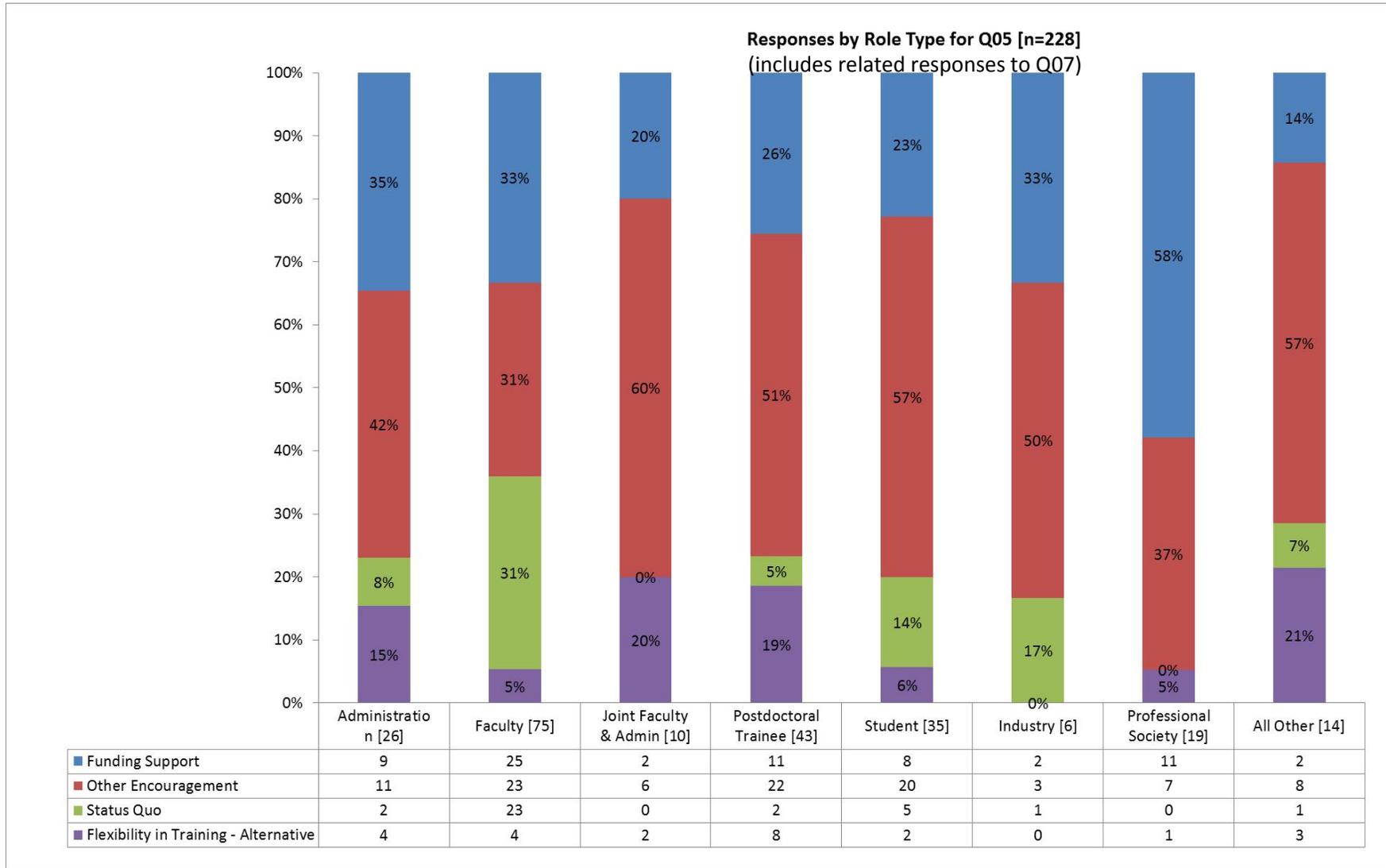
Question Three: What can NIGMS do to encourage an appropriate balance between research productivity and successful outcomes for the mentor's trainees? (includes related responses to Question Seven)



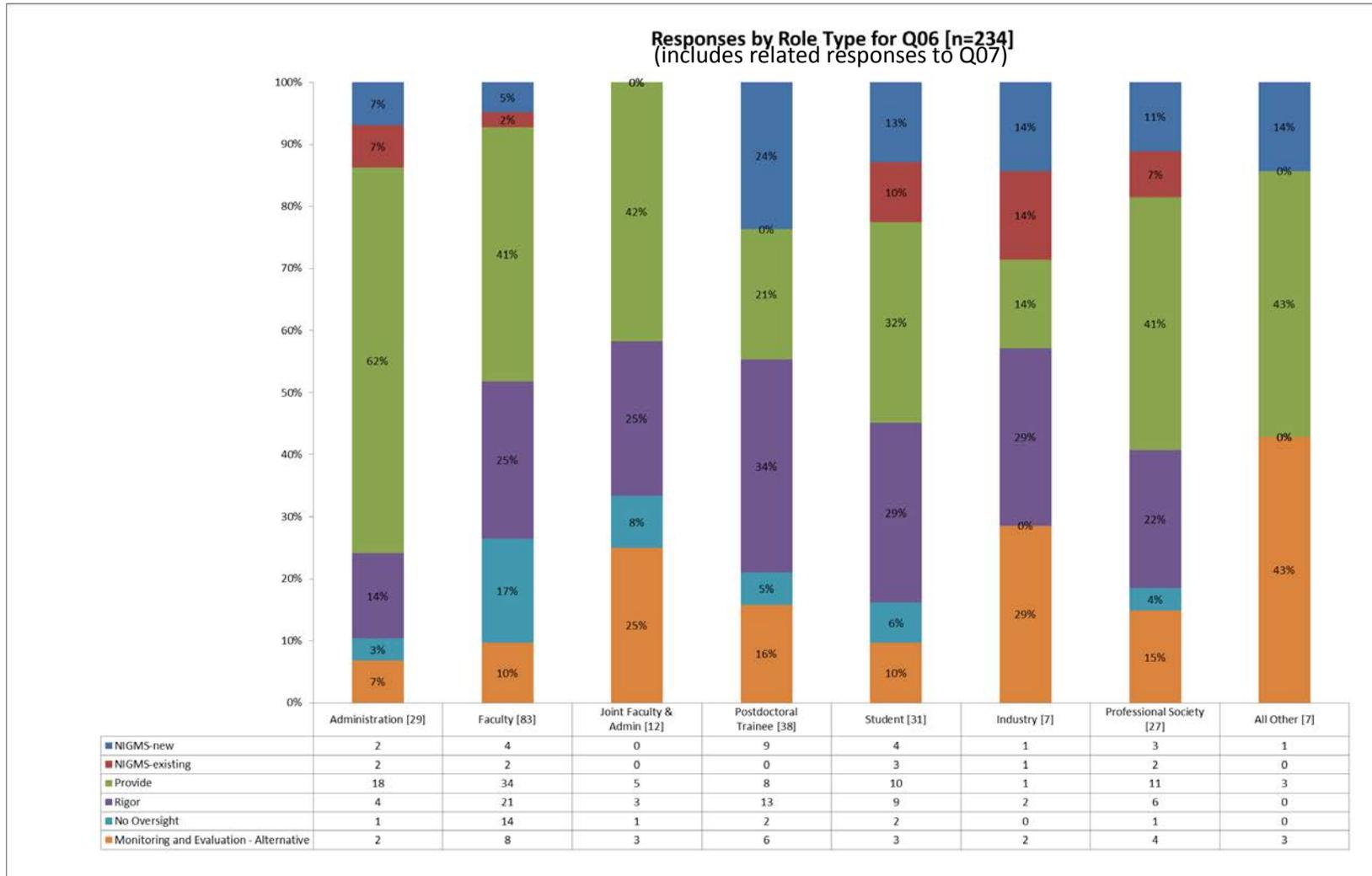
Question Four: What can NIGMS do through its training programs to promote and encourage greater diversity in the biomedical research workforce? (includes related responses to Question Seven)



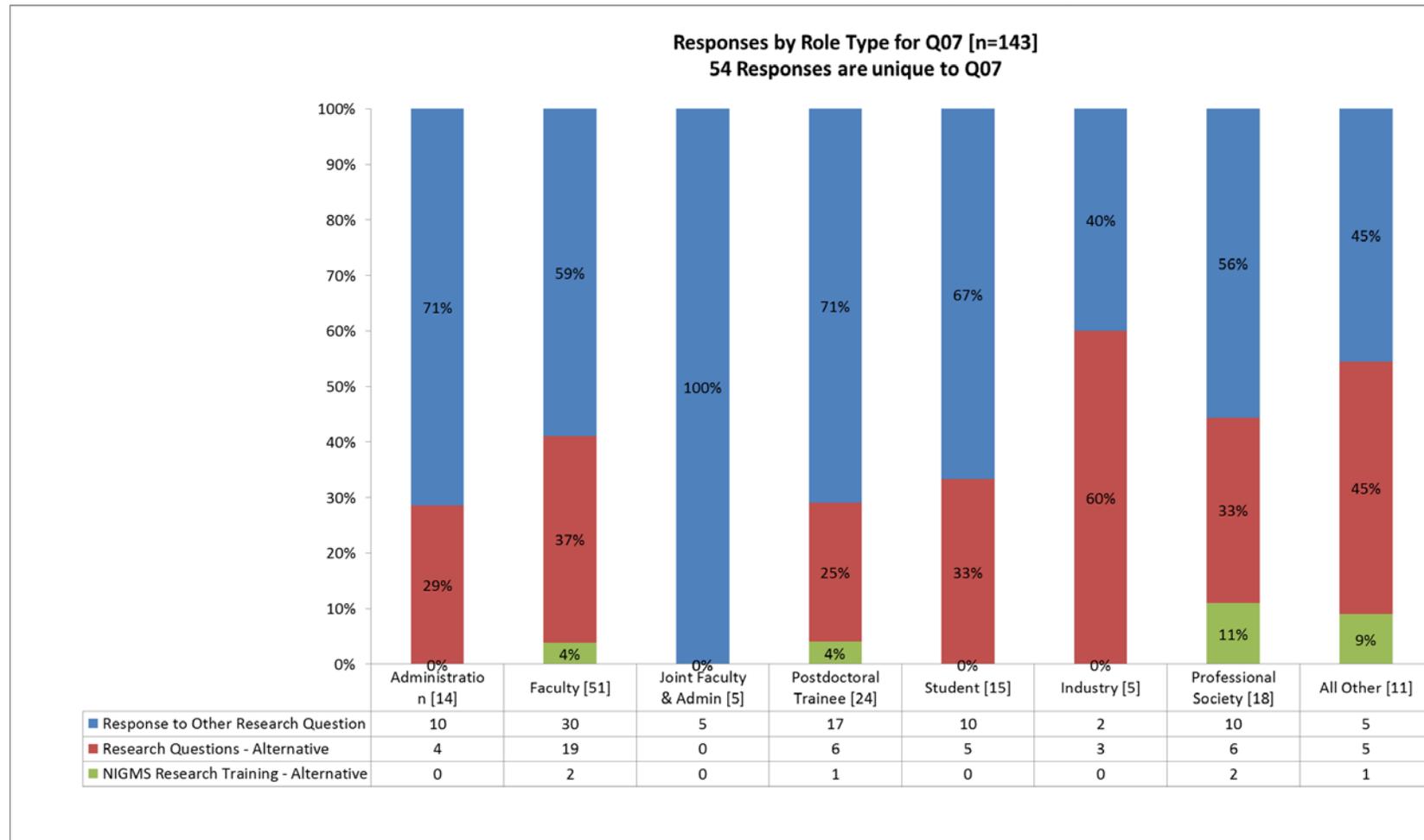
Question Five: Recognizing that students have different career goals and interests, should NIGMS encourage greater flexibility in training, and if so, how? (includes related responses to Question Seven)



Question Six: What should NIGMS do to ensure that institutions monitor, measure, and continuously improve the quality of their training efforts? (includes related responses to Question Seven)

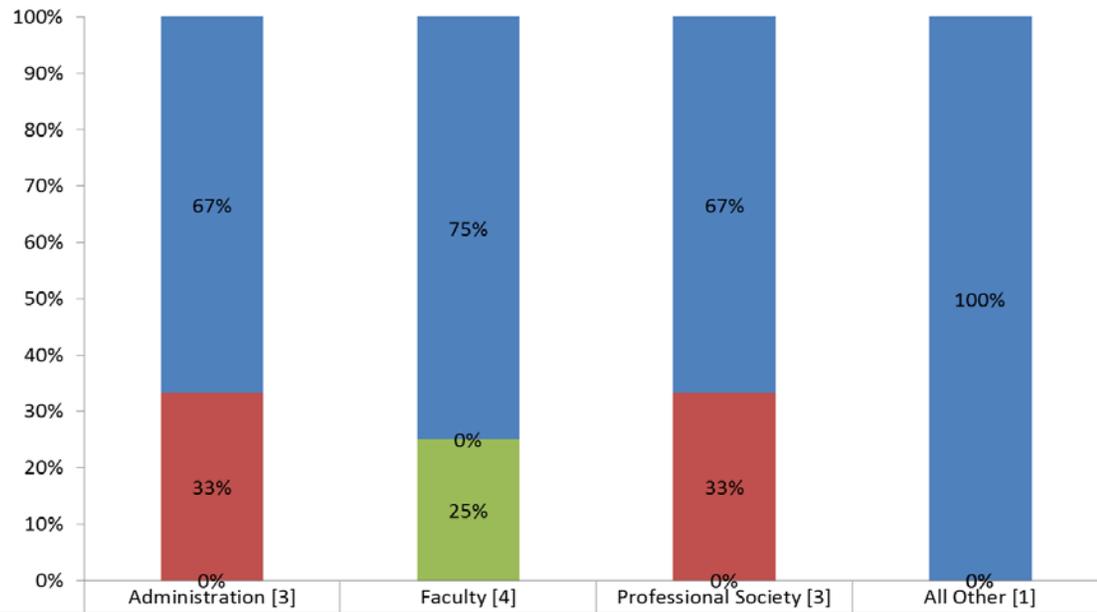


Question Seven: Do you have other comments or recommendations regarding NIGMS-sponsored training?



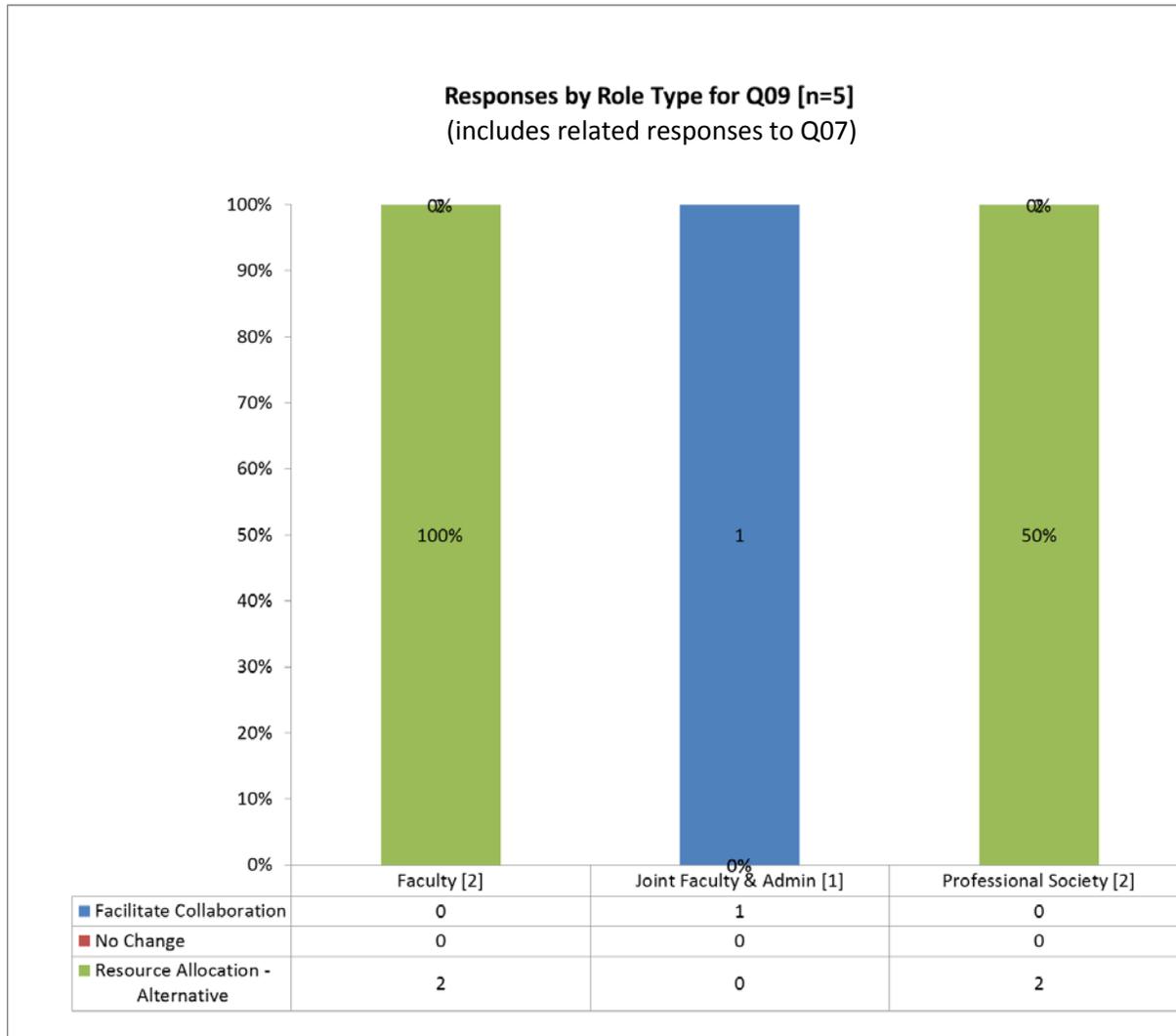
Question Eight: How should NIGMS manage the alignment between training efforts and emerging fields? (includes related responses to Question Seven)

Responses by Role Type for Q08 [n=11]
(includes related responses to Q07)

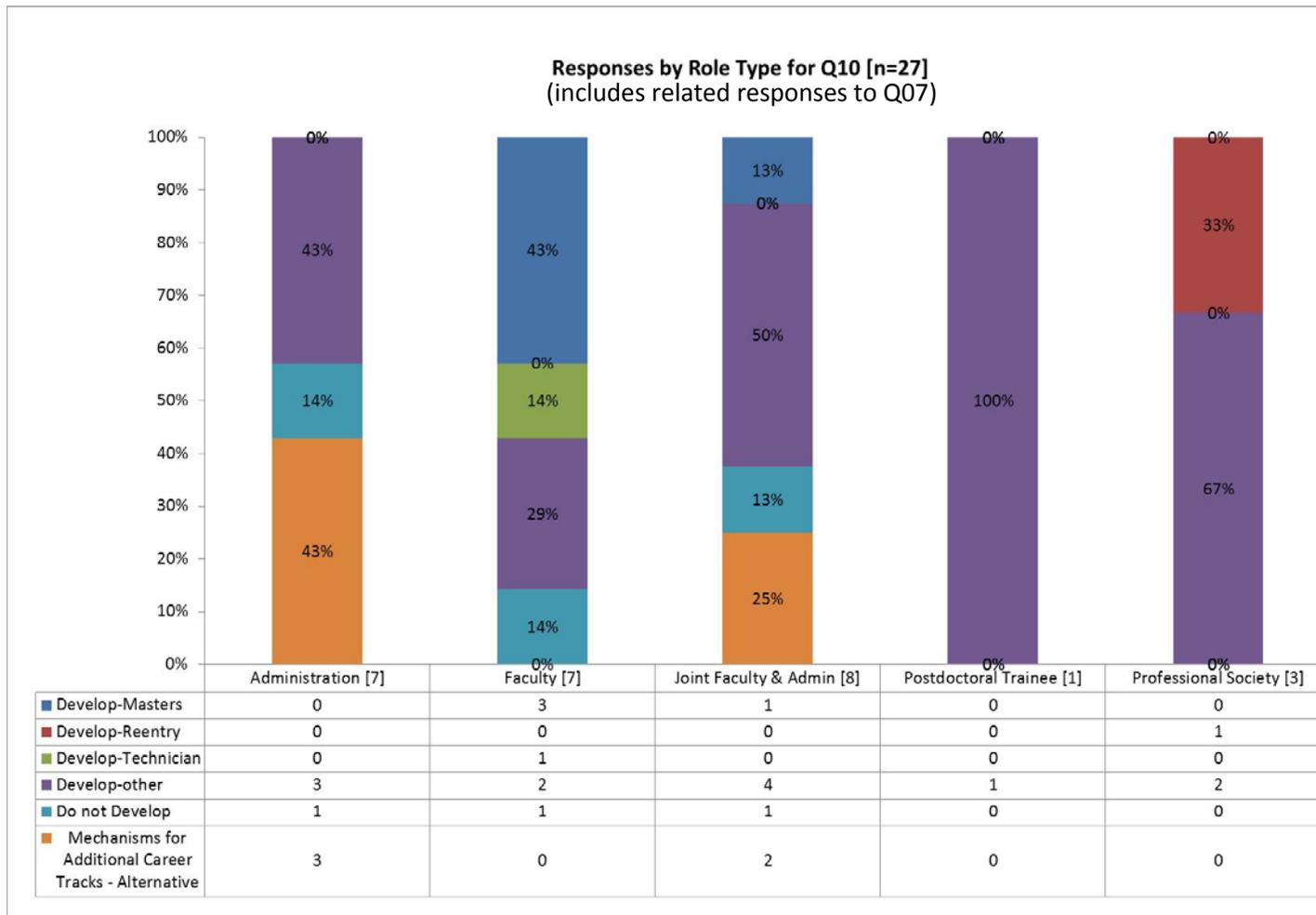


■ Suggestions	2	3	2	1
■ New Programs not Needed	1	0	1	0
■ Alignment of Training Efforts and Emerging Fields - Alternative	0	1	0	0

Question Nine: How should NIGMS manage training resource allocation within and across institutions? (includes responses related to Question Seven)



Question Ten: Should NIGMS help develop support mechanisms for additional research career tracks? (includes responses related to Question Seven)



Chapter 3: Qualitative Analysis

The qualitative analysis described in this chapter was a data-centric inductive process of coding and thematic development. Therefore, rather than following the structure of the research questions posed by NIGMS, this analysis was open to the data and was driven by the content of the data regardless of the research question. Three major themes emerged from the analysis: (1) workforce needs and the scientific enterprise, (2) guidelines for individual and institutional success, and (3) attracting bright minds.

I. Workforce Needs and the Scientific Enterprise

This first major theme addresses several issues related to employment, training, the difference between the two, and suggestions for changing the allocation of funds that would support the necessary skill development required by both an academic and non-academic career. The key problems related to *Workforce Needs and the Scientific Enterprise* are: (1) the institutionalized bias toward training for academic careers and (2) the perceived conflict of interest for PIs who receive NIGMS funding through research mechanisms (primarily the R01). Two sub-themes emerged as suggestions to address key problems related to workforce needs and the scientific enterprise: (a) elevate the value of non-academic careers, and (b) structure research funding to support a training culture.

A. Elevate the Value Non-Academic Careers

Increasing the definition of success from a focus on how many R01 funded scientists are produced to an effective workforce across multiple sectors is essential.

Few respondents supported the deep-seated perception that individual trainees are only successful once they secure an academic position and external funding as an independent investigator. Non-academic career opportunities were perceived as legitimate avenues for making meaningful contributions to society. Informing scientific policy, educating future generations, and communicating science to the public through various professional appointments were a few career tracks respondents consistently pointed to as equally meaningful to society. Continued support for programs that train researchers for rigorous careers in academia was clearly evident, but broad support was expressed for placing greater value on non-academic careers.

Key problems related to the institutionalized bias toward academic careers are the saturation of Ph.D.-level biomedical scientists on the market, the paucity of academic positions available to new researchers, and a perceived lack of the development of skills and abilities relevant for non-academic

careers. To resolve these problems, two main ideas emerged to support the overarching sentiment that individual career paths should reflect the career goals of the trainees: (1) place greater emphasis on Master's degrees, and (2) expand support for alternative training opportunities.

Place Greater Emphasis on Master's Degrees

Recognizing that market forces dominate employment opportunities, both within and outside of academia, respondents suggested that placing greater emphasis on Master's degrees would help bring employment opportunities more in line with the available career opportunities, thus reducing the saturation of Ph.D.-level biomedical scientists on the market. However, motivation for this measure was also in response to a common desire for reduced attrition rates and more efficient selection of trainees to a Ph.D. program (also connected to the issue of attrition). It was further believed that Master's degree programs would be more attractive to minority students and help diversify the biomedical workforce.

The common suggestion was to require a clear distinction between the Master's and doctorate degrees. Faculty members, like the one quoted here, suggested NIGMS consider how other countries manage their graduate training.

Many other countries, including Germany, Canada and others, do not routinely admit undergraduates directly into PhD programs. Rather a Master's degree or Diploma is a prerequisite. The 2-year Master's students conduct supervised research, contribute to the scientific enterprise, and learn whether they have the interest and/or attributes necessary to pursue a research PhD.

Offering and celebrating a Master's degree was considered a means for creating a more accepting and nurturing learning environment. The presence of a Master's program could help reduce the institutional bias toward academic careers and remedy the stigma associated with the choice to leave a doctoral program, or pursue a non-academic career. The perceived benefits of NIGMS support for Master's degree programs included reduced attrition rates, more efficient spending, expanded diversity, and reduced time to degree. Opponents of Master's degree programs worried about the investment of time required to train a Master's student and did not perceive any benefits. There were others who did not necessarily oppose the Master's degree program idea, but supported a continued rate of training Ph.D.-level scientists, claiming that every workplace would benefit from an individual with expert scientific training.

Expand Support for Alternative Training Opportunities

Expanding support for alternative training opportunities was repeatedly offered as a means for addressing the perceived problem of poorly developed trainee skills. Support for two different kinds of

experiences was frequently suggested: short-term experiences that would broaden trainee skills and perspectives and provide opportunities for professional development, and longer-term experiences that would facilitate the development of additional expertise.

Short-term training opportunities referred to attendance at events such as conferences and seminars, which would allow trainees to develop professional relationships, a network of colleagues, and provide exposure to areas of science that trainees may not normally have access to as part of their institutional training. Presenting research at these events should be encouraged if appropriate, but not mandated as part of funding support. As opposed to adding new funding, it was suggested that NIGMS could allocate a specific amount of time for this kind of development as part of existing fellowship and training grants (e.g., 25% of time to professional development). The importance of these types of opportunities was articulated by all types of respondents, from students and faculty to administrators, industry, professional societies, and non-profit organizations.

The more long-term types of experiences identified to address improved skill building referred to experiences that would result in the development of additional expertise. Respondents believed that highly-trained scientists should have the opportunity to specialize in additional fields where their scientific expertise could be utilized professionally in connection with an alternate set of expertise. These careers may or may not be bound to academia, but would impact academia indirectly. Specialized training that focused, for example, on teaching would allow trainees to become not only expert researchers in particular content areas, but, in addition, expert teachers who could then be especially effective at influencing their field. In the case of an NIH award designed to support development in teaching, the individual would be well prepared to teach at several levels, which could include high school, a small college, or a teaching-intensive university. Other frequently suggested ideas for expanded training opportunities included training in science policy and science writing.

The message implicit in this idea, as expressed by this faculty member, was that expertly trained scientists were valuable for contributing to other professions and would become advocates for science in their field of choice, whether in teaching, policy or writing.

With some of the brightest minds in the country obtaining biomedical Ph.D. degrees, just think how we might be able to transform the way society thinks about us if the scientific community encouraged a major portion of those students to choose a career in media or marketing or publishing and be proud of it? I understand the argument that someone with a B.S. or M.S. could also do these jobs, and therefore it is a waste of training money, but I do not agree with that assessment. I believe that a truly bright mind (selection by academic success and ability to obtain a Ph.D. when the B.S. and M.S. students were weeded out at the application process) will probably make amazing advances that outshine those of an average student in whatever they choose to do.

The preferred method frequently cited for delivering these longer-term types of training experiences (especially by students during the webinar) was through coursework, potentially delivered electronically, or through graduate-level certificates, internships or practicum.

It is important to note that quality mentoring is believed to play a key role in ensuring success within the context of expanded training opportunities; due to the significance of mentoring, it is addressed in detail in connection with the second major theme, *Guidelines and Best Practices for Success*.

B. Structure Research Funding to Support a Training Culture

A career in academia is increasingly competitive, and the environment for researchers is perceived as disheartening, unstable, stressful, and “failure filled.” While it was made abundantly clear that more funding and greater stability would relieve stress, enhance morale, and pave the way for adequate time to train, the mere suggestion to increase funding has limited utility. NIH as a whole has been struggling with this problem since the budget doubling that occurred between 1999 and 2003. The relative abundance of available funds during the doubling led to increased expectations and investment at research institutions. However, post-doubling, the NIH budget has not kept pace with inflation, leading to a situation characterized both by reduced purchasing power for NIH and decreased success rates for investigators. The fiscal situation was somewhat brightened by the American Recovery and Reinvestment Act (ARRA) and its \$10 billion boost to NIH funding. However, many are now concerned about a similar fiscal situation that is likely to occur post-ARRA, in which NIH and investigators must cope with an impending funding “cliff.” General sentiment in the extramural research community is that more investigators will face increased competition for smaller amounts of money. It is against this background that comments to “increase funding” should be considered.

Although our analysis did not exclude simple requests for more funding, in the context of the NIGMS Research Training Strategic Plan there is little that can be done about the NIH or NIGMS budget. However, respondents provided many suggestions that NIGMS could implement to ease some of the current and expected pains in such a fiscal environment, and that is the focus of the analysis provided here.

Generally, respondents spoke in support and gratitude about fellowships and training grants provided by NIGMS. In contrast, the key problem of ill-prepared trainees was perceived as an outcome of the research funding mechanism that (a) allows students and postdocs to be hired but does not mandate or provide funding for training/mentoring activities, and (b) is highly competitive to acquire and retain, motivating researchers to distribute their time more towards grant-writing than mentoring and training students and postdocs. Four main ideas emerged to address the key problem related to R01 funding: require training outcomes, re-evaluate the nature of postdoctoral training, support independence, and create new awards for greater funding stability.

Require Training Outcomes

Allowing students and postdocs to be hired on a research grant without articulating specific and required training outcomes has created a phenomenon where scientists, regardless of their interest or skills in training others, become not only PIs upon receipt of their grants, but also mentors responsible for training their students and postdocs as they work together to accomplish research goals. Due to the nature of the current R01 grant structure, PIs are not held accountable for training efforts, nor are they rewarded for them. The current situation is frustrating for both PIs and trainees, and it puts students and postdocs in a vulnerable position.

As a profession, academic scientists have a responsibility to nurture future generations of scientists, but individual researchers take varied degrees of ownership for that responsibility and manage their efforts in different ways. As this faculty member observed, the overall perception was that the PIs career and personal ambitions outweighed their attention to training.

Many of the trainees I know have never written a scientific paper (the PI writes all the papers in the lab) or given a scientific talk. Literally, I am the only one that I know that actually sits down with trainees and writes the paper with them. In many labs, trainees are treated as slave labor; this is unacceptable.

To avoid this perceived conflict of interest for the PI, participants strongly encouraged NIGMS to require that researchers demonstrate training outcomes and mentorship activities as part of the R01 grant application process. For comparison, National Science Foundation (NSF) applications require a mentoring plan to comply with the 2007 America Competes Act. For NSF applications, the mentoring plan is evaluated as part of the Broader Impacts criterion. For NIH, this information could be required in the Facilities and Other Resources section and evaluated either as part of the environment criterion, or as part of an additional review criterion or consideration. This suggestion was the most frequent but was tempered with added advice (from faculty and administrators) that, should this change be implemented, NIGMS provide adequate monetary support and educate reviewers on the new requirements. There was concern that without these added measures of support, true change would not occur; rather, applicants would merely pay “lip service” to the new requirement. Faculty and administrators desired some assurance that the review and evaluation process would account for the value of mentoring by giving due weight to the proposed training outcomes and the researcher’s training track record.

Other ideas repeatedly suggested as changes to the research grant structure: set a limitation on the number of concurrent students and/or postdocs a PI is allowed to have on an NIGMS funded grant, limit training periods and penalize those who fail to meet those deadlines (this was perceived as possible by expanding metrics for success from the number of publications as the primary indicator of success to the overall quality of training experience), and create a means for rewarding quality mentoring.

Re-evaluate the Nature of Postdoctoral Training

The postdoctoral training position has become a purgatory for the current generation of researchers and the age at which they acquire their appropriate career positions continues to get older each year.

Postdoctoral training is poised to become, or has already become, synonymous with semi-permanent employment, and respondents described the problems associated with postdoctoral training as workforce issues. The issues faced by a postdoctoral fellow—the need for professional, early career development, the perceived lack of available employment, the abundance of trained Ph.D.-level scientists, the complexity of scientific research, and increased pressure for PIs to receive grant support—have intersected to influence the diverse nature of the role of today's postdoc. From a PI's perspective, a postdoctoral researcher represents an opportunity to staff the lab and support the research; some PIs mentioned an additional opportunity inherent in a postdoctoral researcher: the opportunity to nurture the next generation of independent researchers.

Question 10, developing support mechanisms for additional research career tracks, was not posed to all participants, and as a result, the data is thin. However, it is worthy to note that the majority of those who commented on the question were in favor of change that would support a new approach. Creating a position, such as a senior research scientist, was suggested as a way to differentiate between employment versus a training position. One member of a professional society speculated that each PI could probably name one to three people who would have made excellent permanent employees:

...there are these invaluable post docs who are really tremendous but you don't picture them being PIs, but they really good with students and they're very good in their technical ability and they're far beyond being a technician. They're much better than that, much brighter than that. So I think it's a very good idea [additional career track]...it could be an answer and take some of the pressure off of all the lab slaves so that you give some independence to some of these people.

There were mixed opinions about what this position may be called, and how it should be funded. One suggestion was to follow the French model where senior scientists are hired by the government and then assigned to different locations over time. Creating a series of new, government-based research positions, which would be flexible and contracted over defined periods of time, would (a) help identify those interested in becoming independent academic researchers (who would then require training through a postdoc), (b) create more stable employment opportunities for biomedical researchers not interested in the academic track, (c) provide PIs with required expertise, and (d) add employment opportunities to the workforce.

In addition to support for creating new employment opportunities, respondents noted the need for providing postdocs a training experience with more structure.

Support Independence

To remove the perceived conflict of interest as described above, some respondents suggested changes to the current research award system, which is characterized primarily by R01 awards, with the goal of providing trainees more financial independence. Several participants suggested increasing the number of fellowships supported by NIGMS; others who liked the idea of greater funding independence did not provide details about how this might be achieved. It was noted that the F31 mechanism is under-used by NIGMS (only available as part of the F31 to promote diversity in health-related research) and could support more fellows.

Other respondents had more unusual ideas about how to create independent students and postdocs. Ideas ranged from restricting research funds from being used to support student and postdoc salaries to decoupling faculty salaries from research grants. One faculty member drew an analogy to social media to explain the latter suggestion:

Graduate students should not be positioned as cheap labor and then sent adrift without proper training. Ideally, funds should be directed at the students themselves thus taking them off the payroll of their mentor and providing them independence. I would strongly support an abundance of one page grants written by students for small sums of money. In a sense, this is "twitter" for grant writing.

It was recognized that independent funding would not guarantee success, and there were certainly those who opposed more fellowships, but one postdoc viewed this means of funding as a way to avoid trainee failures:

Independent funding for trainees (competitive fellowships) would allow them to move from one training environment to another if the first was unsuitable. It would prevent the trainee from being simply an employee of the PI and put some onus on the mentor to provide training or hire technical staff. Separating dollars for training from those for research would allow simpler and much more honest accounting for the NIH.

One scientific society suggested further benefits from moving in this direction, including the scientific freedom to take risks, as well as placing the onus of providing a favorable training environment directly on institutions:

Competitive predoctoral and postdoctoral grant programs similar to the F30, F31, and F32 programs, would require institutions to compete for the best students and in turn focus on how well they actually train students. It would also remove financial pressures from the trainee and encourage students and their mentors alike to pursue more creative, innovative experiments rather than rote, safe ones- because a student can take an extra year to perform a revolutionary, go-for-it experiment without sinking the lab financially. NIGMS should encourage trainees to take

risks and, in turn, learn how to do so responsibly.

The notion that NIGMS favored too much “play-it-safe” science was not uncommon, and this notion was often voiced in connection to a concern that NIGMS failed to spread funding out across enough institutions and PIs. Furthermore, it was noted by some that increasing the number of fellowships would further concentrate funding at institutions already supported by NIGMS.

In contrast to those who thought separating salary support for students and postdocs from research funds would resolve the issue of poor training outcomes, others believed that a larger number of smaller awards to a greater number of researchers would facilitate the development of improved training environments, which would, in turn, facilitate greater diversity in both student composition and research ideas.

Introduce New Funding Mechanisms for Greater Stability

All types of respondents voiced a desire for longer periods of funding, not just for students, but also for faculty. Not everyone viewed the current period of support for most grants as problematic, but there was considerable displeasure expressed about the fractured nature of student funding and the level of competition among PIs for a shrinking pool of research dollars. Ideas for creating new funding arrangements that could provide better stability to students and PIs were offered as a means for (a) encouraging innovative scientific exploration, and (b) reducing the amount of time and energy PIs are currently spending on securing funds, which was perceived as time they could then spend focusing on research and training.

To provide greater stability for students, a few respondents suggested creating a “tiered” funding system, with the idea that a particular student’s career path could be identified early, so that subsequent funding could be allocated according to career track. For example, it was suggested that a tiered system could provide a “super-track” that would identify those destined for an R01 research career and provide funding that would allow continued stability over the course of the trainee’s educational career. Other tracks could identify students en route to an industry position, teaching, public policy, or other professions and offer funding for a period of time deemed sufficient for training related to that specific career goal. Those who voiced disapproval for this kind of structure, either directly or indirectly, pointed to influence of the institutional bias toward academia, the nature of human development (students change their minds), and the belief that a Ph.D. was highly relevant for scientists regardless of career path. We also note potential legal issues with this approach. In contrast, several respondents suggested NIGMS simply support fewer students but fund them more completely.

Respondents who suggested providing more stable funding for PIs tied their suggestion to the idea that improving the perception (and the reality) of a career as a professor would assist with the task of

recruiting and retaining the best and brightest minds in academia. If this goal were accomplished, current students and postdocs would think more positively about a future career in academia, and the culture of academic research would begin to change. New funding mechanisms could require mid-level career researchers to distinguish themselves in a way that would warrant more stable funding, such as that provided by the Howard Hughes Medical Institute. As a more radical idea, NIGMS could restructure its approach to funding PIs and labs, basing funding on supply and demand in the overall market. One faculty member suggested bringing the number of labs in operation in line with the available funding as follows:

You should decide from the start how many biomedical scientists need to be trained, how many academic laboratories you want to support. Then you should support these decisions financially. This means treating PIs as though they are valued employees in whom you've invested years of training. The current system treats us like contract laborers and is indifferent to whether we (and our research programs) sink or swim in the long run. Periodic evaluation and assessment are obviously necessary to ensure that the NIH is standing behind the right researchers. Nonetheless, a system where one's entire career is periodically evaluated would be much preferable to the current system where everyone is left working harder and harder for grants that are effectively shrinking year to year.

On several occasions, the research funding structure was described as “unsustainable” and “broken,” but there was recognition that any major changes directed at reducing the degree of competition for funding would require making tough choices about where to make cuts.

C. Summary

Expanding training support and emphasizing Master’s degrees were suggestions to resolve problems related to workforce development. Respondents felt that providing trainees better access to alternative training experiences, such as support for attending conferences or for the development of additional expertise, and support for Master’s degrees would reduce the number of Ph.D.-level scientists on the market vying for academic positions and provide better training for all individuals regardless of their career goals. Suggestions to improve the research climate and training outcomes associated with the research grant structure included requiring training outcomes as part of the R01 funding award process, re-evaluating the nature of the postdoctoral position and providing alternative employment opportunities, supporting more independent funding either through policy changes or increased support for fellowships, and adding new funding mechanisms to offer greater stability to established PIs.

II. Guidelines for Individual and Institutional Success

The second major theme addresses issues related to the nature of how training programs are delivered, maintained and improved. The key problems associated with this theme are: (1) the creation of

appropriate programs in fast-paced research environments, and (2) ensuring quality training within those programs.

In considering NIGMS efforts to create funding programs specific to emerging research, most respondents suggested NIGMS consider moving away from the approach of creating new and targeted funding programs and focus more on providing guidelines that will allow institutions and PIs the flexibility to pave the way. While heralded as successful for encouraging new directions and methods for discovery, creating new and specific training programs also serve to alienate researchers crossing disciplinary and methodological boundaries in pursuit of meaningful scientific contributions. Respondents trumpeted the success of NIGMS efforts to encourage interdisciplinary and cross-disciplinary research, and they supported continued efforts toward this end but observed that individuals, or groups of investigators, were better positioned to quickly respond to the rapid nature of change within the field.

At the program level, and across all research questions and types of respondents, the overarching sentiment was support for flexible programs embedded within optimal learning environments. Flexibility was perceived as necessary to achieve individual career goals, and optimal learning environments were perceived as the foundation for providing opportunities to master individual competencies. Respondents perceived NIGMS as the guiding force toward defining flexible environments, and as one faculty member explained, the institutional efforts toward creating this type of environment would be well served if NIGMS clearly articulated standards:

It's not helpful for us to pursue potential avenues of greater flexibility if they're a square fit in a round hole. I'm sure you all have a certain amount of wiggle room in terms of the extent to which you are willing and able to extend beyond the traditional focus of moving research forward. But it would be helpful for us to know what the limits are, and in what directions there are and are not flexibility.

To address the key problems associated with the creation of appropriate programs in research environments that are fast-paced and ensuring quality training within programs, respondents repeatedly suggested best practices as a way of setting the standard while allowing for flexibility. Most respondents believed this provision would help support a broader definition of success and reduce the emphasis currently placed on the number of publications as a means for assessing trainee success. As one faculty member pointed out, assessment based on the quality of the research experience for the individual trainee in connection with their career goals would be more difficult but would benefit society in the end.

The "optimal" balance [of breadth and depth] will likely be somewhat different for each trainee and in truth may differ for a given trainee at successive stages of development. NIGMS can best leverage the diversity of strengths among trainees and programs by recognizing this and looking

for adaptive programs in rich training environments rather than homogeneous programs with clear but rigid requirements. This is much harder for reviewers, but much better for the national output of trainees and the unpredictable evolution of rate-limiting skills.

In developing guidelines, respondents suggested that NIGMS facilitate a collaborative process that would involve successful program directors, biomedical educators and social scientists. The process could involve a single meeting or workshop or a series of interactions; once guidelines were created, broad dissemination should follow. Diversity efforts also prompted a request for best practices, but due to the complexity of the diversity issue, it is presented as an independent sub-theme within the next major theme, *Attracting Bright Minds*.

As an addition to developing guidelines, respondents felt it would be helpful if NIGMS could identify specific programs or institutions that exemplify best practices and then offer them as role models for other PIs and institutions.

Respondents offered an array of ideas for what might constitute, or be included in, guidelines or best practices for success. Three major sub-themes emerged from these suggestions: individual competencies, the optimal learning environment, and accountability and assessment.

A. Individual Competencies

Give someone a hammer and all they will treat everything as a nail. Give them a tool belt and they will apply the right tool for each job.

Concern about the quality and types of skills trainees acquire informed this theme, which recognizes dramatic changes in the workforce landscape over the past couple of decades. The skills and abilities required for both academic and non-academic positions share some major overlap, and it was perceived that current training was hitting its target in some areas but missing the mark in others. While there are clearly specific demands from various sectors of the workforce, considering competencies, as opposed to identifying a myriad of specific skills and abilities, broadly defines transferable skill sets and allows individual institutions the flexibility to craft the right kinds of opportunities for developing them. Four major competencies were considered necessary in order to claim trainee success: (1) translation, (2) a scientific mind, (3) professionalism, and (4) resource management.

Translation

The most fundamental component of translation is the ability to communicate effectively. The second, and less frequently identified element of translation, refers to the advocacy role that some respondents believed researchers should serve as they go about their daily lives, interacting with friends, family,

neighbors, and members of the broader community where they live.

The first element of translation, the ability to communicate effectively, is critical for success in any profession; it is especially important for researchers whose vocation involves collaboration and dissemination of findings through different mediums and to different audiences. Effective communication requires listening, questioning, understanding, and the formulation and presentation of ideas, in both verbal and written form, so that target audiences comprehend the intended meaning. Within the scope of their professional day-to-day lives, communicating effectively would involve developing good interpersonal communication skills for interacting with other colleagues, staff and students. More broadly defined, effective communication would involve writing manuscripts, grant applications and other documents, such as CVs, delivering lectures and presentations, and engaging in dialogue with various individuals outside of academia, such as government or the news media.

The second element encompassed by translation is the idea that research scientists, and therefore trainees, should harbor/hold a certain level of joy, excitement and enthusiasm for their research. A number of faculty members voiced the belief that trainees should be more than just vehicles for communicating effective findings, that they should also be advocates for the research enterprise and express in both their personal and professional relations a level of excitement about their work and the field of science in order to engage and motivate others toward an understanding of, and appreciation for, the value of science in society. Respondents admitted that it was difficult to create or require this as part of an evaluation process but offered the idea that nurturing this important emotional predisposition was highly desirable for advancing the scientific enterprise.

A Scientific Mind

The development of a scientific mind emerged from responses about the need for trainees to be fully functioning independent scientific thinkers by the end of their training. The presence of a scientific mind involves the ability to think abstractly and critically, the understanding of and ability to take various theoretical and methodological perspectives, and the ability to move from thinking about specific research questions to thinking about and understanding how those questions fit within the broader context of the goals related to biomedical science. The more tangible elements of a scientific mind would be reflected in an individual's ability to conduct a scientific experiment, from conceptualizing the research problem and question(s) to designing the methods for testing a specific hypothesis to conducting the experiment, processing the results, and presenting them to diverse audiences. Effective leadership and the development of a sense of responsibility for making contributions to the academic and professional communities in which they belong were also used to describe a scientific mind. In essence, respondents referred to the development of a well-rounded scholar, able and willing to make meaningful contributions to the field of science, in whichever professional capacity they choose.

Professionalism

This core competency refers to the professional approach expected of a trained scientist. It goes hand-in-hand with the expectations for a scientific mind, but it refers specifically to the nature in which individuals conduct themselves within the environments they work and live. NIGMS already provides best practices for the responsible conduct of research (RCR), and it was noted that those best practices have been fundamental for the broad inclusion of this element as a requirement of scientific training at most academic institutions. Continued support of strong ethical conduct in connection to research was expected. Beyond RCR, professionalism involves the quality of interactions individuals bring to their work environments. High standards are expected of scientists who function in team environments; respect for individual differences and ideas was key for ensuring effective interactions in the lab, the classroom, amongst colleagues, and other members of the workplace and community.

Resource Management

Trainees destined for both academic and non-academic careers need training in resource management. That observation was made across the board by all types of respondents and was perceived as the area where trainees were least competent at the time of graduation and after a postdoctoral experience. Resource management was often referred to as “business skills” and described the tangible skills that research scientists destined for independent academic research or industry need. Human resource and financial management (e.g., training in conflict resolution, managing personnel, or producing and managing a lab or grant budget) top the list of management skills that should be required as part of scientific training.

B. The Optimal Learning Environment

Creating an optimal learning environment lays the foundation for a flexible and rich training experience. Two themes emerged that describe what respondents believe constitute an optimal learning environment: (1) core content and experiential opportunities and (2) developmental supports. Providing the right kinds of opportunities and developmental supports was perceived as the means for maximizing a trainee’s ability to gain all of the knowledge and experiences necessary for achieving core competencies.

Core Content and Experiential Opportunities

The presence of opportunities to gain fundamental knowledge and experience the full spectrum of the scientific process emerged as two of the five key elements of an optimal learning environment. While program flexibility was highly desired for effectively training biomedical scientists, within the context of flexible environments, several respondents requested that NIGMS establish a recommendation for core

coursework that would emphasize the basic building blocks required for any biomedical scientist entering the field, in any capacity. By providing suggestions for core coursework, NIGMS could set a standard of excellence for the acquisition of fundamental knowledge.

In recognition of the nature of research today, providing opportunities for students to engage in interdisciplinary and cross-disciplinary learning was repeatedly suggested for ensuring breadth and depth but also for providing opportunities to develop core competencies. As a means for identifying interdisciplinary or cross-disciplinary opportunities for learning and research, respondents suggested the presence of productive relationships within and between institutions, industry and community organizations. Those relationships could serve to facilitate collaborative research projects across departments, labs, institutes, and within the community, and provide opportunities for clinical rotations, seminars, internships, practicum, and potentially shared resources (e.g., institutes could share on-line short courses as a means for expanding breadth). Supporting trainees to attend conferences and teach were further suggestions for creating and identifying an optimal learning environment.

Developmental Supports

Developmental supports refer to personal or relational elements that support the individual trainee as they move toward professional goals. Three supports perceived as most influential for trainee success were quality mentoring, career development and human resources. These three suggestions make up the rest of the five key elements of an optimal learning environment. However, because career development and human resources are addressed as part of the third major theme, *Attracting Bright Minds*, the focus of this section is mentoring.

As part of the first major theme, *Workforce Needs and the Scientific Enterprise*, it was suggested that training efforts be required as part of the research award process. That suggestion is relevant here, and now we expand on the issue of mentoring. The importance of mentorship for trainee success is well documented. While the developmental stage of the trainee will influence the degree and frequency with which mentorship support and interactions are necessary, it is well known that mentoring can make the difference between success and failure. Implicit in the discussion surrounding mentoring was the need to make a distinction between training and mentoring. Mentoring requires an investment of time, energy and passion and refers to a commitment of continued engagement with a student toward the goal of professional development. If NIGMS required a training component as part of the research grant application process, respondents suggested mandated mentoring for both students and postdocs as part of the training requirements.

...but that's the reason for having graduate programs, is to have a super structure to have thesis committees, to have this, to have that, to have a formulation that allows the student to get more value added than simply become a pair of hands in the lab.

An uncomfortable acknowledgement was an observation made by several respondents (faculty members, students and postdocs alike) that not all PIs make good mentors. Therefore, best practices should provide flexibility for trainees and PIs to identify multiple mentors, which may or may not include the PI. Encouraging multiple mentors was perceived as a way to avoid putting a PI not interested in mentoring in a conflicting situation and as a way to encourage quality mentoring in all aspects of development. For example, mentors with specific expertise could provide guidance in their content areas, while other mentors with expertise in program or career development could provide guidance toward trainee career goals. The use of individual development plans (IDPs) was frequently pointed to as a concrete tool that should be used for designing, monitoring and measuring student progress and success. Again, NIGMS could provide an example for institutions to follow and could require IDPs as part of the award process.

To encourage and support those PIs who engage in mentoring (or who want to), the most frequent suggestion was to provide either monetary support or recognition for mentoring efforts. As it stands, the incentive for PIs to engage in mentoring is intrinsic. Providing external rewards for mentoring could involve restructuring the research grant program or providing protected time and money through administrative supplements. Ongoing mentorship training for faculty, staff, career counselors, and others engaged in the effort was consistently pointed to as a means for encouraging quality mentoring, and some respondents suggested NIGMS could facilitate forums or conferences where attendees could discuss and share best practices or that NIGMS could sponsor activities provided by professional societies already involved in mentoring.

C. Accountability and Assessment

At the heart of responses to the issue of quality training laid accountability. As previously noted as a means for allowing accountability, several respondents suggested that training efforts be required as part of the research funding award process; however, that step alone was not always perceived as adequate. A further recommendation was to tie funding to evidence of monitoring and evaluation:

An often overlooked component of training programs is evaluation and metrics of success. It is imperative that training programs employ bona fide, validated methods to evaluate curricular offerings, programmatic components (rotations, conferences, etc.), mentors, research experiences, and trainee success as part of a comprehensive quality control/quality assurance program for their training efforts. These ongoing evaluations should provide feedback about what works and what does not, and a plan should be in place to implement appropriate, informed change. Moreover, these elements should be included as part of the required criteria employed for peer review of training programs

Variation on the sentiment for how to achieve tasks related to quality and improvement saw the majority of respondents looking back at NIGMS to either provide direct support or become more

involved in the process. Chapter 2 provides a detailed discussion about how respondents viewed the responsibility for achieving the tasks involved with monitoring, measuring and continuous improvement of programs. Here, we provide a list of elements that respondents identified as important for including as part of guidelines or best practices.

Specific recommendations included long-term career tracking through the use of databases, either at the institutional level or through NIGMS. Currently required measures were consistently encouraged as indicators of short-term success (e.g., attrition rates and career placement [including non-academic placement]), but new elements included a component for assessing core curriculum, the use of trainee and mentor interviews (anonymous for the trainee), and development plans for trainees. As part of the guidelines, it was suggested that NIGMS could create a common evaluation template that institutions could use for self-improvement. Some respondents noted that adequate information was already required and suggested NIGMS step-up use of existing report mechanisms and enforce compliance with existing requirements.

The depth with which best practices should be required was somewhat contested, and as previously mentioned, so was the issue of who should determine whether or not individuals and programs are achieving success within the parameters of best practices. In the case that reviewers would be involved with the process of assessing programs or grant applications for measures of accountability, respondents were adamant that reviewers needed to be trained to recognize and evaluate these efforts according to the new values articulated by NIGMS.

D. Summary

Providing guidelines and best practices was repeatedly suggested as the preferred method for ensuring that quality programs were being delivered and maintained in such a way that would allow for individual development designed to achieve identified career goals. By providing institutions with the appropriate tools for identifying the elements necessary for program success and by ensuring compliance with articulated expectations (in reference to the idea that institutions would be required to demonstrate training, mentoring and monitoring efforts as part of the funding process), most respondents felt that institutions were the ones who should ultimately be responsible for deciding the content of their programs and demonstrating trainee success.

III. Attracting Bright Minds

The perceived changes required to recruit the brightest minds to a research career in biomedical science would occur broadly at the level of society and locally at research institutions. Due to the current bottleneck of biomedical researchers unable to attain faculty positions, there was some disagreement

about whether or not NIGMS should continue funding as many students as it currently does. One postdoc, whose application for a tenure-track position was rejected, was told by the institution that 600 people had applied for that single position:

To address this issue, NIGMS should think about the funding level and the size of these training grants. In most institutions, these training grants cover first one or two years of graduate student life while the rest is covered by either teaching assistantship or by research assistantship through separate grants. Why not support those trainees for at least 4 - 5 years while reducing the number of trainees to half?

Supporting fewer students was not consensual, but the sentiment was echoed by some faculty members, administrators, and other students and postdocs who wished to see high-quality students supported for the majority of their training in order to reduce financial pressures and allow them to focus on their studies. One message that did achieve consensus was that, regardless of the number of students NIGMS supports, attracting bright minds to the field would require improving the public image of the field of biomedical research and the perceived value of a career as a research scientist. This idea is captured in the first of three sub-themes that emerged to inform this major theme, elevate public perception and understanding of the scientific enterprise. The other two sub-themes are empower students and ensure diversity.

A. Elevate Public Perception and Understanding of the Scientific Enterprise

Participants believed that improving public understanding of science in general, and of biomedical research efforts specifically, was the first step toward setting the groundwork for attracting the brightest minds to a career in biomedical research. Improved scientific literacy was fundamental to this effort and could be achieved through public marketing campaigns and improvements to the public school system. While it may seem beyond the scope of NIGMS, one member of a professional society believed NIGMS had the power to influence institutions to make changes toward this end:

Training should include institute driven incentives for mentoring, outreach, publications in lay audience media and cross profession publications (YouTube, traditional newsprint, community newsletters, etc.). Without significantly improving lay audience image and understanding of biomedical research, the U.S. will fail to attract new U.S. based talent to the field.

In connection with increased literacy and understanding, respondents believed promoting the value of science conducted through NIGMS training and research grants would help make the field more reputable in general, and a career in biomedical science revered.

B. Empower Students

The second sub-theme explaining how respondents believed NIGMS could attract high-quality students is about giving students more power to affect their individual training. All of the sub-themes related to the first major theme, *Workforce Needs and the Scientific Enterprise*, are relevant for this sub-theme and can be considered appropriate ways to empower students (greater value for non-academic careers and a supportive training culture).

In considering the different types of trainees, respondents offered both broad suggestions for empowerment that are relevant to all trainees and specific examples relevant for postdocs. The most common suggestion for empowering all levels of trainees came from respondents of all types—give students voice. This idea is connected to the issue of monitoring, measuring and improving programs; the underlying message from students and postdocs was they felt powerless in the training process due to their lack of input. Offering anonymous surveys to students as part of a regular review process at the institutional level was one idea, but another involved student feedback directly to NIGMS. General consensus about the sensitive nature of student input motivated the suggestion for NIGMS to be the point of contact for student input.

Another suggestion for empowering trainees at all levels was development of a tool to help trainees identify and evaluate programs, not just prior to their application, but while they are in the program. Respondents felt NIGMS could either provide students with this tool or encourage institutions to move in that direction. By providing trainees with information about what they should be receiving as part of the training process, they would be empowered to identify, seek out and hold institutions accountable for elements they may not be receiving or elements that are poorly provided. One postdoc suggested that NIH establish a grievance process for students, postdocs and research staff, and that institutions be mandated to provide orientations where student and postdoc supports and rights are clearly identified. Other suggestions included the creation of an on-line social networking community for trainees where they could share their ideas and experiences, receive peer support and advice, and learn about other programs and mentors.

Specifically for postdocs, creating a more structured approach for training was commonly suggested as a way to ensure quality training and prevent some of the pit-falls of the postdoctoral position (e.g., time to degree and failure to acquire core competencies). The National Postdoctoral Association (NPA) offered an array of excellent ideas for building supportive and empowering elements into existing programs. One suggestion involved NIGMS providing incentives to institutions to encourage the establishment of a postdoc office, which would serve as a central point of contact for all postdoc resources, such as program advice and career counseling. While the NPA's suggestions were specific to postdocs, the content of their ideas are mostly applicable to predoctoral trainees as well, especially career counseling. Providing students with opportunities to explore and develop career paths through paid internships, on-line classes and lectures was perceived as outside the scope of what mentors should be expected to do.

C. Ensure Diversity

Viewed broadly, the current training structure is perceived as inaccessible to large portions of the population, not just racial and ethnic minorities, but also a vast number of young people who are not receiving the kind of early education necessary to prepare them for a career in science. Respondents repeatedly pointed to early education as the key for attracting and adequately preparing diverse populations, and in turn, all populations for a career in science, but definitions of what “starting early” meant varied.

Some respondents referred to the need for improved outreach and education as early as grade school but especially high school; while others referred to the undergraduate level as starting early. Improving public education may be outside of the scope of NIGMS efforts, but respondents had suggestions for how NIGMS could improve early outreach at high schools. Most popular was the idea of reinstating support for high school science fairs and summer internships (where science could be taught in the context of virtual games such as “battle of the molecules” and “human anatomy puzzles”).

In addition to the ideas noted above, suggestions for attracting racially diverse students to science included marketing role models to young students as a means of demonstrating the potential for a successful career in science. Respondents also suggested that NIGMS support students at various levels of post-secondary education, including students attending community colleges. NIGMS should encourage outreach to students at the freshman or sophomore levels through student involvement in a practicum or social organization, upgrading the quality of education at feeder institutes, such as Historically Black Colleges and Universities (HBCUs) and Minority Serving Institutions (MSIs), and most frequently, and potentially most importantly, that NIGMS facilitate productive partnerships between institutions. For example, NIGMS could help identify potential relationships between MSIs, or institutions with Minority Opportunities in Research (MORE) programs, and larger institutions either with or without T32 grants and invite these groups to collaborate. Comments from one professional society provide support for this widely suggested effort.

Research indicates the efficacy of departmental/institutional and multi-institutional partnership models for effecting systemic change to increase participation of diverse populations in research training. These models, distinguished by provision of research training funding to institutions (i.e., funding that is not individual -merit-based), serve to withstand the challenge of affirmative action opponents while providing departments/institutions incentives to provide trainee stipends and to effect changes in departments (e.g. related to advising, procedures, tutorials, targeted research skills training, mentoring, etc.) that lead to more supportive academic and social climates for diverse students and others. These models are significantly more cost-effective per student than individual-merit-based models, while evidencing similar “success” rates.

Existing programs, such as the Initiative for Maximizing Student Diversity (IMSD), Minority Access to Research Careers (MARC), Bridges to Baccalaureate, NIH Director's Pathfinder Award to Promote Diversity, and Postbaccalaureate Research Education Program (PREP), received high praise, and requests for increased funding for existing programs was pervasive. However, the primarily supportive and positive sentiment surrounding existing diversity efforts included requests for NIGMS to make improvements. Respondents wanted more slots for students, longer periods of student funding, a re-examination of programs to identify practical limitations (e.g., unnecessarily limiting eligibility demands), better monitoring of current programs, and better marketing to increase awareness of existing opportunities.

From a broader perspective about how best to achieve increased diversity in biomedical science, respondents suggested that NIGMS provide best practices for programs that currently embrace diversity or those that seek to improve their diversity efforts. Once established, best practices could help guide program improvement while serving as the basis for holding institutions accountable for diversity initiatives. In contrast to those who thought guides for achieving increased diversity would suffice, there were those who suggested that, as with mentoring, training and evaluation efforts, NIGMS should tie research funding to diversity efforts in order to force programs to respond.

Creating the right learning environment for diverse students was an important measure identified by countless respondents. Recognizing that diverse students face challenges associated with being in the academic environment where they are not well represented, respondents suggested several methods for improving the likelihood of a quality education for minority students. First, in the process of evaluating minority students for entry into programs, it was suggested that NIGMS encourage programs to focus less on standardized methods of assessment (e.g., GREs) and more on ideas and creativity. Second, it was suggested that diversity training be provided for NIGMS reviewers, project and grant directors, PIs, mentors, career counselors, and individuals involved with admissions. Third, once in the program, providing minority students with quality mentoring was perceived essential for success; therefore, respondents suggested that NIGMS reward mentors who successfully train minority students and train reviewers to place less emphasis on the productivity of mentors who are engaged in mentoring minority students. A fourth suggestion was to recognize and provide time for adequate social supports to operate in the environment.

Identified as part of one of the five elements of the optimal learning environment (see [developmental supports](#)) and as a means for making the field more attractive to all potential trainees, providing adequate human resources was perceived as especially relevant to minority trainees. As this postdoctoral trainee describes, minority students often have extended families to think about:

*Make sure people are paid decently and trained for careers that are in demand and well paid.
People from disadvantaged backgrounds with a boat load of smarts and where-with-all are not*

drawn to low paid careers. Smart people from disadvantaged backgrounds have siblings and parents who they need to provide for. In some cases they are literally the anchor their family has established into the middle class and the more they maximize their income, the better they are able to lift their parents, siblings, and siblings children out of poverty.

In addition to increased wages, a representative of one organization) also suggested expanded loan repayment options, improved benefits (e.g., health and dental care), and policies to improve gender equity:

Underrepresented minorities frequently cite economic disadvantage as a major reason for not pursuing a research career. Similarly, women scientists may find a prolonged postdoctoral period with low salaries and limited benefits to be incompatible with the biological timetable for bearing children. In addition, providing support for child-care or incentives for family-friendly institutional policies could help retain some of the best and brightest researchers who might otherwise leave the research workforce in order to fulfill family obligations.

Several other respondents cited evidence of gender and other bias and voiced displeasure that only racial diversity seemed to be considered. Collectively, respondents suggested the definition of diversity should include women, an underrepresented sex in a specific field (e.g., in nursing men represent the minority), first generation college students, sexual orientation, age, and economic status.

As minority students move through their educational experience, it was suggested that NIGMS encourage and reward minority students to join institutional minority recruitment efforts and other diversity-related initiatives (e.g., developing diversity policy); it was further suggested that the same encouragement be given to training grant directors and PIs. Finally, as there is a paucity of diverse faculty for students to relate to, some respondents believe NIGMS should provide incentives for hiring diverse staff, potentially through transition K awards.

D. Summary

As NIGMS continues efforts to create a pool of talented, vital and productive biomedical scientists, three main ideas echoed throughout the data: improve the public image and understanding of biomedical research, empower students, and ensure diversity. These three measures were identified as a means for attracting bright minds to the biomedical workforce by elevating the prestige of a career in science for all populations and ensuring adequate measures of support for individuals who enter the pipeline.

Chapter 4: Conclusions

The data collected as part of the NIGMS strategic plan for training and career development was rich and plentiful. This chapter includes the most salient issues that emerged as part of our analysis process and reflects major issues facing both NIGMS and the entire scientific community. Organized into two parts, this chapter focuses first on issues specific to NIGMS efforts toward Research Training and Career Development, and then turns to issues relevant to the greater scientific community.

It is worthy for NIGMS to note a recurring theme expressed by several participants as part of this process, and that was gratitude; not only that NIGMS was undertaking this effort, but also that so much effort was made to solicit external input. Stakeholders recognize the importance of NIGMS within NIH as a major player in research training and were encouraged that NIGMS is willing to take the lead in fostering a culture change. Ideally, improvements that originate in NIGMS as a result of this strategic planning process will be considered pilot programs and spread to NIH as a whole.

PART ONE: NIGMS Efforts toward Training and Career Development

Beginning the data collection effort with the question, “What constitutes ‘success’ in biomedical research training from the perspectives of an individual trainee, an institution, and society?” was a creative and effective method for cueing respondents to think holistically about the biomedical scientific enterprise in America, and it served well to set the stage for each respondent’s comments to the full set of research questions. The set of challenging questions posed by NIGMS elicited a plethora of observations about what the optimal outcomes for scientific training should be, what the current problems are, and how best to resolve those problems and achieve optimal outcomes. In response, we have identified four key issues:

- Supporting Non-Academic Careers
- Fostering Successful Training Programs
- Providing Structure to the Postdoctoral Research Position
- Bolstering NIGMS Data Collection and Analysis

I. Supporting Non-Academic Careers

One of the most pressing issues that emerged as part of our analysis was the perceived mismatch between the number of researchers trained and the number of opportunities believed to be available

for gainful employment. Respondents defined failure as the inability of NIGMS-supported trainees to secure employment where their expertise could be utilized for the betterment of society. Based on the broad recognition that the academic tenure track cannot absorb the number of biomedical scientists being produced, the message was loud and clear that NIGMS needs to train for careers outside of academia.

Considering the interrelated nature of the NIGMS research questions and the overlap in responses by participants, achieving the goal of training for careers outside of academia would require action in multiple domains, many of which are beyond the reach of NIGMS. However, more than 75% of respondents consistently supported improvements that NIGMS could make toward broadening the definition of success, encouraging a balance between breadth and depth, encouraging greater flexibility in research training, and enhancing diversity efforts. Progress toward these aims would contribute to the articulated need for training that prepares biomedical researchers for careers other than the academic tenure track.

II. Fostering Successful Training Programs

In the context of training for careers beyond the academic tenure track, and considering some of the changes that could help facilitate that goal, respondents frequently called for guidelines to help foster training success. As previously mentioned, respondents were in support of broadening definitions of success, encouraged by the idea of increasing breadth or supporting a balance of breadth and depth, and they felt strongly that flexible learning environments would support these efforts and provide opportunities for students and postdocs to develop required competencies. However, respondents were concerned about how elements of a successful program would be known to institutions, evaluated by reviewers, and monitored by institutions and PIs.

As a way to address these concerns, respondents suggested establishing guidelines that would highlight elements of a successful program, including mentorship and diversity. First, a common set of guidelines would articulate the same set of standards to administrators, PIs, and reviewers, thus creating a level playing field for all parties involved in the delivery and evaluation of training. Second, the provision of quality mentorship was far and beyond the most frequently noted omission of research funding mechanisms, most notably, the R01. Respondents suggested that including guidelines for mentorship, and specifically for the development and use of Individual Development Plans (IDPs), could resolve the issue of managing the mentorship relationship in such a way that ensures trainee success and provides an element of accountability. Third, guidelines to effectively recruit and train diverse populations would satisfy a large number of respondents who requested assistance on how best to achieve diversification of both their student body and faculty. The majority of respondents were in support of continued and enhanced diversity efforts (including improved compliance), and the most fruitful way respondents perceived to achieve this goal was through relationship building between major research institutions

(not just those receiving a T32) and one or more of the following: MSIs, institutions with Minority Opportunities in Research (MORE) programs, and community colleges.

III. Providing Structure to the Postdoctoral Research Position

The lack of structure surrounding the post-doctoral research position is contributing to the steady increase in the amount of time individuals are spending in their “training” phase, and also contributing to the vast differences in the nature and overall quality of the experience. While predocs are trained within the context of well-established graduate programs, postdocs do not enjoy the same structure and can be vulnerable to the whims of the PI under which they are funded. Participants most frequently suggested clearly defining the roles and expectations of the postdoc and PI prior to beginning the postdoctoral position, potentially through the use of a formal contract or Individual Development Plan (IDP). Providing structure would be a positive step toward preserving the intent of the postdoctoral training experience.

IV. Bolstering NIGMS Data Collection and Analysis

Reactions to Question 6 (“What should NIGMS do to ensure that institutions monitor, measure, and continuously improve the quality of their training efforts?”) generated a medley of ideas about how programs should be measured and monitored, and who should be doing what. While unrealistic and unexpected that NIGMS be responsible for all monitoring efforts, several respondents suggested that NIGMS could do more with the reports already being provided by institutions and PIs, perhaps through analysis and aggregate reports made available on the NIGMS website. In addition, since the enactment of the recent NIH Reform Act mandating NIH-funded degree-granting institutions to report to the NIH (and to prospective students) information about recent graduates¹⁶, and due to the multiple requests by respondents for a centralized location to access information about trainees and career tracking, NIGMS could consider creating a public repository for training data.

PART TWO: NIGMS and Broad Issues Facing the Greater Scientific Community

In contrast to Part One, which summarized straightforward responses to the research questions, the ideas presented in Part Two require additional context in order to nest respondent concerns, observations, and ideas in a meaningful way.

¹⁶ <http://www.nih.gov/about/reauthorization/>

Three issues presented here effect, but transcend NIGMS:

- Improving the Public Image of the Scientific Enterprise
- Ensuring Continued Research Funding in the Modern Fiscal Environment
- Preventing the Indentured Use of Trainees

I. Improving the Public Image of the Scientific Enterprise

The public image of science in general and the related level of public understanding and support for scientific research are in need of a healthy boost. A long term approach for improving the understanding of science by the public came from respondents who pointed to the K-12 public school system as a key part of the problem. They noted that early exposure to quality science education and the development of the required skills to follow the scientific path was essential. Respondents suggested that NIGMS reinstate support for programs that reach down into the lower grades in order to attract and prepare potential young scientists, and improve scientific literacy, which would eventually improve how much the public values the scientific enterprise, and thus increase the prestige of a career in science.

Thinking about the current situation in relationship to the general population, respondents observed that improving public perception and understanding of biomedical research would require some public marketing efforts. Ideally, public campaigns would result in greater public support for research and a broader capacity for attracting quality students to a revered career. However, from the public's point of view, engaging in activities related to improving one's public image could seem fiscally irresponsible. Therefore, NIGMS could encourage others, such as non-government organizations and professional societies, to engage in public marketing campaigns designed to promote medical research and the scientific enterprise as an important element of a society dedicated to improving the human condition.

II. Ensuring Continued Research Funding in the Modern Fiscal Environment

A number of academic scientists believe that claiming independence from market forces is a cornerstone for maintaining scientific integrity, yet laying claim to complete independence is a luxury of days past. Sources of funding for scientific research have expanded over the last century to regularly include government, industry and the non-profit sectors, and current employment trends find a vast number of trained scientists working in the for-profit sector or for non-governmental organizations. Although partnership with industry was not a direct question, some respondents suggested institutions need to improve efforts at bridging the gap in relations between academia and industry. The current economic climate is ripe for continued and more robust development of public-private partnerships; more importantly, public funds for research are not likely to continue growing at the same rate enjoyed

in recent years. Most likely, researchers will continue competing for limited funds and see further financial restrictions enacted. In such a fiscal environment, enhancing partnerships with the private sector would be a bold move that would affect the entire research funding structure.

NIH already employs many public-private partnerships through the use of the NIH Roadmap Public-Private Partnership program office and the Foundation for the NIH. NIGMS could work closely with these offices in an effort to create or enhance dual funding opportunities for research. In this fashion, NIGMS will have sufficient opportunity and support for creating a structure that protects the integrity of the research conducted under such a funding opportunity.

In addition to creating funding opportunities through the use of public-private partnerships, NIGMS could regularly consider industry partners as future funding sources for research and research training opportunities. Measured and regulated steps taken now can help to ensure the desired outcome of continued biomedical funding with appropriate protections.

III. Preventing the Indentured Use of Trainees

As noted by NIGMS in the key observations that precipitated this strategic planning effort, the number of U.S. graduate students supported by any kind of traineeship, fellowship or teaching assistantship has been fairly constant since 1990, while the number supported by research assistantships has increased.

At the same time, universities are expecting investigators to shoulder more costs (both research costs and salary costs for personnel), increasing the pressure on investigators to produce successful grant applications and decreasing the time they have to devote to mentoring and training students and postdocs.

At the heart of this issue is the funding mechanism used most by NIH to support the extramural community. While the training grants and specified training resources received praised, the R01 award received criticism. As it stands, the R01 award provides funds to support the *labor* of students and postdocs working with the PI, but it does not provide funds or accountability for the *training* of these individuals. Respondents offered two suggestions to remedy the situation: (1) require accountability for training students and postdocs, with or without providing additional funds for this activity, and (2) decouple these two activities, so that funds for students and postdocs (including both labor and training funds) are not part of the R01 award structure.