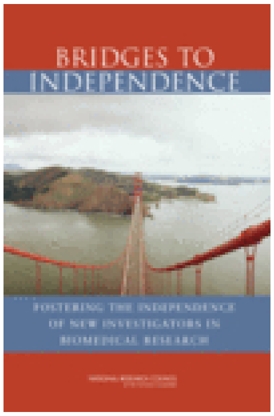


**Bridges to Independence: Fostering the Independence of New Investigators in Biomedical Research**

Committee on Bridges to Independence: Identifying Opportunities for and Challenges to Fostering the Independence of Young Investigators in the Life Sciences, National Research Council

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# BRIDGES TO INDEPENDENCE

## FOSTERING THE INDEPENDENCE OF NEW INVESTIGATORS IN BIOMEDICAL RESEARCH

Committee on Bridges to Independence:
Identifying Opportunities for and Challenges to Fostering the
Independence of Young Investigators in the Life Sciences

Board on Life Sciences

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# COMMITTEE ON BRIDGES TO INDEPENDENCE: IDENTIFYING OPPORTUNITIES FOR AND CHALLENGES TO FOSTERING THE INDEPENDENCE OF YOUNG INVESTIGATORS IN THE LIFE SCIENCES

**THOMAS R. CECH** (*Chair*), Howard Hughes Medical Institute, Chevy Chase, Maryland
**AARON DIANTONIO**, Washington University, St. Louis, Missouri
**JANICE G. DOUGLAS**, Case Western Reserve University, Cleveland, Ohio
**SUSAN A. GERBI**, Brown University, Providence, Rhode Island
**BRUCE R. LEVIN**, Emory University, Atlanta, Georgia
**CAROL L. MANAHAN**, AAAS Science and Technology Policy Fellow,[1] Arlington, Virginia
**GEORGINE M. PION**, Vanderbilt University, Nashville, Tennessee
**DAGMAR RINGE**, Brandeis University, Waltham, Massachusetts
**JULIE A. THERIOT**, Stanford University, Stanford, California
**KEITH R. YAMAMOTO**, University of California, San Francisco, California

## Staff

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**KERRY A. BRENNER**, Senior Program Officer
**CARA B. ALLEN**, Christine Mirzayan Science and Technology Policy Graduate Fellow
**SETH H. STRONGIN**, Senior Program Assistant
**BRENDAN BRADLEY**, Program Assistant/Research Intern
**KATHI E. HANNA**, Writer
**PAULA T. WHITACRE**, Editor

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[1]Placed at the National Science Foundation through the AAAS/NSF Science and Engineering Fellowship Program.

# Foreword

The year is 2029. Alarmed by the evidence that most of the breakthroughs in biomedical science are coming from Asia and Europe, the newly inaugurated President of the United States asks the National Academy of Sciences (NAS) to help the nation understand how we lost our preeminent leadership position.

The concern was not merely academic, not just the fact that Americans were now only occasionally seen in the ranks of awardees of Nobel Prizes and constituted fewer and fewer of the authors of articles in the very top scientific journals. Instead, the public's concern was mostly economic: several new blockbuster pharmaceuticals were coming onto the market each year, highly successful treatments for several kinds of cancer, diabetes, Parkinson's disease, and schizophrenia. Most were invented, patented, tested, and manufactured in Asia and Europe; none in the United States. Essentially all of the economic stimuli created by these drugs—including all of the jobs—had been unintentionally "outsourced." Worse yet, a country that had developed powerful antiviral compounds to treat the last two pandemic bird flu viruses was on rocky political terms with the United States and had refused shipments of the drugs; a vigorous black market had developed, but there was no legal supply.

It was not difficult for the NAS Committee in 2029 to trace the root causes of the U.S. fall from preeminence in biomedical science. American college students had always paid close attention to what their peers had to say: The stories of a decade-long post-baccalaureate training period characterized by long hours and low pay were discouraging enough, but when coupled with the slim chance of advancing to an independent research position before the age of 40, few of the most talented American students were enticed.

Further, the supply of foreign scholars who wished to study or obtain jobs in the United States had dwindled. The intellectually hungry from abroad, who had increasingly filled in the workforce gap in U.S. biomedical sciences during the 1990s and 2000s, now found vibrant opportunities in their home countries and were no longer clamoring to immigrate, or even to visit. At U.S. universities and medical schools, the decades of training required before appointments to faculty positions had combined with tenure without a mandatory retirement age to increase the median faculty member's age at research institutions to nearly 60 years old.

Ironically, the problems had their root in the very success of the National Institutes of Health (NIH) system, which continued to fund most academic biomedical research. The NIH system had been the envy of the world in the 1990s: Research grant funds were distributed through a merit-based, peer-reviewed, non-political process. The system was steeped in integrity. But the very success of the system led to a complacency that became its downfall. Competency and productivity were honored to the point that they became the enemies of greatness. The system placed too much emphasis on the number of papers published, too little on whether really important problems were even being tackled. Because requests for grant funds from new investigators were evaluated on the basis of "preliminary results," most funded research became constrained to well-worn research paths—those previously pursued by the new investigators when they were postdoctoral fellows in established laboratories. In short, innovation was the victim of a system that had become much too risk adverse.

Well, it is 2005, not 2029. Although we fear that our nation may be traveling the path described above, there is still time to redirect our steps. This National Research Council (NRC) report on *Bridges to Independence* is but the most recent of an ongoing series of recommendations for reform of the NIH grant system and of the treatment of postdoctoral researchers. The Committee notes that many of the ideas in this report have been recommended in earlier reports—but not implemented. After examining some of the reasons why previous recommendations have not been implemented, the Committee urges that the NIH treat the suggested innovations as a collection of bold ideas to be tried at least on an experimental basis, if not implemented full scale, to improve support for researchers making the transition to independence.

The goal is a transformation of NIH support for biomedical research that strongly promotes the new ideas of our best early career stage scientists, while preserving the peer review and integrity of current NIH processes. The status quo will certainly not do: it is well past time for our scientific leadership to be bold in ensuring the future of our nation's remarkably successful biomedical research system.

Thomas R. Cech, PhD
President, Howard Hughes Medical Institute;
Chair, Authoring Committee

Bruce Alberts, PhD
President, National Academy of Sciences;
Chair, National Research Council

# Acknowledgments

The report benefited from the contribution of many individuals who provided their expertise, insight, and research. The committee would like to especially thank the speakers and participants in the June 16, 2004, public workshop, for providing data on the issues confronting new investigators in the life sciences; the workshop agenda and participant list are included in Appendix B.

Data on issues related to career progression was provided by James Voytuk of the Board on Higher Education and Workforce at the National Research Council.

Data on NIH grant applications and success rates was provided by the Office of Extramural Research at the National Institutes of Health (NIH); the committee would like to especially acknowledge the assistance of Norka Ruiz Bravo, Walter Schaffer, Bill McGarvey, Bob Moore, James Onken, and Karl Malik. Additional information and insight from NIH was provided by Ruth Kirschstein, Jeremy Berg, Ellie Ehrenfeld, Brent Stanfield, Belinda Seto, Walter Schaffer, and Deborah Swope.

Information about postdoctoral policies was provided by Keith Micoli and Alyson Reed of the National Postdoctoral Association. Data on postdocs was also provided by Maxine Singer and Laurel Haak.

Information about model programs was taken from program websites as well as from program officials and recipients including Douglas Hanahan, Martin Ionescu-Pioggia, George Reinhart, Allan Spradling, Kevin Eggan, Alan Jasanoff, Saurabh Jha, Dmitri Petrov, and Judith Yanowitz.

This report has been reviewed in draft form by persons chosen for their diverse perspectives and technical expertise in accordance with procedures approved by the National Research Council's Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the institution in making its published report as sound as possible and to ensure that the report meets institutional standards of objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process. We wish to thank the following individuals for their review of this report:

**Karen S. Christopherson**, Stanford University
**Robert D. Goldman**, Northwestern University
**Jason Lieb**, University of North Carolina at Chapel Hill
**Shirley M. Malcom**, American Association for the Advancement of Science
**Ed Penhoet**, Gordon and Betty Moore Foundation
**Maxine Singer**, Carnegie Institution of Washington
**Paula E. Stephan**, Georgia State University
**Charles F. Stevens**, Salk Institute for Biological Studies
**Jack L. Strominger**, Harvard University
**Jane Sullivan**, University of Washington
**Michael Teitelbaum**, Alfred P. Sloan Foundation
**Shirley M. Tilghman**, Princeton University
**James Wells**, Sunesis Pharmaceuticals, Inc.
**Marylynn V. Yates**, University of California, Riverside

Although the reviewers listed above have provided constructive comments and suggestions, they were not asked to endorse the conclusions or recommendations, nor did they see the final draft of the report before its release. The review of this report was overseen by **Alan I. Leshner**, American Association for the Advancement of Science, and **Elena O. Nightingale**, Scholar-in-Residence, Institute of Medicine. Appointed by the National Research Council, they were responsible for making certain that an independent examination of this report was carried out in accordance with institutional procedures and that all review comments were carefully considered. Responsibility for the final content of this report rests entirely with the authoring committee and the institution.

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# Summary

The age at which scientific investigators receive their first research grant from the National Institutes of Health (NIH) has been increasing in recent decades. The number and percentage of grants awarded to younger researchers has been decreasing. While investigators under the age of 40 received over half of the competitive research awards in 1980, that age cohort received fewer than 17 percent of awards in 2003. As of 2002, the median age at which PhD researchers receive their first research grant was 42. Moreover, the percentage and absolute number of awards made to new investigators—regardless of age—has declined over the last several years, with new investigators receiving less than 4 percent of NIH research awards made in 2002.

Academic biomedical researchers are therefore spending long periods of time at the beginning of their careers unable to set their own research directions or establish their independence. This has led to a fear that promising prospective scientists will choose not to pursue a career in academic biomedical research and, instead, opt for career paths that provide a greater chance for independence. This "crisis of expectation" has severe and troubling implications for the future of biomedical research in the United States. The first effects may be starting to occur as recent data have indicated a decline in the number of U.S.-trained postdoctoral researchers in the biomedical sciences even while the rate of new PhDs has remained constant.

Moreover, there is a serious concern that new investigators are being driven to pursue more conservative research projects instead of the high-risk, high-reward research that can significantly advance science. The special creativity that younger scientists may bring to their work is also lost as these investigators are forced to focus on others' research.

Because of concerns about the effects of the increasing age of first grant on the careers of academic scientists and their ability to undertake high-risk research, the NIH has asked the National Academies to recommend mechanisms to foster the independence of new investigators in biomedical research. This report therefore focuses on the transition to independence of postdoctoral researchers and entry-level faculty with emphases on mechanisms to enhance the quality and effectiveness of postdoctoral training, the ability of young scientists to receive independent research funding, and the establishment of stable research programs. The committee convened a public workshop as the principal data-gathering event of the study. Over 150 people participating in person and 100 more via a live webcast engaged in consideration of available data, model programs to support new investigators, as well as the previous recommendations and the impediments that have prevented them from being put into practice.

Simply put, there are not enough tenure-track academic positions for the available pool of biomedical researchers. Very little that the committee can recommend will cause a sudden explosion in the number of such positions and consideration of the appropriate size of the pool is beyond the scope of this committee. As such, the report focuses on other mechanisms to enhance the quality of training and foster opportunities for independence.

NIH has significant responsibility for the current state of affairs, but also a significant ability to help reverse the increasing age of independence. Lengthy training periods and the requirement for preliminary data in grant proposals are the result of NIH policies and available funding. However, one cannot isolate the role of NIH from that of other stakeholder groups—including universities, professional societies, public and private funding agencies, academic administrators, senior faculty, junior faculty, staff scientists, and postdoctoral scientists. The findings and recommendations in this report are provided for all of these groups, in addition to the NIH itself.

## DEFINITIONS

The definition of "independence" as a researcher in a tenure-track faculty position who has received his or her first R01 research project grant[1] is outdated. With changes in scientific research and the academic biomedical research workforce, independence must also incorporate non-tenure-track researchers, those without their own research laboratory, and those who work as part of large research teams. In this way, we define an "independent investigator" as one who enjoys independence of thought—the freedom to define the problem of interest and/or to choose or develop the best strategies and approaches to address that problem. Under this definition, an independent scientist may work alone, as the intellectual leader of a research group, or as a member of a consortium of investigators each contributing distinct expertise. "Independence" does not mean necessarily "isolated" or "solitary," or imply "self-sustaining" or "separately funded."

In addition, the committee has affirmed the interconnectedness of scientific research and research training. Mentoring and research training cannot be separated from scientific research for anyone in postdoctoral—or graduate student—positions and should not be considered as separate objectives.

## CONTEXT

The committee did not begin its consideration *de novo* as there is a history of concern for these issues and many previous recommendations have been offered to address them. However, there has been disappointingly little progress in improving the situation confronting new investigators or in implementing previous recommendations. In formulating its recommendations, the present committee has considered the earlier recommendations and the challenges that have prevented them from being implemented or from producing the desired effect.

Overall, NIH has not implemented most of the previous recommendations. The committee did not have an opportunity to fully investigate the reasons for the slow progress in implementing previous recommendations.

Several of the programs that are advertised as helping new investigators are actually designed to meet specific institute goals, rather than the more general needs of new investigators. While the committee appreci-

[1]R01 research project grants are the predominant mechanism for individual investigator research funding from NIH. As defined by the NIH, "the Research Project (R01) grant is an award made to support a discrete, specified, circumscribed project to be performed by the named investigator(s) in an area representing the investigator's specific interest and competencies, based on the mission of the NIH." (Source: http://grants2.nih.gov/grants/funding/r01.htm)

ates the need to meet a variety of objectives, fostering the independence of new investigators has not been a significant NIH-wide goal addressed in a coordinated fashion. The committee hopes that the NIH Roadmap and its initiatives will provide a unifying structure for implementing trans-NIH initiatives, such as efforts needed to foster the independence of new investigators. The discussion that follows proceeds by career stage, looking first to the postdoctoral training period, followed by the transition to the first independent position, and finally the establishment of stable research programs. The 14 recommendations are numbered according to the chapters in which they appear.

## OPTIMIZING POSTDOCTORAL TRAINING

Postdoctoral training has become almost required in the biomedical sciences with early-career researchers spending several years in one or more postdoctoral positions. A 1998 National Research Council (NRC) report on *Trends in the Early Careers of Life Scientists* commented that the postdoctoral period has become too much of a "holding pattern" for many young scientists. In addition, many postdoctoral experiences more closely resemble employment than they do training. The postdoc is a crucial opportunity for providing early-career researchers with skills and experiences that will help foster their transition to independence. The committee has, therefore, paid particular attention to programs and cultures that can help optimize postdoctoral training for all aspiring researchers.

### Shorten the Postdoctoral Appointment

The NRC and others have emphasized that postdoctoral training should be a temporary appointment, with researchers transitioning to a variety of other positions after no more than 5 years as a postdoc. Moreover, researchers who choose to stay in the same laboratory after the 5-year limit should be promoted to staff scientist positions, with a full complement of benefits and appropriate levels of responsibility. NIH and many academic institutions and scientific organizations have agreed to the principle of the term limit, but do not always have a mechanism for enforcing the limit. In fact, NIH makes no mention of this limit in the guidelines for research awards, even though the vast majority of NIH-supported postdocs are funded on investigator research grants.

**4.1 NIH should enforce a 5-year limit on the use of any funding mechanism—including research grants—to support postdoctoral researchers. The nature of the position, including responsibilities and benefits, should change for those researchers who transition to staff scientist positions after 5 years.**

NIH should require and enforce that a person can only be classified as a "postdoctoral researcher"—or other title used by the institution for the position—for no longer than 5 years total (whether at one or multiple institutions), regardless of the type of award. That is, the time limit will apply equally to postdoctoral scientists supported with individual Ruth L. Kirschstein National Research Service Awards (NRSAs), training grants, or R01s. In circumstances where a postdoctoral scientist requires an extra year beyond the 5 years to complete an already-started job search, a professional development plan should be submitted to NIH indicating why a single extra year is needed to achieve career success and independence.

Five years is meant to be the *maximum* duration of a postdoctoral position, with the *expected* duration much shorter. A postdoctoral tenure should last only as long as is needed to prepare the investigator for the next career stage. The committee hopes that the normal length of postdoctoral training will be closer to 3 years, whether in one or multiple environments. This is consistent with an overall training period—including graduate and postdoctoral training—of no more than 10 years.

### Reallocate NIH Resources for Postdoctoral Support

The use of the R01 as the predominant mechanism to support postdoctoral scientists poses problems, as almost all postdocs are supported on research grants made to others. These postdocs may thereby be required to spend 100 percent of their time on the research plan described in the R01 of the Principal Investigator (PI), stifling the ability of postdoctoral researchers to pursue independent research. Postdoctoral scientists would be better served if they received their own support through individual awards—such as the NRSAs and career development K awards—or through training grants that at least diminish the employment relationship between postdoc and PI. At the same time, innovation and discovery in American biomedical science would be stimulated by postdoctoral scientists having more of a role in designing, conducting, and evaluating their own research projects, while still under the mentorship of more senior investigators.

**4.2 Postdoctoral researchers should be more independent and less dependent on the research grants of PIs. NIH should reallocate some of the resources for postdoctoral support away from the R01 and toward individual awards and training grants.**

This realignment in mechanisms of support for postdoctoral scientists would increase accountability for mentorship and training responsibilities. The proposed increase in the number of awards made to individual postdoctoral scientists would encourage postdocs to take ownership of the conceptualization, design, and scientific direction for their research.

The committee recognizes that such a shift is not without possible challenges, including the effect on university budgets with significant differences in indirect cost recovery between research and training awards and a possible mismatch between research funding of PIs and the workforce needed to conduct that research. But the viewpoint of this committee is that postdocs are not simply workers, but scholars with their own ability to contribute. This committee's focus on the quality of biomedical research training to foster independence causes it to conclude that funding of postdocs through individual awards and training grants is preferable to funding on PI research awards. Furthermore, if eligibility for postdoctoral training support is expanded to include non-U.S. citizens, as recommended below, then the size of the applicant pool could double.

One difficulty of an increased reliance on training awards is that they are restricted to U.S. citizens and permanent residents. Yet the number of postdoctoral biomedical scientists in the United States on temporary visas has increased dramatically in the last 20 years so that today, more than half of the biomedical postdoctoral researchers in this country hold non-U.S. citizenship. It is difficult to consider the U.S. biomedical research enterprise without acknowledging the critical role played by scientists from outside the U.S. At present, the only way that these individuals can be supported with NIH funds is through research grants to a PI. Non-U.S. citizens contribute significantly to biomedical research, but cannot apply for training awards. Therefore, to increase innovation and discovery in U.S. biomedical science, it is critical that all postdocs have such training opportunities.

**4.3 In order to provide equal opportunities for non-U.S. citizens, the citizenship requirement for NRSAs and related postdoctoral training awards should either be modified, or alternative and equivalent mechanisms of support should be available for those who are not U.S. citizens or permanent residents.**

The best interest of biomedical research and biomedical researchers calls for effective training opportunities for all conducting research in the United States. This recommendation could increase the competition for existing awards by doubling the pool of potential applicants. This effect would be mitigated, however, by also implementing recommendation 4.2 that calls for increased support for individual fellowships and training grants overall. In addition, making federal support available to those who are not U.S. citizens or permanent residents can be controversial, but it is important to recognize that those who would receive such training awards are likely *already* supported on research grants and are, in fact, critical to the advances in U.S. biomedical research. The NIH has already committed to providing international postdoctoral trainees with a similar level of support and training environment as U.S. citizens, but progress has been slow in implementing a broad plan to achieve this goal.

## Provide Independent Funding

In order to further promote increasing independence for postdoctoral scientists, the NIH should create targeted mechanisms that allow postdoctoral scholars to receive individual research grants. They would conduct this research in the laboratory of an identified mentor.

**4.4 A new research award is needed at NIH to provide postdoctoral researchers with the opportunity to conduct an independent project under the mentorship of a senior investigator. This postdoctoral independent research award would complement, but not replace, the existing NRSA.**

The new award would constitute a research grant to the postdoctoral researcher for a particular project conducted with an identified mentor. The awards would be portable and have sufficient resources for the institution to provide benefits—as well as salary—for the postdoc. Host laboratories would benefit from the expertise and experience of independent researchers as well as the broadening of the laboratory's research interests.

The proposed awards would encourage independence for postdoctoral researchers by giving them more control in determining the subject and course of their research interests than is currently available. Because they could take extensions of the project with them, the odds of achieving successful independence are enhanced.

## Clarify the Mentorship Responsibilities of PIs

The R01 is currently by far the predominant mechanism by which postdoctoral researchers receive support. This use of the R01 has resulted in the dependence of PIs on trainees to produce work for their publications and grant renewals as well as the dependence of trainees on their PIs for support. Even though all postdoctoral scientists would benefit from enhanced training from their mentors, reviews of R01 proposals do not consider training; as such, training only tends to occur at the discretion of the PI. The R01 application and review process should be modified to correct these deficiencies.

**4.5 NIH should modify the application for R01s so that requests for postdoctoral research positions include a description of how the postdoc will be prepared for an independent career (training) and a description of the elements of the proposed project in which the postdoctoral researcher will be involved. PIs should provide basic information for all current postdocs and those supported within the last 10 years to include name, time in the laboratory, and their current title and institution.**

Adding these requirements to the R01 would reinforce upon faculty the responsibility they have toward the postdoctoral researchers whom they supervise, not as employers, but as educators. It would also underline the critical interconnection between research and training and emphasize that research is enhanced by effective training. While some could see this as one more administrative burden for PIs and administrators, it only makes explicit what should always have been implicit: that is, all trainees should benefit from mentoring to allow them to achieve the goals of their training.

### Broaden Educational Opportunities

Many of the skills required of PIs and faculty are not well taught—or possibly never mentioned—to postdoctoral researchers. Instead, PI mentors and postdocs spend almost all of their time on research without acknowledging the kinds and complexities of issues that faculty members and PIs confront. Institutions and programs should provide a variety of opportunities offering training and experience in different skill sets.

**4.6 Postdoctoral scientists should receive improved career advising, mentoring, and skills training. Universities, academic departments, and research institutions should broaden educational and training opportunities for postdoctoral researchers to include, for example, training in laboratory and project management, grant writing, and mentoring. NIH should take steps to foster these changes, including by making funds available to facilitate these endeavors.**

Funding should be made available for institutions or groups of institutions to develop career guidance and professional development courses (e.g., mentoring, grant writing, laboratory management, budgeting, publishing and authorship, conducting collaborative science, and project management). Funding could also be used to host workshops by experts from outside of the institution.

### Program Evaluation

The difference of opinion on the appropriate balance of support for postdoctoral researchers between research grants, training programs, and individual fellowships emphasizes the need for a rigorous independent analysis of NIH postdoc programs.

**4.8 NIH should commission an independent evaluation of the different models of postdoctoral support.**

Such a study could compare different postdoctoral funding mechanisms to evaluate the relative merits and success of each approach.

## TRANSITION TO FIRST INDEPENDENT POSITION

Postdoctoral researchers express concern as they look to the future. In particular, many have difficulties in making the transition from postdoctoral researcher to independent investigator. What mechanisms will help bridge this transition?

### Career Transition Research Grants

A small number of career transition awards offered by private foundations have shown success in facilitating the transition to independence for new investigators. They provide opportunities for independent research while still in postdoctoral positions, facilitate movement into career positions, provide stable resources and protected time to establish an independent laboratory, and enhance the ability to pursue novel research and collect preliminary data for future grant proposals.

Although NIH offers the K22 career transition award, it is actually a collection of different awards, many of which have not successfully attracted applicants. An NIH-wide award that draws upon the best aspects of the K awards and private career transition awards should replace the K22s.

**5.1 NIH should establish a program to promote the conduct of innovative research by scientists transitioning into their first independent positions. These research grants, to replace the collection of K22 awards, would provide sufficient funding and resources for promising scientists to initiate an independent research program and allow for increased risk-taking during the final phase of their mentored postdoctoral training and during the initial phase of their independent research effort. The program should make 200 grants annually of $500,000 each, payable over 5 years.**

These awards would provide postdoctoral training support for a maximum of 2 years for the awardee to develop an independent research program and 3 or more years of support once a fully independent research position has been obtained. After approximately a year of mentored postdoctoral training, the award would support the transition to independence by providing research support in tenure-track or other career-path positions. Resources would provide at least partial salary support and funds for research and career development activities. The award would have uniform requirements across all NIH institutes and neither be limited to NIH intramural candidates nor require that the postdoctoral training phase be carried out at an NIH intramural laboratory. These grants would replace the current collection of K22 awards, which differ from institute to institute. The award amount and duration is similar to that of the Burroughs Wellcome Career Awards, which have shown success at fostering the independence of new investigators.

## ESTABLISHING STABLE RESEARCH PROGRAMS

American science would benefit from a system that encourages new investigators to try out new ideas and approaches as they begin their independent research careers. The present system of research support does just the opposite. New investigators are ranked relative to previously-funded investigators by study sections, even though new investigators lack the "preliminary results" that study sections rank highly. New investigators thus tend to continue their postdoctoral projects since proposing something different with greatly increased risk places even more obstacles to obtaining funding.

### R01s for New Investigators

The receipt of an R01 award is crucial in the career of an early-career researcher and unmatched by any other awards: Anything but the "R01" designation is devalued in the eyes of promotion and tenure committees. Meanwhile, R01 applications require submission of preliminary data that would predict the success of the proposed project, but new investigators who wish to do something original have difficulty obtaining such preliminary data. Therefore, the committee proposes a new investigator R01 award that would substitute a discussion of previous experience instead of preliminary data.

**6.1 NIH should establish and implement uniformly across all of its institutes a New Investigator R01 grant. The "preliminary results" section of the application should be replaced by "previous experi-**

**ence" so as to be appropriate for new investigators and to encourage higher-risk proposals or scientists branching out into new areas. This award should include a full budget and have a 5-year term. NIH should track new investigator R01 awardees in a uniform manner including success on future R01 applications.**

The award should be designated as an R01 and have the same budget as other R01s. All new investigator R01s should have a term of 5 years to allow researchers time to establish a laboratory, train personnel, and collect data without a need to renew research support immediately. The regular study sections should review the proposals, but do so *en bloc* with appropriate instructions so that they fully consider the different criteria for new investigator awards. Funding for this program should be allocated separately from those of previously-funded investigators so that new investigators are not competing against those with more experience. All new investigator R01s should be scored in order to provide complete feedback on their proposals even when they are not funded.

A transition to independence is not really complete if the first research grant is the only research grant. That is, an investigator must not only be able to be funded through targeted programs for new investigators, but have a possibility of stable research funding. Moreover, the capacity for stable funding should apply to all types of independent investigators including both tenure-track and non-tenure-track.

### Support for Non-Tenure-Track Scientists

Very few postdoctoral researchers obtain a tenure-track position in academia. A growing percentage enter non-tenure-track positions. They may conduct independent research, but without running a large research laboratory. However, they find it difficult to receive independent support because they are competing with larger research groups. Although some biomedical research has already entered an era of big science, there is still much to be gained from maintaining a broad platform of independent research projects, which has been the hallmark of NIH's success.

**6.2 NIH should establish a new renewable R01-like grant program for small science projects (less than $100,000 direct costs per year), open to researchers who do not have PI status on another significant research grant, including "soft-money" staff and research-track scientists. This program should receive its own set-aside funding from the NIH budget.**

These funds would be directed at applicants who work as independent investigators but have positions other than traditional tenure-track faculty appointments. Scientists with PI status on other research grants would normally not be allowed to apply. By recommending this grant program, the committee does not intend to encourage the creation of additional "soft-money" positions; rather, it recognizes the reality of the growing number of these researchers and seeks to provide them with increased opportunities for independence.

## Providing for Enhanced Job Security

The number of tenured and tenure-track faculty in research universities and institutions has remained approximately constant over the last decade, while the ranks of non-tenure-track scientists have swelled. The contribution of these researchers must be acknowledged with opportunities for them to pursue their own independent research support.

Such non-tenure-track scientists are generally completely dependent on external grant support. They rarely have any job security and may have to take on teaching or clinical responsibilities that further inhibit their chances at independence. Institutions should provide some means of job security and protection against a single unfunded grant proposal. Moreover, NIH should provide bridge support for the most highly deserving applicants who do not have additional funding.

**6.3 Non-tenure-track "soft-money" researchers should have a budgetary "safety net" that provides time to reapply for grant support if their funding lapses. This safety net should be a joint responsibility of the NIH and the host institution: NIH should expand the Shannon Award to provide merit-based bridge awards for those without other sources of support and host institutions should offer multi-year renewable contracts to its staff scientists that guarantee space, salary, and minimal research support even in the absence of external funding.**

The NIH James A. Shannon Director's Award (R55) program should be expanded to incorporate a special program of merit-based bridge funding that will be awarded to the most promising researchers who do not have other means of support. That is, NIH should examine whether applications that fall just below the payline are submitted by "soft-money" researchers who have no other source of support. Since the positions held by these applicants will be put in jeopardy by a funding lapse, a small bridging award will allow them to revise and strengthen a grant proposal for resubmission.

At present, institutional commitment to "soft-money" researchers seems almost entirely tied to external funding; that is, if the funding is lost, so is the position, often before the applicant has the chance to even submit a revised proposal. The committee encourages institutions to offer multi-year renewable contracts to its non-tenure-track researchers so that they have some means of security and are protected from a single unfunded proposal.

## ENHANCE DATA COLLECTION AND PROGRAM EVALUATION

It is critical that NIH have informative data on the populations of all areas of the scientific workforce, including postdoctoral researchers, tenure-track and non-tenure-track researchers. In all data collection efforts, data should be disaggregated to detect trends among and between demographic and other groups. Different sub-populations may face obstacles that should not be ignored and might shed light on overcoming challenges for the population as a whole.

For example, it is incomprehensible that NIH cannot provide anything more than an educated guess on the number of postdocs it supports through research grants. The lack of reliable data on the scientific workshop limits decision makers' ability to analyze the effectiveness of scientific programs and funding mechanisms.

The committee has chosen to make recommendations about data collection in each of chapters 4, 5, and 6 to emphasize the importance for each career stage.

**4.7 NIH should develop enhanced data collection systems on postdoctoral researchers to include all NIH-supported postdoctoral researchers, regardless of specific funding mechanism. This will allow NIH to track the effectiveness of its programs and thereby make more informed programmatic decisions.**

**5.2 NIH should develop enhanced data collection systems on staff scientists and other non-tenure-track researchers to include all NIH-supported researchers, regardless of specific funding mechanism. This will allow NIH to track the effectiveness of its programs and thereby make more informed programmatic decisions.**

**6.3 NIH should develop enhanced data collection systems on all NIH-supported researchers, regardless of specific funding mechanism. This will allow NIH to track the effectiveness of its programs, make more informed programmatic decisions, and monitor the career progression of supported researchers.**

The committee would prefer that data collection be integrated across career stages instead of a different system for postdocs than for PIs than for staff scientists. NIH needs to gather data on all supported personnel regardless of their funding mechanism and track these individuals as they progress through their careers. Such data are likely to inform NIH leadership about the relative successes of various funding mechanisms and programs in fostering independence. The committee suggests that the NIH work with other federal agencies and private sector funders that support researchers to enable cross-agency data collection. This could provide a common set of definitions and measures that would enable cross-agency comparisons.

Data should be disaggregated to detect different trends among different demographic and other groups.

## CONCLUSIONS

Despite a long history of concern on these issues, progress has been slow. The time for action is now. Every year of delay in implementing change affects tens of thousands of scientists already pursuing biomedical careers and an untold number of those who might have pursued such a career. The personal concern for this issue by leaders at the highest levels of NIH and of science in general provides a reason for optimism. But it is not only the leaders of NIH who must be convinced of the urgency. Advisory Councils, study sections, and staff members at NIH must all play their part in enacting these recommendations now. University administrators, department chairs, and faculty must recognize that the biomedical research enterprise is not the same as it was when they were new investigators and take steps to acknowledge this new reality. New faculty members, postdoctoral researchers, staff scientists, and graduate students must also recognize these realities and be proactive and realistic about their own careers.

This report presents an overview of biomedical research careers and the pipeline of recruiting, retaining, and supporting new investigators in biomedical research. While recognizing the realities of the present situation, it offers a vision for the future that will help ensure the continued vitality of the biomedical research enterprise and its workforce. The recommendations are bold, but realistic and practical. Their successful implementation relies on the participation of all stakeholders in biomedical and academic research. Working together, the stakeholders can meet their responsibility to provide a bridge to independence by helping to foster the independence of new investigators in biomedical research.

# 1

# Introduction

The age at which scientific investigators receive their first research grant from the National Institutes of Health (NIH) has been increasing in recent decades. The number and percentage of grants awarded to younger researchers has been decreasing (Figures 1-1 and 1-2), and the number of awards made to researchers age 35 and younger declined by over 75 percent since 1980, even as the overall number of grants has increased (Figure 1-3). For example, in 2002, the median age for new research grant recipients was 42. Moreover, the percentage and absolute number of awards made to new investigators—regardless of age—has declined over the last several years (Figure 1-4). At a June 16, 2004, National Academies workshop on this issue, NIH Director Elias A. Zerhouni identified his major concern that creative young scientists might choose other careers to avoid the uncertainty of basic academic research: "[It] is not manageable . . . [to have] a culture where young investigators are discouraged from either entering the field or, when in the field, get discouraged about taking risks and bringing science into the new directions that it needs to go." Many people, including Nobel laureates, share the concern that scientists at the beginning of their research careers who are unsuccessful at obtaining initial grant support may leave the academic research enterprise altogether (Jenkins, 2003).

New investigators are particularly vulnerable to difficulties in obtaining research funding since they are less likely to have other grants or the protection of tenure than more established investigators. Thus funding difficulties and discouraging prospects for independence have especially high stakes for new investigators. This "crisis of expectation" has severe

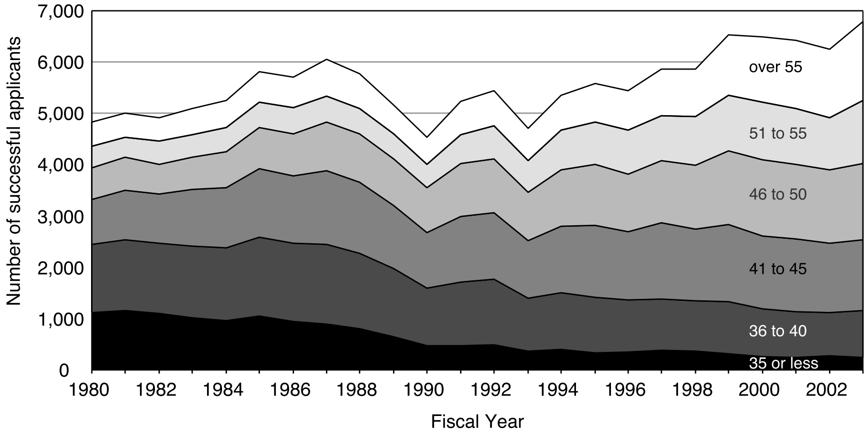


**FIGURE 1-1** Age distribution of principal investigators receiving competing R01, R23, R29, and R37 research awards, by number of awards made to each age cohort. Source: Office of Extramural Research, NIH.

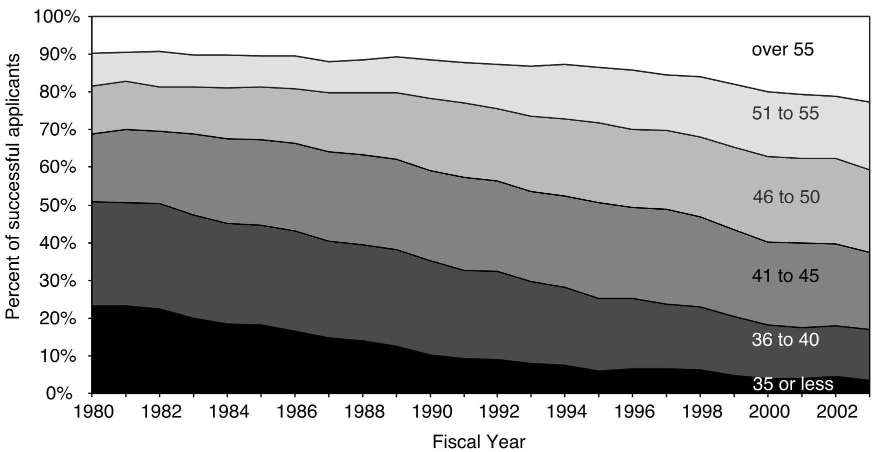


**FIGURE 1-2** Age distribution of principal investigators receiving competing R01, R23, R29, and R37 research awards, by percentage of total awards made to each age cohort. Source: Office of Extramural Research, NIH.

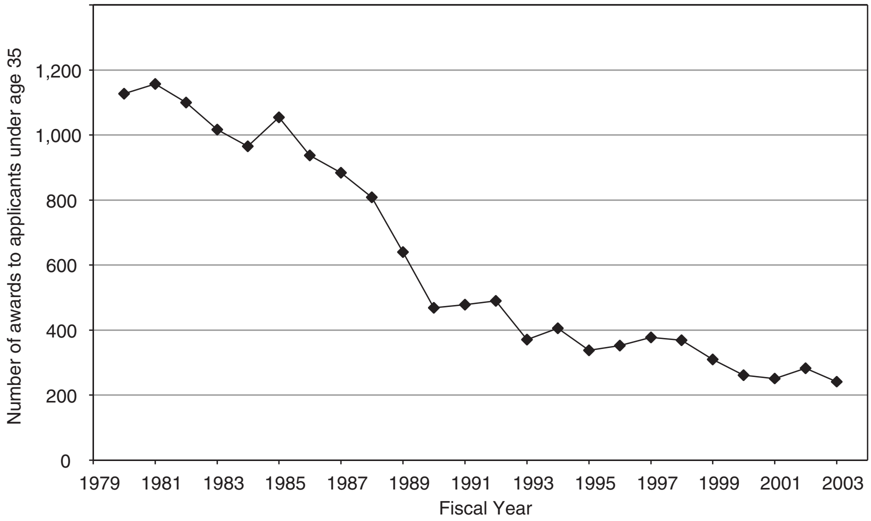


**FIGURE 1-3** Number of NIH research awards made to PIs 35 years of age and younger. Source: Office of Extramural Research, NIH.

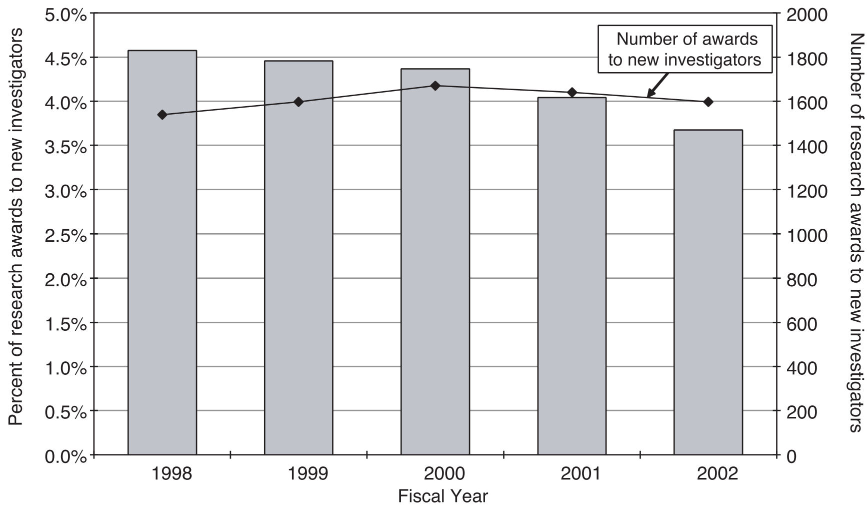


**FIGURE 1-4** NIH awards made to new investigators. The histogram shows the percentage of NIH research awards that have been made to new investigators (left axis), while the line shows the total number of awards made to new investigators (right axis). Source: http://grants1.nih.gov/grants/award/trends/icfund9803.html.

and troubling implications for the future of biomedical research in the United States (NRC, 1998).

A 1997 survey conducted by the American Society for Cell Biology (ASCB) provides evidence for further concern. When a sample of its membership was asked if they would pursue their doctoral degree if they had it do over again, 31 percent of those who received their degrees in the 1990s would "probably" or "definitely" *not* do it again. This compares with only 16 percent of those who received degrees in the 1970s (Marincola and Solomon, 1998a; http://www.ascb.org/survey/survey.htm). In addition, data from 2001—the most recent year for which data are available—show a decline in the number of U.S.-trained PhDs in biomedical postdoctoral appointments across all employment sections. Among the reasons cited for this decline are long periods of training with few benefits, the perception that postdoctoral appointments are more like low-paying jobs than training experiences, and poor prospects for independent follow-up positions (NRC, 2005).

Many of the greatest contributions in science were made by those who were independent investigators at an early age. Marshall Nirenberg, for instance, had his own independent lab at NIH when he was just 27 after only 2 years of postdoctoral training, unraveled the genetic code when he was 31, was an NIH section head at 35, and received a Nobel Prize at 41. He was doing risky independent research with intramural support from the NIH in his 20s. In today's climate, Nirenberg might have received his Nobel Prize before his first NIH grant. Nirenberg is not unique; Stephan and Levin (1993) examined the age at which Nobel laureates in physiology or medicine performed their critical experiments, finding a median age of 38 years. Further, the highest honor in mathematics—the Fields Medal—is awarded only to individuals under age 40. Thus, a researcher in mathematics might reach a career pinnacle before a biomedical researcher has first established independence.

As National Academy of Sciences President Bruce Alberts related in his 2003 President's Address,

> During a period when the total amount of federal funds available to support science at the National Institutes of Health has doubled, it is incredible to me that the average age at which scientists first become funded continues to rise. [In the early 1970s,] many of my colleagues and I were awarded our first independent funding when we were under 30 years old. We did not have preliminary results, because we were trying something completely new. [Now] almost no one finds it possible to start an independent scientific career under the age of 35. Moreover, whereas in 1991 one-third of the principal investigators with NIH funds were under 40, by the year 2002 this fraction had dropped to one-sixth. Even the most talented of our young people seem to be forced to endure several

> years of rejected grant applications before they finally acquire enough "preliminary data" to assure the reviewers that they are likely to accomplish their stated goals. (Alberts, 2003).

These challenges are likely to be even more pronounced in the near future. An NIH budget expected to be nearly constant for the next several years will especially constrain the amount of resources available for new awards. If new investigators were finding it difficult to secure research support in a time of NIH budget expansion, how much more difficult will it be when the budget is flat and many of the resources allocated to continuing awards?

The years in which one might be establishing or waiting for independence coincide with marriage and family life for many new investigators, placing additional personal costs on the delay of independence. As these issues affect men and women differently, it is essential to disaggregate data on biomedical careers by gender. There are also significant financial costs in which additional time spent in low-paid postdoctoral positions comes at the expense of possibilities for greater compensation in industry or in other career endeavors.

## COMMITTEE STATEMENT OF TASK

Because of concerns about the effect of this increasing age of first grant on the careers of new investigators and their ability to undertake high-risk research, the NIH asked the National Academies to recommend some mechanisms to foster the independence of new investigators in biomedical research. The complete committee statement of task is in Appendix A and is summarized in Box 1-1.

In his remarks at a June 16, 2004, workshop convened by the committee, Dr. Zerhouni added additional requests for the committee to consider:

- "come up with pragmatic recommendations that the agency [NIH] can follow, that might, in fact, propel us to try new models, and to try to encourage new thinking in terms of who we bring into the scientific enterprise, and when do we bring them in, and how do we encourage them to stay in, and to be productive."
- "come up with testable pilots—not just wishful pilots—pilots that can lead to a tangible measurement of whether or not we are accomplishing what we want to accomplish. . . . The hope is that, instead of general principles, that we come up with very specific action steps that the agency can implement, but that can lead also to more knowledge about the issues that we are dealing with."

**BOX 1-1**
**Summary of the Committee Statement of Task**

The National Academies will convene a workshop as the principal data-gathering event of a study to explore issues related to fostering the independence of early-career scientists (postdoctoral researchers and young faculty) in order to enhance the vitality of the biomedical research enterprise and its workforce. This workshop will build upon an October 23-24 (2003) meeting held at the National Institutes of Health (NIH) that addressed training and opportunities for postdoctoral scientists and on previous reports on postdocs and young faculty issued by the National Academies and others (e.g., *Enhancing the Postdoctoral Experience for Scientists and Engineers* [2000] and *Trends in the Early Careers of Life Scientists* [1998]). The proposed workshop will focus on the transition to independence of postdoctoral researchers and entry-level faculty with particular emphases on mechanisms to enhance the quality and effectiveness of postdoctoral training and the ability of young faculty to receive independent research funding. Previous recommendations from other studies will be considered and participants will be asked to identify and consider means to address the impediments that have prevented many of these recommendations from being put into practice. The workshop will consider whether existing programs within NIH could be expanded (e.g., K awards) and will include discussion of some of the successful programs and models being used outside NIH and to determine which features of these programs might be transferable to NIH and other large research-sponsoring organization settings.

A report will be prepared identifying the challenges and presenting ideas for enhancing the opportunities for young investigators to gain independent research funding. The report will also make recommendations on those topics where consensus can be reached. The study will focus on mechanisms for fostering independent funding in the life sciences, but it may also identify challenges or recommend solutions for dealing with the larger biomedical research and academic structures.

- "create pathways for physical sciences to enter biomedical sciences, to work within scientific teams—mathematicians, physicists, chemists."
- ". . . and last but not least, let's not be shy. It may be that, in fact, NIH needs to work with the academic institutions and the National Academies and everybody else to redefine career pathways."

Simply put, there are not enough tenure-track academic positions for the available pool of biomedical researchers. Very little that the committee can recommend will cause a sudden explosion in the number of such positions and consideration of the appropriate size of the pool is beyond the scope of this committee (cf. NRC 2000, 2005). As such, the report focuses on other mechanisms to enhance the quality of training and foster opportunities for independence.

In many ways, the biomedical research enterprise is not designed to support the establishment of independence. The structure of academic biomedical research training is largely a byproduct of funding mechanisms and reward structures, not one with specifically identified goals to foster the development of independent researchers.

NIH has significant responsibility for the current state of affairs, but also a significant ability to help reverse the increasing age of independence. Lengthy graduate student and postdoctoral training periods—and the massive growth in the number of such positions—result largely from the availability of NIH funding. Moreover, the increasing dependence on non-tenure-track "soft-money" researchers would not have happened without available soft money from the NIH.

In considering its charge, however, the committee recognizes that one cannot isolate the role of NIH from that of other stakeholder groups. Universities, research institutions, professional societies, public and private funding agencies, academic administrators, senior faculty, junior faculty, staff scientists, postdoctoral scientists, and others have a responsibility for working together to address these issues. The committee provides its report and recommendations for all of these groups in addition to the NIH itself. In fact, the report explicitly calls upon action by universities and research institutions in several places (e.g., Recommendations 4.6, 6.2).

Further, grant funding from the NIH interconnects with a collection of many other issues related to the process of science, the scientific workforce, and the settings in which researchers work. The availability of academic positions, requirements for tenure, retirement policies and rates, start-up costs, research infrastructure, indirect cost recovery, university budgets, postdoctoral scientist stipends and benefits, visa and immigration policies, and overall economic forces are just some of the many issues that have a significant impact on new investigators. The preparation of scientists striving to establish independence also reaches back through postdoctoral and graduate student periods, into undergraduate years, and back to K-12 education. The committee has tried to keep the focus on the issues that are most central to fostering the independence of new investigators. The report, therefore, may not fully explore all of the related issues, many of which The National Academies and others have previously addressed and will continue to address. For example, the committee was not asked to consider the appropriate number of biomedical researchers; in fact, the "supply" of available scientists has been considered by a number of committees in detail (NRC 1998, 2000, 2005). This report does not assume that, at present, there is necessarily a shortage—or surplus—of biomedical researchers. However, today's new investigators are finding greater difficulties achieving their independence than in the past: they are spending longer periods in mentored positions, choosing to pursue more conservative research directions, and being discouraged about their prospects for independence. Rather than argue for a greater number of independent positions, the report considers that the current career structures and opportunities for independence adversely affect the future of the biomedical research workforce as well as the success, productivity, and research directions of individuals who do pursue such careers.

The increase in age of independence for new investigators has largely coincided with the growth of the biotechnology and pharmaceutical industries. Even though this report focuses on *academic* biomedical research, the increase in industrial opportunities may have effects on the academic research environment as well. Many promising young scientists may have been opting for careers in industry where financial compensation, research funding, and opportunities for directing research programs can be more plentiful. For example, it is estimated that the percentage of biological sciences PhDs pursuing careers in industry was approximately 35 percent in 2001, up from approximately 25 percent in 1991 and 15 percent in 1981 (C. Kuh, unpub., with data from Survey of Doctorate Recipients, NSF). It could be that the recent declines in the number of grants to new investigators, the number of postdoctoral researchers, and the duration of postdoctoral positions are due, in part, to the migration of researchers to industry. With a slowdown in biotechnology in the last few years, it is possible that there might be a renewed influx of researchers into academic careers and a worsening of the prospects for independence.

While the committee realizes that some of the recommendations will require dedication of resources, it has not proposed specific programs that should be reduced to provide the necessary funds—except when the proposed programs are meant to replace existing ones. For the most part, however, the individuals who would be supported on the proposed programs are already supported by existing programs. So the budget considerations are generally modest redistributions of existing resources that would support the same investigators but in a way that contributes to their own career development. For example, independent support for postdoctoral researchers or staff scientists could be shifted from the mechanisms currently used to support them to the targeted independent programs described here. The committee also recognizes that implementation of some recommendations may require action outside of the NIH. While most of the recommendations can be implemented by NIH leadership and advisory councils, a few require Congressional action.

The committee has considered previous recommendations from earlier studies (many of which are outlined below) and successful programs and models from within and outside of NIH (many of which are described in Chapter 2). The contents of this report have been influenced by the general themes, issues, and recommendations from those other sources. In many cases, explicit reference is made to other work, but other reports and programs may have inspired aspects of this report even without mention of a specific connection.

The committee has proposed pragmatic recommendations related to several different stages of a biomedical research career. The various programs discussed in the report are meant to complement each other and provide opportunities for members of a diverse scientific workforce with varying career objectives. In most cases, the pragmatic recommendations provide a framework for a new policy or program, discussing the salient characteristics but without stipulating every detail; the committee feels that the NIH staff, with appropriate backing and resources, is well positioned to use its reasoned discretion in determining the appropriate implementation. In some instances when previous recommendations have not proved successful, however, the committee has found it helpful to specify how its recommendations should be implemented and to provide a rationale for those details. The committee has suggested mechanisms for assessing the effectiveness of these recommendations once implemented. The various challenges described in the report have existed for far too long, and many previous recommendations for improving the situation have not been implemented. The NIH Director has expressed his commitment to act and the committee anticipates that the policies and programs recommended here will be put into effect as soon as possible. The methods of evaluation suggested here can provide formative data on the new programs that can assess their effectiveness while new investigators have the opportunity to take advantage of them.

The committee has not been able to fully define pathways for physical scientists to move into biomedical research. In many ways, this issue is not specific to new investigators since the challenges and difficulties of switching fields apply to new and experienced investigators alike (COSEPUP, 2004). While the committee appreciates the need for developing these pathways into biomedical research, it feels that this topic would not have gotten the attention it deserves had it been more fully explored here. Therefore, this topic needs further investigation focusing explicitly on the similarities and differences between fields and requires a broader charge than only considering new investigators. The present committee recognizes that experienced researchers in the physical sciences likely need different mechanisms and programs for entering biomedical research than those without an established track record, even in the physical sciences. Thus, this report discusses and recommends the programs and procedures that might be especially useful for those making an early-career transition from the physical to biomedical sciences. However, it does not explore the issue fully for the reasons stated above.

Finally, as to the issue of "shyness" mentioned by Dr. Zerhouni, the committee—and the workshop participants—have done a lot of "out of the box" thinking. The committee considered a number of radical possibilities, including reconfiguring entire biomedical funding and career structures. Overall, the committee found it important to make recommendations that are not only appropriate, but also practical and possible.

The committee has also been careful not to offer recommendations that might endanger the enormous success of the biomedical research enterprise and the groundbreaking research that NIH supports. Moreover, none of the recommendations contained in this report are intended to threaten the autonomy or independence of established investigators or to make it any more difficult for them to obtain research funding (though tight budgets necessarily mean that funds spent on one program will not be available elsewhere). The focus on new investigators does not mean that the continuing challenges faced by previously funded investigators are not also of concern. Rather, the focus is on the overall research enterprise, whose future relies upon attracting and supporting new investigators who will become the established researchers of the future.

## A TIME FOR ACTION

Despite a long history of concern on these issues, progress has been slow. Previous recommendations have been offered but, in many cases, not even attempted. Since ignored previous recommendations were offered, the situation has worsened for new investigators. The time for action is now. Every year of delay in implementing change affects tens of thousands of scientists already pursuing biomedical careers and an untold number of those who might have pursued such a career. Scientists who have the creativity to cure disease and advance biomedical research significantly are being discouraged from pursuing that research.

Fortunately, the time is right to take action. The personal concern for this issue by leaders at the highest levels of NIH and of science in general provides a reason for optimism. But it is not only the leaders of NIH who must be convinced of the urgency. Advisory Councils, study sections, and staff members at NIH must all play their part in enacting these recommendations now. University administrators, department chairs, and faculty must recognize that the biomedical research enterprise is not the same as it was when they were new investigators and take steps to acknowledge this new reality. New faculty members, postdoctoral researchers,

**BOX 1-2**
**NIH Definition of New Investigator**

"Applicants are considered new investigators if they have not previously served as the principal investigators (PI) on any Public Health Service-supported research project other than a small grant (R03), an Academic Research Enhancement Award (R15), an exploratory/developmental grant (R21), or certain research career awards directed principally to physicians, dentists, or veterinarians at the beginning of their research career (K01, K08, and K12). Current or past recipients of Independent Scientist and other nonmentored career awards (K02, K04) are not considered new investigators."

Source: http://grants2.nih.gov/grants/guide/notice-files/not97-231.html

staff scientists, and graduate students must also recognize these realities and be proactive and realistic about their own careers.

## DEFINITIONS

The meanings of "new" and "young" investigator blur. The major issue addressed in this report is moving new (i.e., previously unfunded) researchers into the ranks of funded independent scientists, regardless of age. Even though not all new investigators are "young," many of the relevant data are based on the age of the applicant.[1] Thus, various types of data are cited in the report; although chronological or even professional age data may not always present an accurate picture of all new investigators, in many cases, those are the only data sources available. The focus of this report and its recommendation is on new investigators. (See Box 1-2 for NIH's definition of new investigator.)

The traditional view of "independence" in academic biomedical sciences as being listed as a Principal Investigator (PI) on a traditional NIH investigator-initiated research award—the R01 grant[2]—does not accurately reflect what it means to be independent. Box 1-3 includes the

[1]Some data sources use the "professional age" of an applicant, i.e., years post-PhD.
[2]The list of abbreviations in Appendix C defines each of the NIH grant award types discussed in this report.

**BOX 1-3**
**Independence**

An "independent investigator" is one who enjoys independence of thought—the freedom to define the problem of interest and/or to choose or develop the best strategies and approaches to address that problem. Under this definition, an independent scientist may work alone, as the intellectual leader of a research group, or as a member of a consortium of investigators each contributing distinct expertise. Specifically, we do not intend "independence" to mean necessarily "isolated" or "solitary," or to imply "self-sustaining" or "separately funded."

committee's interpretation of "independence." The committee seeks to broaden the concept of independence beyond that of a tenure-track professor to include other career trajectories such as a staff-scientist track of highly trained and talented individuals engaged in independent research but without necessarily having their own laboratory. Moreover, increasingly collaborative research projects with multiple investigators and the growth in non-tenure-track positions necessarily alter what independence means. Even those working in large research groups who have overall goals set by others can and do exercise independence by developing the strategies in pursuit of those goals. The research environment of the future will likely incorporate both large collaborative teams and individual investigators with small research groups, and both models will be necessary for advances in biomedical research. Individuals will need to be able to direct their own research and pursue independent directions within both of these contexts—and be skilled at moving between them.

The committee also recognizes that independence means not only initially establishing independent research funding, but also sustaining it. Any programs explicitly for new investigators should be designed to help put researchers in a position to subsequently compete for funding with established investigators.

Finally, the committee has affirmed the interconnectedness of scientific research and research training. For those engaged in mentored research as postdoctoral researchers and graduate students, research cannot be separated from the training and mentorship offered to them. Even if a postdoctoral or graduate trainee is supported by a research grant, the principal investigator, institution, and granting agency have a responsibility to ensure that the trainee receives the appropriate guidance, mentoring, and training.

## CONTEXT AND BACKGROUND

This committee is not the first to explore issues of fostering the independence of new investigators in biomedical research. Several National Academies reports are among those that have explored this or closely related issues (e.g., NRC, 1994, 1998, 2000; COSEPUP, 2000; Institute of Medicine, 1990); additional recommendations have been made by private funding agencies, professional societies, advocacy groups, and researchers (e.g., ACS/BWF/HHMI, 2000; FASEB, 1998; National Postdoctoral Association, 2003; Petsko, 2001). But there has been disappointingly little progress in improving the situation confronting new investigators or in implementing previous recommendations. In formulating its recommendations, the present committee has considered the earlier recommendations and the challenges that have prevented them from being implemented or in producing the desired effect.

One crosscutting message is that NIH has not implemented most of the previous recommendations. The committee did not have an opportunity to fully investigate the reasons for the slow progress in implementing previous recommendations.

Several of the recommendations to support new investigators rely upon devoting significant resources to individuals who have not already demonstrated their abilities in the specific areas they seek to address. The reliance on preliminary results as one of the most important criteria for peer review necessarily disadvantages those who have not been in a position to already conduct the research for which they are applying. While study sections may feel that focusing resources on individuals and projects that are already proven is responsible, there is also a need to provide support for more "risky" research and researchers.

Responses to more specific concerns have generally only been addressed indirectly—if at all. For example, almost all attention to postdoctoral researchers has been focused on the NRSAs, ignoring the far larger number of postdocs who are supported on research awards. And the earlier recommendation to establish career transition awards provided a set of very focused programs designed to meet specific institute goals, rather than the more general program suggested. While the committee appreciates the need to meet a variety of objectives, fostering the independence of new investigators has not been a significant NIH-wide goal addressed in a coordinated fashion.

The committee feels that NIH action on issues related to new investigators and on the issues mentioned in this report should have a coordinated response so that the 27 NIH institutes and centers work together. The NIH Roadmap[3] provides a helpful framework for such unified actions on issues of concern across NIH.

[3]http://nihroadmap.nih.gov/

## Career Transition Awards

Career transition grants, which support a period of mentored postdoctoral tenure followed by the first several years of independent research support, have been recommended by the National Research Council (1998), COSEPUP (2000), and the National Postdoctoral Association (2003) among others. Although a number of private funding agencies—including the Burroughs Wellcome Fund, the National Multiple Sclerosis Society, and the discontinued Markey Charitable Trust—have established such awards, the total number of them is quite small (less than 40 annually across several private foundations). The NIH awards fewer than 100 each year, and many of these are quite restrictive. In particular, the NIH's K22 career transition award program is actually not one program, but many. Each of the 12 NIH institutes that offers the award has a different set of requirements and expectations, several of which require that the mentored postdoctoral fellowship be conducted in an intramural NIH laboratory. Further, not all the institutes award the K22, and the National Institute of General Medical Sciences, one of the most important supporters of basic biomedical research, does not have a K22 program. It is clear that the K22 awards are designed to fulfill specific research goals of the institutes that offer them, rather than provide the more general career development function advocated in the previous recommendations.

The Federation of American Societies for Experimental Biology (FASEB) (1998) has recommended that NIH establish a program of "NIH Scholars Awards," which would competitively select individuals to start faculty appointments at geographically diverse host institutions. The program would provide salary and start-up costs for the most outstanding postdoctoral researchers across the country as they launch independent research careers. Petsko (2001) goes even farther in suggesting that NIH designate three starting faculty from each biomedical sciences PhD-awarding institution to receive $175,000 for each of the first three years of their career without need for a proposal or review. Neither of these ideas has been tried.

## Review of Grant Applications

A 1994 National Research Council (NRC) committee and others have recommended that a grant application from a new investigator should be "judged on its merits and on its likelihood of providing new information, without a requirement for extensive evidence that it will succeed" (NRC, 1994, p. 87). The 1994 committee even suggested that letters of recommendation from past preceptors could replace preliminary data to provide the evidence of success. The difficulty new investigators have in obtaining preliminary data further discourages new investigators from trying new ideas and pursuing novel areas of research.

That committee also recommended the separation of review of new investigator applications from that of more established PIs (NRC, 1994). At NIH, applications from new investigators are identified as such, and study sections are advised to follow modified guidelines for them, but these applications are still reviewed in the same pool as those from established researchers and are generally not considered *en bloc* at study section meetings. Separately constituted study sections to consider new investigator applications might solve one problem but create others because there are relatively few applications from new investigators during any one review cycle. Thus, new investigator study sections would either have to review very broad ranges of proposals—risking insufficient scientific expertise in some areas—or pool applications over longer periods of time—delaying the consideration of proposals from new investigators. Finally, reviewing all the proposals from both new and previously funded investigators together allows study sections to better sense the direction of research in their respective fields.

The emphasis on the new investigator status of certain applications and how to consider them is at the discretion of the Center for Scientific Review (CSR) scientific review administrator and the study section, so the treatment of new investigators is not consistent across study sections. There are anecdotal reports of special consideration for new investigators being almost completely disregarded or even actively discouraged. Even though these instances may be specific to individual study sections and not a general phenomenon, new investigators whose proposals are considered by those study sections are not getting the intended consideration. It should be noted that CSR sees the review process as solely to determine scientific merit, with decisions about whether to fund proposals and programmatic decisions on funding priorities the purview of individual institutes. For example, "select pay" mechanisms may allow for funding of proposals whose scores do not fall within the range of those that would normally be funded but that are relevant to the overall mission of an institute (see Boxes 2-4 and 2-5 for discussion of policies benefiting new investigators in two institutes).

### Sufficient Resources and Funding Policies

R03 (small research projects) and R21 (exploratory or developmental research) awards do not require preliminary data, but are not generally targeted specifically to new investigators. Rather, they are meant to achieve certain programmatic aims of an institute and to stimulate research in new areas. The level of funding is generally not sufficient for supporting an entire research laboratory, leading new investigators attracted to such programs—because of the lack of preliminary data—scrambling to find funding from many different sources.

Previous reports have strongly recommended providing sufficient levels of funding for new investigator awards. For instance, before the R29 program was eliminated, the National Research Council (1994) recommended that the maximum level of support for this new investigator award increase by over 75 percent. Although new investigators are unlikely to have large research teams of many postdoctoral scientists, graduate students, and technicians, they do have additional costs associated with *establishing* a research program and laboratory and training personnel. In addition, a new investigator's laboratory is likely to grow quickly over the award tenure as projects become established and new personnel join the group. This increases the need for programs intended to support independent research groups—including those overseen by new investigators—to have the necessary resources. In addition, some researchers, especially at medical schools, are often expected to pay for a fraction of their own salary out of grants, putting additional demands on the size of awards.

New investigators face particular challenges as they establish labs and train personnel, all while trying to collect enough data to apply for continued funding, publish their research, and possibly prepare for tenure consideration (NRC, 1994). Shorter award tenures may exacerbate these difficulties and discourage investigators from pursuing novel, more risky research, because of the need to publish results before the grant comes up for renewal.

## Protected Time

It has been suggested that grants should reward institutions for limiting the administrative, clinical, and teaching responsibilities of new investigators, allowing them to focus time on research (NRC, 1994). Many of NIH's programs—including all of the K awards—stipulate a minimum percentage of time a PI must devote to research. Many of the career transition and other new investigator grants in the private sector require a similar commitment to dedicated research time. However, protected research time must not disengage the scientist from other activities essential for other aspects of their career development. For example, scientists engaged in clinical research may benefit from clinical responsibilities. And teaching may help beginning faculty to recruit graduate and undergraduate students to work in their laboratory. In any case, teaching often helps faculty to generate new ideas. Further, new faculty may be some of the most innovative teachers and best able to relate to undergraduate and graduate students. The Faculty Early Career Development Program (CAREER) grants of the National Science Foundation take this into consideration, and CAREER awards are specifically intended for teacher-scholars who plan to integrate research and educational activities.

### Feedback

A 1990 Institute of Medicine (IOM) committee recommended that the R29 new investigator award program include a formalized assessment of progress by a scientific panel in the third year of the 5-year award (IOM, 1990). This mid-course review would help ensure that new investigators are moving in the right programmatic direction to be competitive for the "normal" R01 grant system. For the most part, no such interim review exists for NIH-funded grants. While most PIs are required to file annual progress reports, the vast majority of these reports have little consequence. In fact, only in the rare situation of extremely serious concern is any feedback provided (generally by discontinuing funding). For some of the K awards, the mentor files the report. This may encourage the mentor's involvement with and feedback to the trainee, but does not help the mentee receive feedback from NIH. In the private sector, most grants require formal annual progress and financial reports, but again, without substantive feedback. However, grant programs administered by private funding agencies are more likely to have annual meetings and other networking functions that create informal communities of awardees and, sometimes, representatives of the funding organization can provide informal feedback.

### Career Guidance

The Committee on Science, Engineering, and Public Policy (COSEPUP, 2000), National Postdoctoral Association (NPA), and others have called for increased attention to substantive career guidance, career planning, and training enhancement opportunities by advisors, institutions, disciplinary societies, and funding organizations. While institutions and some disciplinary societies have had some success in implementing such programs, much more progress is needed. With this in mind, one recommendation coming out of the October 23-24, 2003, NIH meeting on postdoctoral issues was to provide seed money to assist institutions in establishing postdoctoral offices to help coordinate and conduct such career development and training activities (Henry, 2004; Jenkins, 2004).

### Need for Data

Finally, there have been many calls for increased data collection and reporting on the biomedical workforce. As identified by COSEPUP (2000), many institutions have very little idea how many postdocs and "soft-money" scientists are in residence. And very few reliable national data exist on the number of postdoctoral researchers. In fact, NIH cannot provide anything more than an educated guess when asked about the number of postdocs it supports on extramural research grants. Clearly, there is a problem with data collection and reporting. The NRC (2000), NPA (2003), the October 2003 NIH postdoc meeting (Henry, 2004), and even the NIH (2001) itself are among those who have called for increased data collection for all NIH-funded postdocs. The growing population of staff scientists and other non-tenure-track researchers (see Chapter 2) must also be reflected in appropriate data about all career stages of the biomedical workforce. Moreover, data collection strategies should also be constructed to allow for disaggregated information to detect different trends between sub-populations of the biomedical research workforce.

## WORK OF THE COMMITTEE

As outlined in its charge, the committee's data-gathering efforts centered on a daylong public workshop dedicated to exploring issues related to fostering the independence of new investigators in the life sciences (Appendix B). Approximately 150 individuals attended the June 16, 2004, workshop held at the Keck Center of the National Academies in Washington, D.C., and about 100 listened on a live audio Webcast. (A list of registered attendees is included in Appendix B.) In addition to speakers and committee members, workshop participants included representatives from the NIH—ranging from postdoctoral researchers to institute directors—and other government agencies, professional scientific societies, university researchers and administrators, tenured faculty, untenured faculty, staff scientists, postdoctoral researchers, and others interested in and knowledgeable about the issues confronting new investigators.

Through a series of presentations, discussions, and breakout sessions, the committee heard about data regarding new investigators, challenges facing new investigators and institutions, and some promising programs and efforts designed to address those challenges. Much of what was discussed at the workshop (agenda in Appendix B) is summarized in Chapter 2 and referenced throughout the report. Audio files and presentations are also archived on the project web site.[4]

[4]http://dels.nas.edu/bls/bridges.html

The committee received and reviewed additional information, including sections of previous studies from the National Academies and others, relevant articles, material provided by NIH officials and others, grant announcement and review guidelines, and additional background research conducted by National Academies staff. The committee also requested and received analyses of personnel and grant award data from the Office of Extramural Research at the NIH and the National Academies Board on Higher Education and Workforce.

The committee met in person immediately following the workshop to plan the structure and scope of the report and to begin work on recommendations. Committee members worked to develop, discuss, and refine their findings and recommendations by teleconference over the next several months.

## ORGANIZATION OF THE REPORT

Chapter 2 describes the current patterns and data for biomedical research careers and highlights some of the present challenges. Chapter 3 presents a vision for the future and offers a roadmap for where we want to be in 5 years. The next three chapters walk through various career stages and the steps needed to foster scientific independence at each of those steps: Chapter 4 focuses on the postdoctoral experience, Chapter 5 on the transition to a first independent position, and Chapter 6 on establishing stable research programs. Finally, Chapter 7 offers the committee's conclusions.

# 2

# Where Are We Now?

As noted in many other studies and reports, academic biomedical research is changing (e.g., NRC, 1998; COSEPUP, 2004). What was once the exclusive domain of individual scientists is being supplemented by large teams of scientists. Where there once was collaboration between individual research groups, now networks and consortia include scientists spread around the world. What was once exclusively the realm of biologists and biochemists now includes physicists, mathematicians, computer scientists, and engineers working together in interdisciplinary teams. Where basic and clinical research were once separate domains, they are now integrated into single research programs. Where there was once a well-defined academic career path and plenty of research positions, there is now a complex network of multiple careers paths and career transitions. Each of these changes has relevance for the issues confronting new investigators.

The effect of "big science" on traditional investigator-initiated "small science" in the biomedical sciences has been discussed for over 20 years (e.g., Alberts, 1985). With more collaborative research projects involving tens or hundreds of scientists, often at multiple locations, crediting individual researchers for their contributions to the team effort has become a challenge. In fact, growth in NIH funding for research centers has outstripped that for research project grants by over 30 percent between 1998 and 2005 (Check, 2004). This trend toward research center funding is especially important for new investigators who are unlikely to serve as principal investigator (PI) or even leader of a collaborating team.

There is growing interdisciplinarity in biomedical research with physical scientists, computer scientists, and engineers working with biologists in research areas traditionally the exclusive domains of biology. As suggested by Dr. Zerhouni in his remarks at the committee's June 2004 workshop, pathways are needed to move physical scientists into biomedical research and to provide opportunities for building interdisciplinary research teams. Moreover, opportunities for moving between and among increasingly overlapping disciplines need to be available to early-career scientists as well as those who have already established their independent disciplinary research program.

Biomedical career pathways have traditionally been viewed as linear progressions with individuals moving directly from graduate school to postdoctoral positions to assistant professorships, then obtaining funding and tenure. Regardless of how accurate this view was in the past, clearly this linear pathway is far less common today. The system by which established scientists "clone themselves" through their postdocs and graduate students is increasingly challenged by new, different directions and objectives. Many people who receive PhDs in biomedical sciences opt to pursue careers outside of academic research: in industry, biotechnology, investment, policy, teaching, writing, or any number of other sectors. And there is significantly more movement in and out of the research career track; individual scientists move between disciplines; they take time out for family or to work outside scientific research. Figure 2-1 shows the complexity of the current network of career trajectories in biomedical research. The figure illustrates the many pathways to achieve independence; focusing on only a single pathway puts artificial limits on who may become an independent investigator. Therefore, research funding and training opportunities now need to fit the needs of a variety of careers and allow for transitions among different areas of research.

The availability of research funding drives not only the specific research questions investigated, but also the scientific workforce available to carry out that research. NIH grant programs can stimulate the creation of new research positions by providing partial or full salary support. While non-tenure-track "soft-money" positions especially depend on external sources for salary support, a significant number of tenure-track faculty also depend upon grant funding. For instance, a study of the Association of American Medical Colleges (AAMC) indicated that tenure does not carry any financial guarantee for basic science appointments at 30.8 percent of medical schools in 2002, up from 24.4 percent just 3 years earlier. And the percentage of medical schools indicating that tenure guarantees total institutional salary for basic sciences faculty dropped from 38.6 percent in 1999 to 21.7 percent in 2002 (Liu and Mallon, 2004).

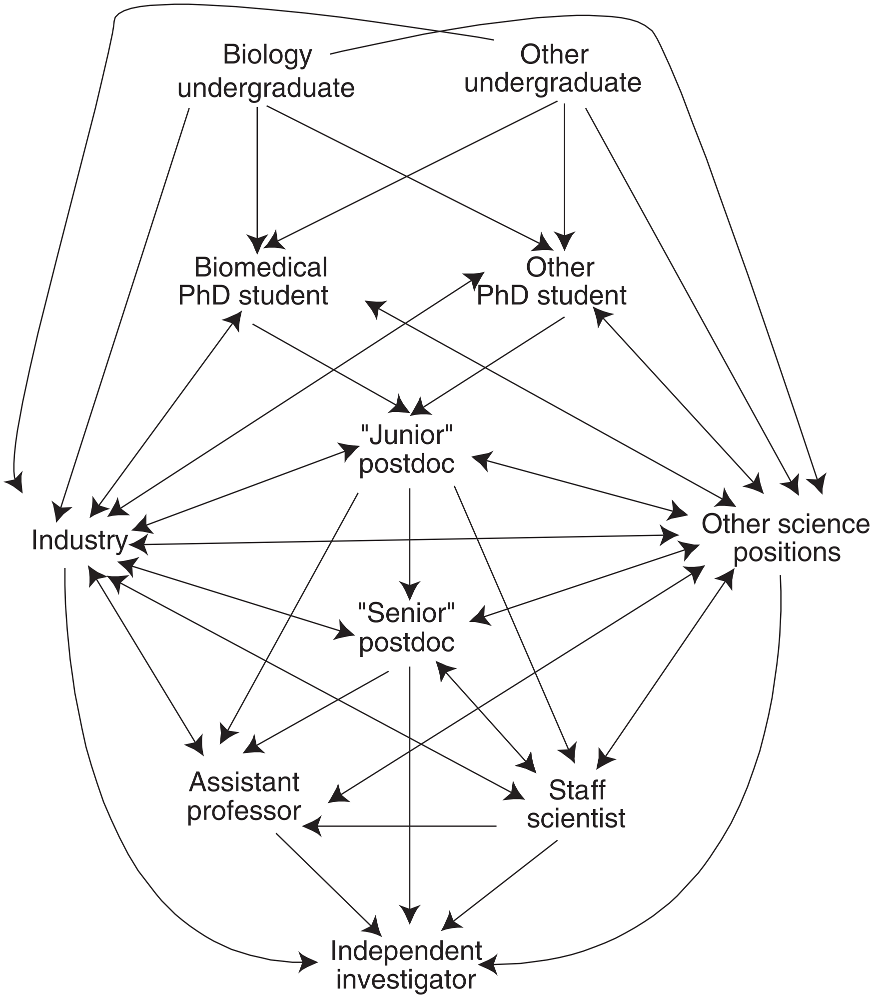


**FIGURE 2-1** Complex network of current career pathways to independent investigator. The former linear pathway from undergraduate to PhD student in the biomedical sciences to postdoc to assistant professor to independent investigator has been replaced by a complex network with many paths to multiples types of independent research.

## GRANT SUCCESS BY AGE

Each year, both new and experienced investigators compete in a Darwinian-like system (Freeman et al., 2001) for the portion of the NIH extramural budget not already committed to continuing awards. According to Norka Ruiz Bravo, NIH associate director for extramural research, the youngest investigators (ages 35 or younger) have the highest R01 and R29 success rates (Figure 2-2), though it may take a resubmission and more than one study section round for success. That is, of the age cohorts applying for NIH research awards (Figure 2-3), those 35 and under are funded a greater percentage of the time than those in older age cohorts. But that may include multiple grant proposals, resubmissions, and rounds of peer review.

Nonetheless, the average age at which investigators receive their first independent research support is creeping upward (in 2002, age 42 for PhDs and age 44 for MDs) (see Figure 2-4). The average age at which investigators receive their first faculty appointments at U.S. medical schools shows the same trend (in 2002, age 38 for PhDs and age 37 for MDs) (data from the AAMC Faculty Roster as of March 31, 2004; Figure 2-

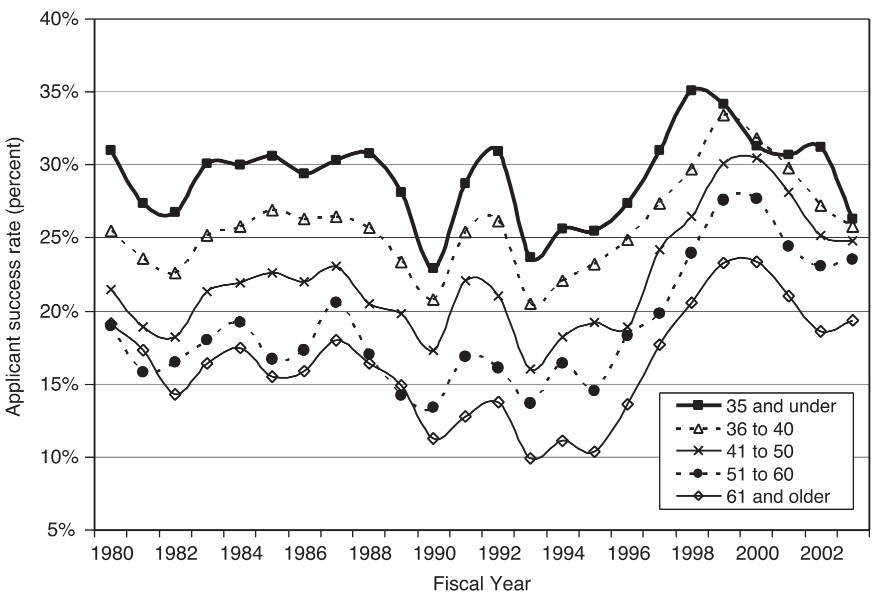


**FIGURE 2-2** Success rate of competing new R01 and R29 grant application by age of principal investigator. Source: Office of Extramural Research, NIH.

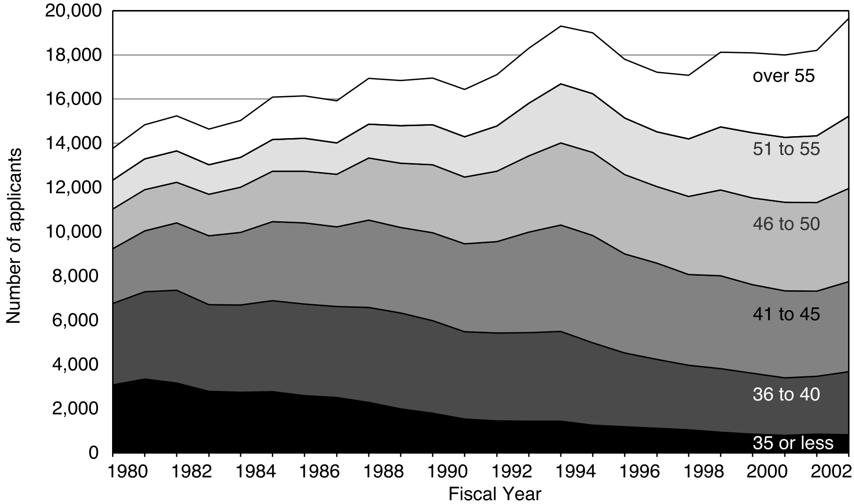


**FIGURE 2-3** Number of R01, R23, R29, or R37 applicants by age cohort. Source: Office of Extramural Research, NIH.

4). The number of biomedical tenure-track faculty in the 33–34 age cohort decreased by half between 1985 and 2001 even though the number of eligible PhD recipients increased during that period (NRC, 2005). But even though the increasing age at receipt of first award seems to follow the increasing age of obtaining the faculty position, a 4–7 year lag persists between becoming a faculty member and receiving a first R01.

It should be noted that the data on grant success at NIH differ significantly between different institutes and centers (ICs). In fact, the absolute number of new investigators receiving R01 awards from some ICs has declined significantly over the last few years (for example, the National Cancer Institute, which was the largest supporter of new investigators in the mid- and late-1990s has had more than a 15 percent decline in the number of new investigators supported between 1997 and 2002).

New and previously funded investigators both seem to be awarded grants at approximately the same age at which they apply (Table 2-1). However, while there may not be evidence of explicit discrimination against younger investigators in the grant process (Goldman and Marshall, 2002), it may take one or more resubmissions for funding; even one resubmission may introduce a 2-year delay in receipt of finding (Coleman, 2005).

NIH still holds at least partial responsibility for the increasing age at which biomedical researchers receive their independence. The current

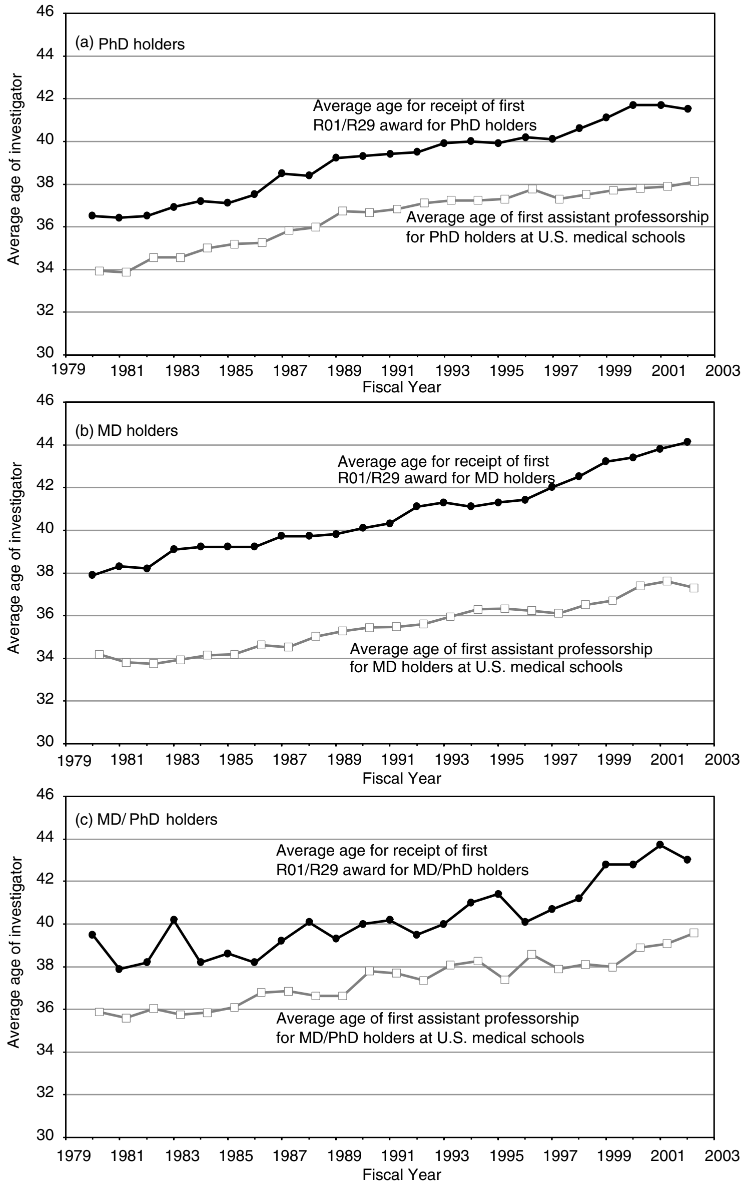


**FIGURE 2-4** Average age at time of first assistant professorship at U.S. medical schools and receipt of first R01/R29 award. *(a)* PhD holders. *(b)* MD holders. *(c)* MD/PhD holders. Source: AAMC Faculty Roster Data, as analyzed by Office of Extramural Research, NIH (age at first faculty appointment); Office of Extramural Research, NIH (age at receipt of first NIH award).

**TABLE 2-1** Average Age for Applicants and Awardees for Competing Awards for New and Previously Funded Investigators. Source: Office of Extramural Research, NIH

| | Applicants | Awardees |
|---|---|---|
| All applicants | 48 | 47 |
| New investigators (previously unfunded) | 44 | 43 |
| Previously funded | 52 | 50 |

NIH research funding system may have direct and indirect effects on the progression of researchers through the early stages of their careers: direct in the lack of realistic funding opportunities for new investigators to establish their independence, and indirect in the distribution of independent positions influenced by funding policies and programs.

The success of new investigators did not improve despite a doubling of the NIH budget (1998–2003). Even with more money available, no evidence indicates that new investigators received a larger share of funds as a result (in fact, Figure 1-4 shows a decreasing percentage of awards made to new investigators in recent years). Rather, it seems that those with existing funding and established research programs received increased funding, in part to hire additional postdoctoral and graduate student researchers and further exacerbate the imbalance between trained researchers and available positions (Freeman, 2004). In an effort to provide incentives and opportunities for new investigators, NIH has implemented two changes. First, new investigators are designated for special treatment in peer review and in funding decisions by identifying themselves as such on their grant application (referred to as "self-designation"; Figure 2-5). Second, NIH developed the following programs of special relevance for new investigators:

- R23 New Investigator Research and R29 FIRST Awards: These grants were designed specifically for and restricted to new investigators to support the first few years of a faculty position. They are now discontinued, for reasons described below.
- R03 Small Research Grant (pilot): These grants are small ($50,000 for direct costs per year for 2 years) and support self-contained studies. Some institutes use them as a way for new investigators to enter the system.
- R21 Exploratory/Development Grant: These grants are for a total

Form Approved Through 09/30/2007 OMB No. 0925-0001

Department of Health and Human Services
Public Health Services

**Grant Application**

*Do not exceed character length restrictions indicated.*

| **LEAVE BLANK—FOR PHS USE ONLY.** | | |
|---|---|---|
| Type | Activity | Number |
| Review Group | | Formerly |
| Council/Board (Month, Year) | | Date Received |

1. TITLE OF PROJECT *(Do not exceed 81 characters, including spaces and punctuation.)*

2. RESPONSE TO SPECIFIC REQUEST FOR APPLICATIONS OR PROGRAM ANNOUNCEMENT OR SOLICITATION ☐ NO ☐ YES
*(If "Yes," state number and title)*
Number: Title:

**3. PRINCIPAL INVESTIGATOR/PROGRAM DIRECTOR** — **New Investigator** ☐ **No** ☐ **Yes**

3a. NAME (Last, first, middle) | 3b. DEGREE(S) | 3h. eRA Commons User Name

3c. POSITION TITLE | 3d. MAILING ADDRESS *(Street, city, state, zip code)*

3e. DEPARTMENT, SERVICE, LABORATORY, OR EQUIVALENT

3f. MAJOR SUBDIVISION

3g. TELEPHONE AND FAX *(Area code, number and extension)*
TEL: FAX: | E-MAIL ADDRESS:

4. HUMAN SUBJECTS RESEARCH No ☐ Yes ☐ | 4b. Human Subjects Assurance No. | 4c. Clinical Trial ☐ No ☐ Yes | 4d. NIH-defined Phase III Clinical Trial ☐ No ☐ Yes

4a. Research Exempt No ☐ Yes ☐ | If "Yes," Exemption No.

5. VERTEBRATE ANIMALS ☐ No ☐ Yes | 5a. If "Yes," IACUC approval Date | 5b. Animal welfare assurance no.

6. DATES OF PROPOSED PERIOD OF SUPPORT *(month, day, year—MM/DD/YY)* From | Through

7. COSTS REQUESTED FOR INITIAL BUDGET PERIOD 7a. Direct Costs ($) | 7b. Total Costs ($)

8. COSTS REQUESTED FOR PROPOSED PERIOD OF SUPPORT 8a. Direct Costs ($) | 8b. Total Costs ($)

9. APPLICANT ORGANIZATION
Name
Address

10. TYPE OF ORGANIZATION
Public: → ☐ Federal ☐ State ☐ Local
Private: → ☐ Private Nonprofit
For-profit: → ☐ General ☐ Small Business
☐ Woman-owned ☐ Socially and Economically Disadvantaged

11. ENTITY IDENTIFICATION NUMBER
DUNS NO. | Cong. District

12. ADMINISTRATIVE OFFICIAL TO BE NOTIFIED IF AWARD IS MADE
Name
Title
Address
Tel: FAX:
E-Mail:

13. OFFICIAL SIGNING FOR APPLICANT ORGANIZATION
Name
Title
Address
Tel: FAX:
E-Mail:

14. PRINCIPAL INVESTIGATOR/PROGRAM DIRECTOR ASSURANCE: I certify that the statements herein are true, complete and accurate to the best of my knowledge. I am aware that any false, fictitious, or fraudulent statements or claims may subject me to criminal, civil, or administrative penalties. I agree to accept responsibility for the scientific conduct of the project and to provide the required progress reports if a grant is awarded as a result of this application. | SIGNATURE OF PI/PD NAMED IN 3a. *(In ink. "Per" signature not acceptable.)* | DATE

15. APPLICANT ORGANIZATION CERTIFICATION AND ACCEPTANCE: I certify that the statements herein are true, complete and accurate to the best of my knowledge, and accept the obligation to comply with Public Health Services terms and conditions if a grant is awarded as a result of this application. I am aware that any false, fictitious, or fraudulent statements or claims may subject me to criminal, civil, or administrative penalties. | SIGNATURE OF OFFICIAL NAMED IN 13. *(In ink. "Per" signature not acceptable.)* | DATE

PHS 398 (Rev. 09/04) Face Page **Form Page 1**

New Investigator. Check "Yes" in the "New Investigator" box only if the principal investigator has not previously served as such on any PHS-supported research project other than a small grant (R03), an Academic Research Enhancement Award (R15), an exploratory/developmental grant (R21), or mentored career development awards for persons at the beginning of their research career (K01, K08, K22, and K23, K25). If the principal investigator/program director is not a new investigator, check "No." Current or past recipients of Independent Scientist and other non-mentored career awards (K02, K05, K24, and K26) are not considered new investigators.

**FIGURE 2-5** Instructions for PHS 398. U.S. Department of Health and Human Services Public Health Service Grant Application (PHS 398) Part I Instructions. OMB 0925-0001. Rev. 09/2004.

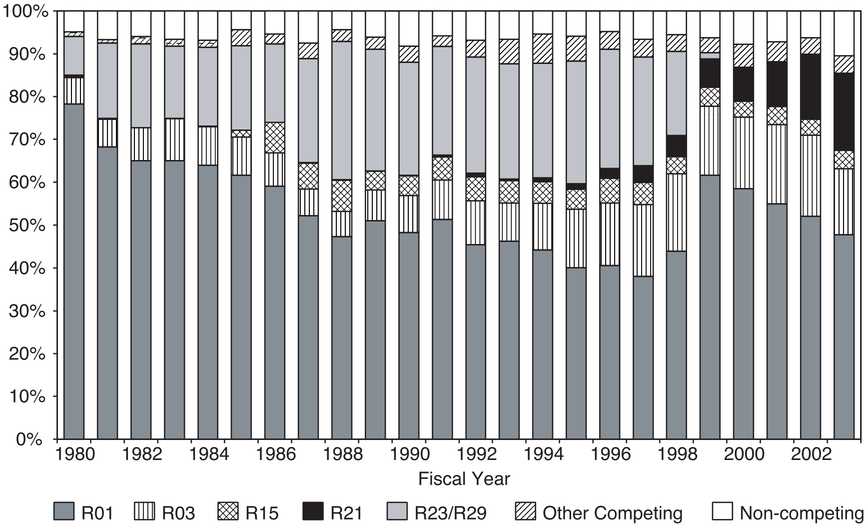


**FIGURE 2-6** First NIH award for new investigators. The figure shows that the R23 and R29 grants specifically created for new investigators are being replaced by the R21 award, whose purpose is generally not specific for new investigators. Also notice the declining percentage of new investigators receiving R01s as their first award over the last several years. Source: Office of Extramural Research, NIH.

of $275,000 in direct costs for 1 to 2 years (but no more than $200,000 in a single year) and support the early stages of exploratory and developmental research projects.

- K Awards: These awards support career development for research or health professional doctorates.

R03 and K awardees have higher success rates in applying for subsequent R01 awards than do those with no prior awards.[1] It appears that R21 recipients have no greater success at subsequent R01s (data from Office of Extramural Research, NIH, not shown).

Yet, the R21 now appears to be the first NIH award for many new investigators (Figure 2-6). Historically, the R23 New Investigator Award was popular among new investigators until its demise. Then its replacement, the R29 FIRST Award took over as a popular award for new investigators. With the elimination of the R29 (see below for the reasons for this

[1]Although the advantage might derive from the fact that those who have received these awards are still considered to be "new investigators" for R01 purposes.

elimination), new investigators are turning to the R21 exploratory/development grant, even though it is not specifically designed to support new investigators. The appeal of the R21 may be that it does not require discussion of preliminary data and is, therefore, seen as easier to obtain for new investigators.

NIH analysis shows that new investigators are entering the system at a higher rate than experienced researchers are leaving it. From 1980 to 1998, the average ingress rate for new investigators was 11.0 percent, and the average egress rate for experienced investigators was 8.4 percent (see Figure 2-7). In particular, researchers appear to stay in the funding system later and later. Investigators over age 55 received 22.7 percent of research awards in 2003, up from only 9.7 percent in 1980 (Figure 1-2).

The age distribution of those receiving competing NIH research awards has been increasing with few individuals under age 40 now receiving awards. In 2003, for instance, only 16.9 percent of those receiving R01, R29, or R37 awards were age 40 or younger, a significant decrease from the 50.4 percent in 1980 (see Figure 1-2).

The average age of first-time research grant recipients is quite consistent across institution types. Recipients of first research grants average 43 years of age at medical schools and research institutions and 42 at non-medical school academic environments and hospitals (data from Fiscal Year 2003 provided by NIH). The average age of first-time recipients of

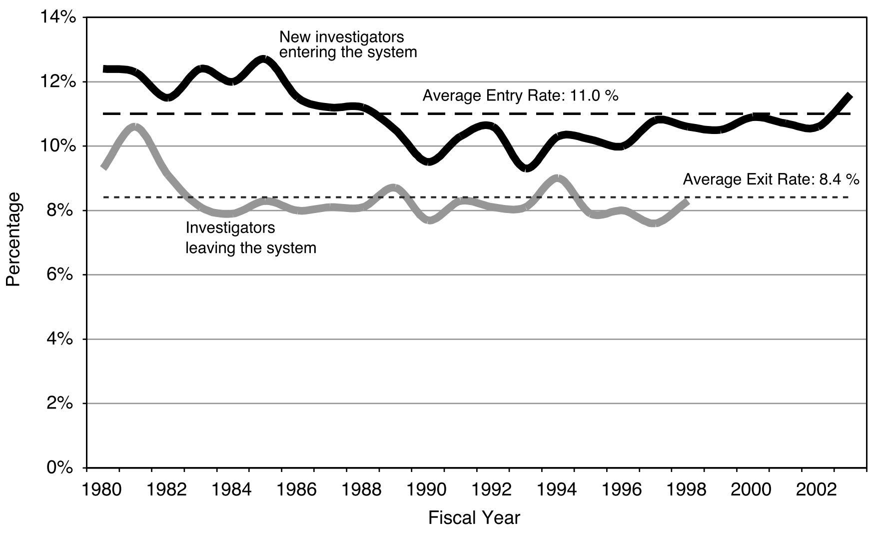


**FIGURE 2-7** Entry and egress rates of NIH research project grant investigators. Source: Office of Extramural Research, NIH.

awards involving human subjects and those without human subjects involvement differs slightly (overall, 43 for human subjects, 41 without).

Some gender differential exists across various NIH grant programs. Although men are, on average, a half-year younger than women (42.26 for men vs. 42.82 for women) at receipt of first award, the difference is reversed—and more pronounced—for the R15 and R21 awards. For the R21, in particular, women are over 2 years younger than their male colleagues at receipt of first award (40.45 for women, 42.60 for men). PhD holders are, on average, younger (41.38±7.30) than either MD/PhD (43.79±6.49) or MD (43.83±6.54) holders at receipt of first NIH research award (data provided by NIH).

Not only chronological age demonstrates the difficulties for new investigators. For instance, in its 1997 survey, the American Society for Cell Biology (ASCB) found that 71 percent of those receiving PhDs before 1970 obtained grant funding from the NIH, NSF, or American Cancer Society on their first attempt. That number drops to 43 percent of those graduating in the 1980s and 25 percent of those graduating in the 1990s (Marincola and Solomon, 1998a; http://www.ascb.org/survey/survey.htm).

## DEMOGRAPHIC DATA

A demographic analysis of available data[2] provides some insight on why the number of awards to new investigators is so low and has declined over time (see Figure 1-3). How have PhDs ages 35 and younger and educated in the United States fared in recent years? Data presented by Paula Stephan about U.S. PhD recipients from 1993 to 2001 reveal the following:

- The number of life scientists ages 35 and younger increased 59 percent (see Figure 2-8)
- The number of life scientists ages 35 and younger in tenure-track positions increased 6.7 percent, and
- The number of life scientists ages 35 and younger in tenure-track positions in Research I institutions[3] declined 12.1 percent (from 618 to 543).

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[2]As discussed in several places throughout the report, the available data are not always what is needed. Box 2-1 summarizes the major data sources for information on the biomedical workforce.

[3]The Carnegie Classification of Institutions of Higher Education is the leading typology of American colleges and universities. It is the framework in which institutional diversity in U.S. higher education is commonly described. Research I institutions offer a wide range of baccalaureate and doctoral programs, and include most of the major academic research institutions in the U.S.

## BOX 2-1
## Data Sources on the Biomedical Workforce

Several data sources on the biomedical workforce are referenced throughout this report. Each has deficiencies that limit the ability to gather appropriate statistics.

*Survey of Earned Doctorates (SED)*. The SED is completed by each person receiving his or her first research doctorate at a U.S. institution.[a] Forms are distributed, collected, and submitted by the institutions themselves, and completed by the individual when the degree is awarded. In addition to collecting demographic information about the PhD recipient and the individual's field of study, the SED asks about postdoctoral plans. Thus, the SED can provide information about work *plans* at receipt of the PhD, but does not provide an accurate count of actual postdoctoral activities.

*Survey of Doctorate Recipients (SDR)*. The SDR is conducted on an 8 percent sample of respondents to the SED under age 76 living in the United States. The survey is designed to provide longitudinal demographic and career-history information on individuals holding PhDs from U.S. institutions. Advertised as "the only source of national data on the careers of the science and engineering doctorate holders," the SDR excludes those with doctorates from non-U.S. institutions or those with non-research doctorates (such as MDs).[b]

*Survey of Graduate Students and Postdoctorates in Science and Engineering (GSS)*. The GSS is a survey of 600 U.S. academic institutions with data collected at the level of departments. It collects demographic information on full- and part-time graduate students and postdoctoral scholars. Summary information on other doctorate non-faculty research personnel is also collected. The GSS provides the only information about foreign doctorate-holders working at U.S. institutions. However, the survey only includes those working in formal departments at academic institutions and excludes those in government, industrial, nonprofit, and other non-academic settings. Further, since it relies on reporting by individual departments and institutions, which may fail to follow survey definitions, it may not count individuals correctly.

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[a]Approximately 92 percent of those receiving a research doctorate complete the SED in each year, with non-respondents concentrated in a handful of institutions (http://www.nsf.gov/sbe/srs/ssed/sedmeth.htm).

[b]The NSF is reported to be considering integrating existing workforce data with information from the Student and Exchange Visitor Information System (SEVIS) to incorporate information about foreigners (Carlson, 2004).

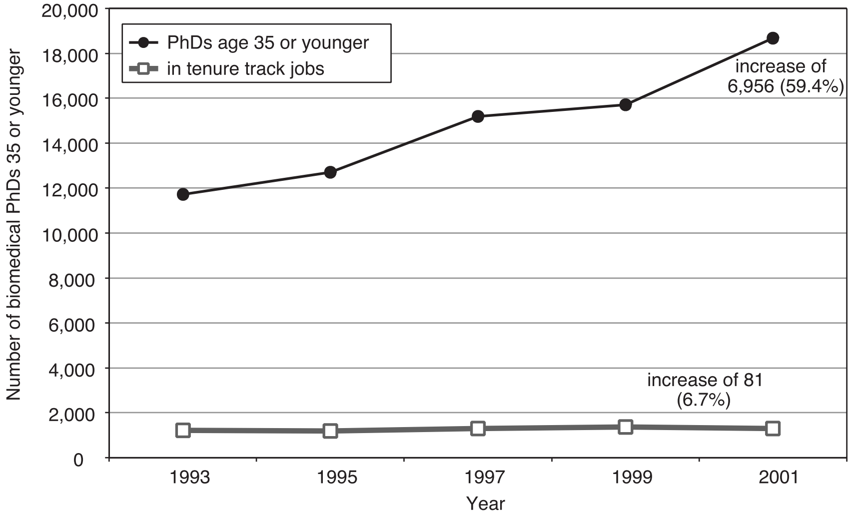


**FIGURE 2-8** Number of biomedical PhDs age 35 or younger and the number of those holding tenure-track positions. Source: Weighted data from Survey of Doctorate Recipients, National Science Foundation, as analyzed and presented by Paula Stephan, Georgia State University.

That is, the number of early-career life scientists with PhDs increased substantially, while the number of tenure-track positions has increased only marginally—with tenure-track positions at top research institutions actually decreasing in number. Not surprisingly, the percentage of biological science PhDs pursuing careers in academia has declined, with more opting for industry (perhaps as many as 35 percent of those in the biological sciences, C. Kuh, unpub.). Those who do opt for academia include more women, more underrepresented minorities, and more non-U.S. citizens (C. Kuh, unpub.). The increase in biomedical PhDs has come mainly from the increased participation of women and temporary residents (NRC, 2005).

A major cause for the increased age of independence is the long time it takes to earn a PhD and complete postdoctoral training. Thorough consideration of graduate training is outside the scope of this report, but is worthy of an updated look (cf. COSEPUP, 1995). What is relevant here is the *overall* length of training, including both graduate school and postdoctoral years, which lasts too long. Not all of the growth in training length has happened over the last few years. For example, the available data suggest that even though time to the PhD degree has increased over the last 30 years, it has stayed relatively constant over the last 10 (NRC, 2005). For example, the median age at receipt of a PhD has remained constant at 29 years, and the years elapsed and years enrolled from bachelor's to doctoral degree in the biological sciences has remained constant—or even slightly decreased—over the last 10 years (National Science Board, 2004). Thus, the length of graduate training alone does not explain all the increase in the age of new investigators. The postdoctoral situation, however, is more difficult to sort out.

The number of *U.S.-earned* biomedical PhDs performing postdoctoral work has leveled off in recent years and even declined in 2001—the most recent data available (NRC, 2005). However, the total pool of postdoctoral researchers has continued to grow due to the influx of scientists from foreign countries (Garrison et al., 2003). In the last 25 years, the number of temporary residents who assume science and engineering postdocs has increased 278 percent, with only a 36 percent growth for U.S. citizens and permanent residents (Babco, 2003). However, the vast majority of these temporary residents are not included in the limited data that exists about postdoctoral scientists. Thus, it is difficult to determine an accurate estimate for the average postdoctoral tenure of all biomedical PhDs. Making generalizations based only upon U.S.-earned PhDs may significantly misrepresent the overall postdoctoral experience, but information on U.S. degree holders is largely the only data available.

Focusing on those with U.S. degrees as measured by the SDR, the percentage of PhDs performing postdoctoral work by time since earning their degree declined overall in every time category studied, which suggests that the amount of time U.S. PhD holders spend in postdoctoral positions may be decreasing (Garrison et al., 2003). It does not necessarily follow from the data, however, that the duration is evenly distributed across different career options. For instance, it would be possible for the growing number of PhDs who opt for non-academic career paths to have only short postdoctoral tenures, while those who pursue tenure-track academic positions spend longer periods in postdocs. The available data do not allow significant insight into the current postdoctoral situation. It is clear, however, that regardless of any changes in the last several years, postdoctoral tenures have significantly lengthened from 20 or 30 years ago.

Meanwhile, the mix of research positions is changing. The ratio of full-time, non-tenure-track researchers to total, full-time faculty has increased, with the highest ratios for Research I institutions. Between 1991 and 2001, full-time faculty positions grew about 8 percent (down from growth rates of 18-34 percent from 1975-1991), while full-time non-tenure-track positions and postdocs grew by 55 percent (National Science Board, 2004). The overall faculty share of academic positions decreased from 85 percent in the late 1970s to only 76 percent in 2001, despite significantly increased spending on academic research. Looking in more detail at the status of biomedical PhDs employed in academic institutions shows that the percentage in tenured and tenure-track positions decreased between 1989 and 2001 (Figure 2-9), while non-tenure-track, postdoc, and other academic positions increased over that period. These data also show a marked difference between men and women with significantly more men in tenured positions, while women are more represented in postdoctoral and other academic positions. The available data cannot explain reasons for this gender disparity and deserve further study.

We can also investigate cohorts of U.S.-earned biomedical PhDs several years out from their PhDs. The analysis presented in Figure 2-10 looks at cohorts several years before the 1993 and 2001 surveys, sampled from the SDR. The data show that the 3-4 year cohort (i.e., biomedical PhDs who earned their degree 3-4 years before the survey) are increasingly more likely to inhabit postdoctoral positions in 2001 than in 1993, with a corresponding decline in the percentage of biomedical PhDs with tenure-track and non-tenure-track positions (Figure 2.10*a*). Moving ahead to the 5-6 year cohort, Figure 2.10*b* illustrates an even greater change in the percentage in tenure-track and tenure positions; those from the 2001 cohort dem-

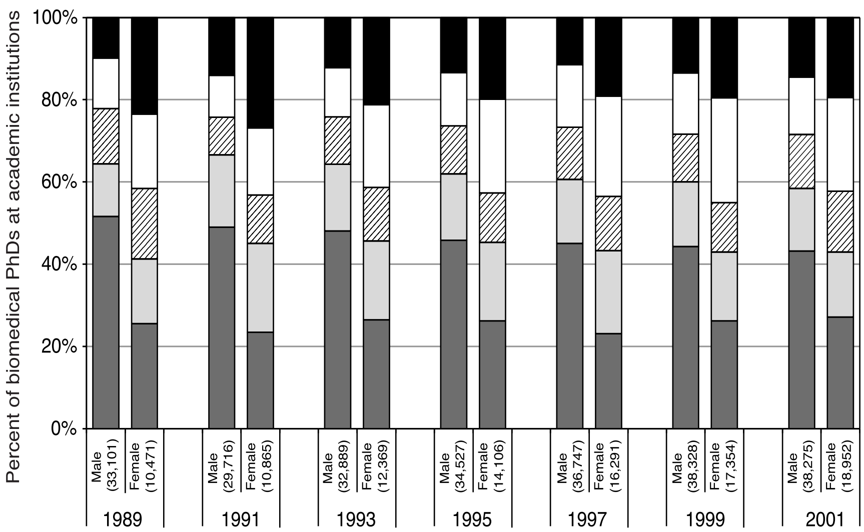


**FIGURE 2-9** Status of U.S.-earned biomedical PhDs employed at academic institutions, by gender. There has been a gradual decline in the percentage of tenured faculty, while the percentage of non-tenure-track, postdoc, and other academic positions has increased. Source: Survey of Doctorate Recipients, National Science Foundation.

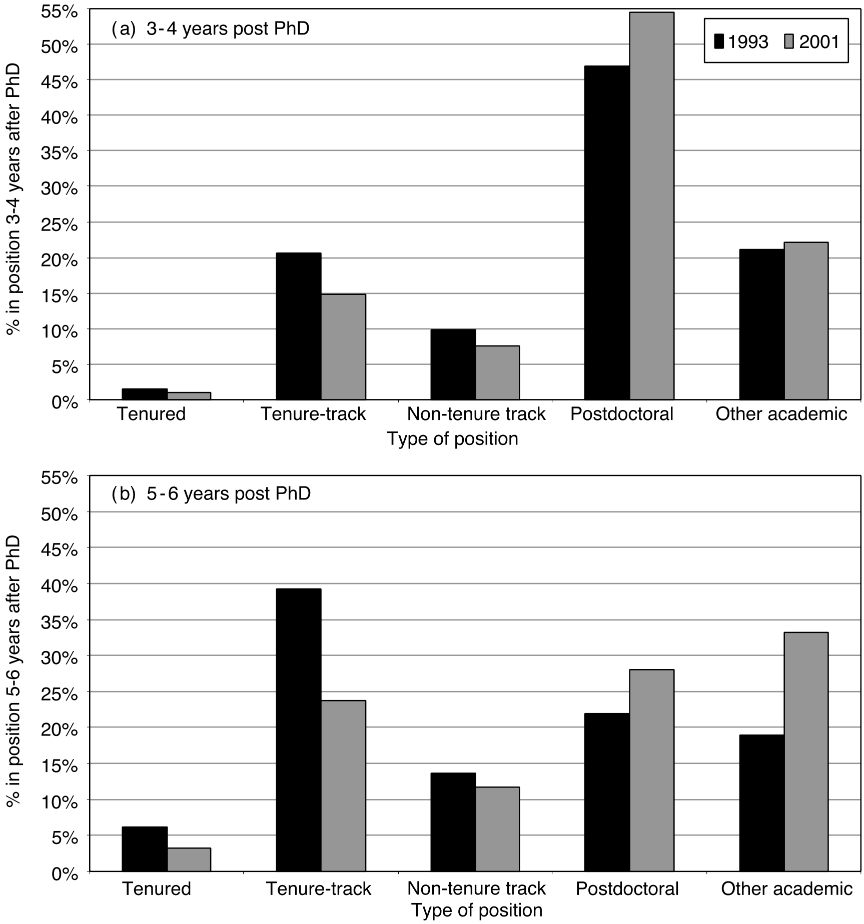


**FIGURE 2-10** Cohort analysis of U.S.-earned biomedical PhDs employed at academic institutions. *(a)* 3-4 year cohort refers to individuals who had earned their PhDs 3-4 years prior to the survey (i.e., 1989-90 PhDs in the 1993 survey and 1997-98 for the 2001 survey). *(b)* 5-6 year cohort refers to individuals who had earned their PhDs 5-6 years prior to the survey (i.e., 1987-88 PhDs in the 1993 survey and 1995-96 for the 2001 survey). Source: Survey of Doctorate Recipients, National Science Foundation.

onstrate an explosion of those in "other academic" positions (33 percent in 2001 vs. 19 percent in 1993).

The 1997 ASCB survey provides related evidence on the number of positions applied for after postdoctoral study: pre-1970 PhD recipients report applying for a mean of four to five permanent positions before securing a job, while 1980s graduates applied for a mean of more than 30 permanent positions. In addition, only 1 percent of those receiving their PhDs before 1980 report a year or more spent searching for a first permanent position; this percentage increased to greater than 21 percent of those receiving degrees since 1980. Moreover, 9 in 10 of all respondents to the ASCB survey who advise or oversee the work of trainees indicate that obtaining a desirable full-time position is more difficult than when the advisors were first seeking such a position (Marincola and Solomon, 1998a).

Furthermore, when universities do hire into a new position or to fill a vacancy, they do so more for non-tenure-track than tenure-track positions. The hiring trend can be explained by the following economic factors:

- Budget crunches and endowment payouts affect hiring
- Higher salaries and expensive start-up packages are often required for tenure-track positions
- Grants, or "soft-money," are available to fund non-permanent positions
- Non-tenure-track and therefore non-permanent positions are more flexible and potentially allow the institution to make more rapid changes in focus.

In addition to these "soft-money," "other academic" positions, where are the increasing number of total biomedical PhDs going? One destination is industry. U.S. citizens and permanent residents with biomedical science PhDs working in industry have increased from 27.3 percent in 1997 to 31.6 percent in 2001, while the percentage employed in academia decreased from 55.6 percent to 52.6 percent (Garrison et al., 2003).

## GRANT PROPOSALS FROM NEW INVESTIGATORS

Once they have an appropriate position from which they can apply for competitive awards from the NIH (e.g., R01s), new investigators identify themselves by means of a checkbox on the front of the application (see Figure 2-5). New investigators are defined as people applying for an R01/R29 award who have not been a principal investigator (PI) on any prior NIH research grant except a K01, K08, K22, K23, R03, R15, or R21 (see Box 1-2). Most "new investigators" are early-career scientists who have become eligible to be a PI by virtue of obtaining a new faculty or research position. However, this category also includes those moving into biomedical research from other disciplines; in some cases, they may have served as a PI on research projects with funding from other federal and nonfederal sources. Others include scientists who have heretofore received all funding from non-NIH sources, such as scientists from other countries. NIH staff members in the Center for Scientific Review (CSR) check whether the new investigator checkbox has been marked appropriately. For example, many applicants erroneously identify themselves as new investigators, thinking that it means only that the application is new and not a renewal.

## REVIEW PROCESS

The peer review process at NIH (described in Box 2-2) is the critical stage in the evaluation of proposals from both new and experienced investigators. As explained by Brent Stanfield, CSR acting director, the study section reviews an application in terms of the significance of the project, the approach or methods to be used, the innovation of its concepts, the investigator's qualifications, and the probability of success due to environment. Applications may be deferred (rarely), unscored, or scored. An unscored application is one that is deemed noncompetitive, while a scored application has a high likelihood of funding and merits further discussion. Some people suggest that new investigators are especially discouraged by being unscored, but their rates of resubmission are the same as for experienced investigators.

Concerns have also been raised about the time in takes for review of extramural grant applications, with a 9-month review time considered standard (Coleman, 2005). Those not funded on the first application must prepare another submission and then wait an additional 9 months for review of the resubmission. New investigators are especially likely not to receive funding with the first application. In addition, new investigators are unlikely to have other grants in place to carry aspects of their research through until resubmission.

After NIH abolished the R29, CSR developed a one-page sheet that provides guidelines for reviewing applications from new investigators (Box 2-3). The guidelines state that all applicants should be evaluated in a manner appropriate for the stage of their career. More specifically, reviewers should place more emphasis on a new investigator's demonstration that the techniques and approaches are feasible, rather than on preliminary results. They should also place greater emphasis on a new investigator's training and research potential, rather than his or her track record and number of publications. Finally, the reviewers should consider the environment appropriately—whether or not the institution is invested in the researcher.

How have new investigators fared under these guidelines? Data presented by Dr. Stanfield from the October 2003 to May 2004 NIH council rounds show that 32 percent of applications from experienced investiga-

**BOX 2-2**
**Overview of NIH Grant Review Process**

Scientists applying for NIH grants must generally do so with the sponsorship of their institution to which the award would be made. Institutional policies on eligibility differ.

Once an application has been submitted by the institution on behalf of the principal investigator (PI), it is usually reviewed on at least two sequential levels by the NIH, designed to separate the scientific assessment of the proposal from policy and resource decisions. The evaluation of scientific and technical merit is generally conducted by scientific study sections chartered by the Center for Scientific Review (CSR) or by individual institutes and centers. The study section, organized around scientific specialty, may consist of as many as 16-20 members, primarily non-federal scientists, supervised by a scientific review administrator (SRA) on the NIH staff. The reviewers study each application individually before a meeting of the study section; some reviewers are assigned to prepare written critiques for each application. Approximately half of the applications are considered competitive, fully discussed at the study section meeting, and given a priority score based on the scientific merits of the project. Priority scores run on a scale from 100 to 500, with lower scores indicating more meritorious proposals. The overall priority score is an average of all the numerical ratings from individual reviewers in the study section. Study sections are encouraged to score about half of the applications (with the remaining "unscored") and to have a median score of 300.

The National Advisory Board or Council for the relevant institute or center then performs a second review. These panels of 12-18 scientists and laypeople consider the priority score from the study section against a background of relevance, program goals, and available resources.

Source: Adapted from http://grants1.nih.gov/grants/intro2oer.htm, http://www.csr.nih.gov/REVIEW/scoringprocedure.htm

tors were unscored (see Box 2-2 for a discussion of the scoring process), compared to 46 percent for those from new investigators (see Figure 2-11). The overall distributions of scores were similar, but the median scores differed considerably (300 for new investigators and 232 for experienced investigators; lower scores are better).

However, the experienced investigators' applications include those for new studies (Type 1, which new or previously funded investigators can file) or for competitive renewals of ongoing studies (Type 2, which only previously funded investigators can file). If these two types are separated out, 17 percent of Type 2 applications, 37 percent of Type 1 applica-

**BOX 2-3**
**Guidelines for Reviewers of New Investigator R01s**

"New investigators are important to the future of biomedical research. In order to provide new investigators maximum freedom in identifying the level and period of support needed for the work they are planning and thus enhance their opportunities to establish careers in research, NIH has announced a new policy. Under this policy, new investigators are encouraged to submit traditional research project grant (R01) applications, which will be identified as being from new investigators. First Independent Research and Transition (FIRST; R29) award applications are no longer accepted (effective June 1998). A new investigator is one who has not previously served as such on any PHS-supported research project other than a small grant (R03), an Academic Research Enhancement Award (R15), an exploratory/developmental grant (R21), or certain research career awards directed principally to physicians, dentists, or veterinarians at the beginning of their research career (K01, K08, K22, and K23). Current or past recipients of Independent Scientist and other nonmentored career awards (K02 and K04) are not considered new investigators.

New investigators are typically less experienced in the preparation of applications and expression of their research plans. To ensure fair reviews for new investigators, the NIH has revised application forms to allow new investigators to indicate this status and thus ensure that reviewers can readily identify applications that are submitted by new investigators. The biosketch should also be used to identify new investigators. All applicants should be evaluated in a manner appropriate for the present stage in their careers.

**IMPLEMENTATION:** When reviewing these applications, reviewers should keep in mind the experience of and the resources available to the new investigator. When considering an application from a new investigator the five new review criteria must be evaluated in a manner appropriate to the expectations for and problems likely to be faced by a new investigator. Specifically, when considering:

**Approach:** more emphasis should be placed on demonstrating that the techniques/approaches are feasible than on preliminary results.

**Investigator:** more emphasis should be placed on their training and their research potential than on their track record and number of publications.

**Environment:** there should be some evidence of institutional commitment in terms of space and time to perform the research."

Source: http://www.csr.nih.gov/guidelines/newinvestigator.htm

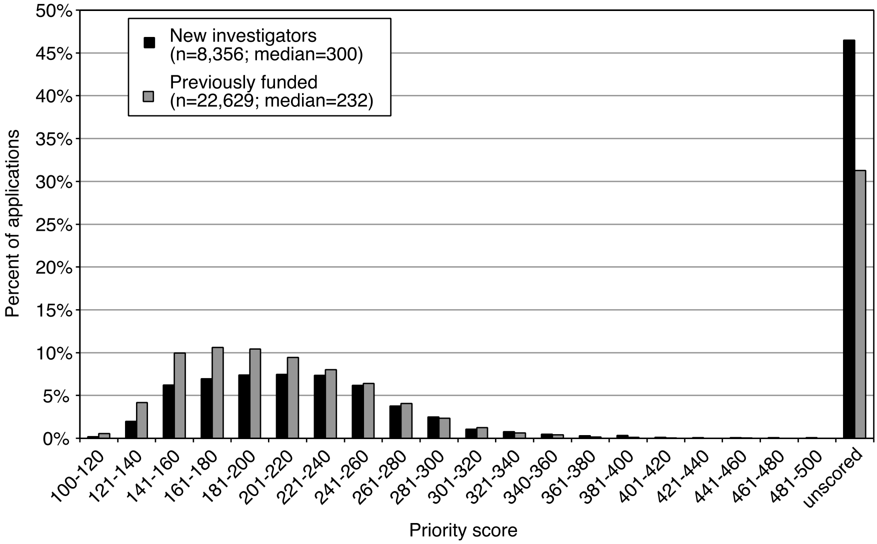


**FIGURE 2-11** Distribution of priority scores for R01 applications for new and previously funded investigators, October 2003–May 2004 Council rounds. Unscored applications account for 46% of new investigator applicants and 32% from those previously funded. Lower priority scores are better. Source: Center for Scientific Review, NIH.

tions by previously funded investigators, and, again, 46 percent of new investigator applications went unscored. Similarly, the median score for Type 2 applications is 196, versus 251 for Type 1 applications by previously funded investigators and 300 for new investigator applications.

CSR compiles the results of each study section's last three meetings and plots the differences between the mean and median scores for new and previously funded investigators. The distribution curves generally skew to the right, meaning the study sections assign better scores to previously funded investigators (see Figure 2-12). CSR also plots the scores for new investigators only—assigning unscored applications a "score" of 500. CSR provides the graphs to the study sections before each meeting to remind them of their behavior during the last three meetings and to help them appreciate whether they are giving new investigators a fair chance.

It is difficult to *a priori* decide on an appropriate success rate for new investigator applications. Given the relatively few tenure-track positions for an increasing biomedical PhD pool, obtaining such an academic research position has become more competitive. As such, one might expect

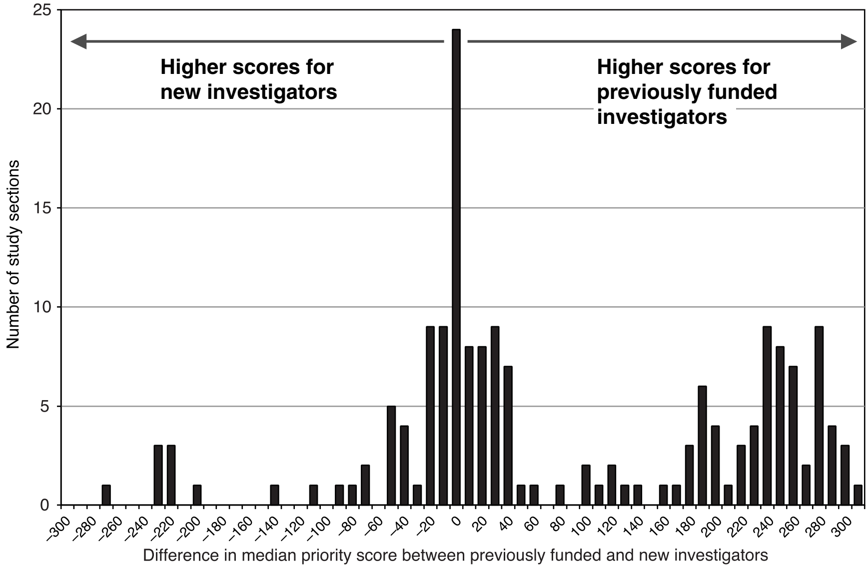


**FIGURE 2-12** Differences in median priority scores within study sections between new and previously funded investigators for new R01 applications. A difference of 0 suggests no difference between priority scores given to new and previously funded investigators. Positive scores (to the right on the figure) indicate higher scores given to previously funded investigators. Source: Center for Scientific Review, NIH.

new investigators to be of higher quality than a few years ago and have, consequently, a *higher* success rate than in the past. Instead, success rates have been relatively flat. One measure of how new investigators are treated by study sections can be obtained from staff members of the CSR. For example, a 2003 analysis of neuroscience study sections and the review process suggests a need for concern. When asked to assess to what extent new investigators are reviewed appropriately by study sections, 54 percent of CSR staff members surveyed said about half the time or less often (Malik and Pion, 2003).

The committee is pleased to learn that several NIH institutes have been taking steps to improve the application success rate for new investigators. Actions taken by the National Institute of Biomedical Imaging and Bioengineering (NIBIB) are described in Box 2-4 and those taken by the National Institute of General Medical Sciences (NIGMS) in Box 2-5. However, not all institutes have addressed this situation with as much con-

**BOX 2-4**
**NIBIB New Investigator Policy**

"The NIBIB [National Institute of Biomedical Imaging and Bioengineering] has established a New Investigator Pay Plan with the aim of improving the success that new investigators have in applying for R01 awards.

Specifically:

- NIBIB staff will identify grant applications by investigators new to the NIH;
- New investigators who have scores within 5 percentile points of the NIBIB stated pay line for any given fiscal year will be selected for funding.

This policy will apply only to Program Announcement and unsolicited R01 applications."

Source of quoted material:
http://www.nibib.nih.gov/research/newinvestigators.html

Despite the preference given to new investigators for R01 applications, new investigators seem to be applying for R21 exploratory/developmental grants in greater numbers. Only 11 R01 grant applications from new investigators were received by NIBIB in fiscal year 2004. In contrast, 35 new investigators received funding through the R21 program (Laas, 2005). At its January 2005 meeting, the NIBIB advisory council suggested providing grant-writing skills to help new investigators fare better in the review process (Laas, 2005).

cern. In fact, the absolute number of awards made to new investigators has actually decreased in some institutes even as the scale of total extramural research support has increased substantially. As such, these issues must be considered and implemented NIH-wide.

## RISK TAKING

Many observers believe that NIH is too conservative in granting funds (Mervis, 2004a). As mentioned previously, NIH wants to see significant preliminary results before funding a new project. Some savvy researchers have found a way around this as evidenced by the saying in the field: "You apply for things you have already done and use the funds for things you intend to do." But this only works for those already in the system.

Although many scientists wish to conduct "high-risk" research (Mervis, 2004a), the system discourages such risk-taking at many levels. If an investigator proposes a "risky" project that has no guarantee of success, it is likely that the investigator will not receive the grant and, instead, be asked to reapply with more evidence of feasibility, i.e., more "preliminary results." Even an investigator with a "risky" project fortunate to be funded will be expected to have publications documenting completion of parts of the project within only three or so years—at the time of application for renewal.[4] Unlike more experienced researchers, new investigators do not have long track records of publications and scientific credibility. They are often perceived to respond to these pressures by proposing more straightforward, dependable, and, often, more conservative projects. Thus, researchers who may be at the most creative and free-thinking times in their career may also be the least able to conduct such potentially ground-breaking and innovative research.

The peer review processes, described above, also have an almost inherent tendency towards conservatism. Even if not a conscious process, those on study sections are more likely to rank "familiar" proposals more favorably. Reviewers are naturally attracted to proposals that remind them of their own research and suspicious of proposals that significantly differ from the status quo. Moreover, when faced with limited resources, study sections may believe they have a responsibility to select the most cost-efficient proposals. Proposals deemed to have a high probability of success will therefore be likely to be judged more favorably than those not necessarily viewed as doable.

The NIH Director's Pioneer Award (NDPA) has been created "to encourage creative, outside-the-box thinkers to pursue exciting and innovative ideas about biomedical research."[5] As described below, however, at least in its current implementation, the NDPA is not expected to have any significant effect on fostering the independence of new investigators.

## CURRENT AND RECENT OPPORTUNITIES FOR NEW INVESTIGATORS

Federal agencies and the private sector have developed a number of research award programs targeted to new investigators in biomedical research. These awards may explicitly target researchers who have not received previous support or are still in mentored positions. They generally also do not require submission of preliminary data, which can be

[4]Publications are also essential for institutional advancement, i.e., tenure and promotion.
[5]http://nihroadmap.nih.gov/highrisk/index.asp

**BOX 2-5**
**NIGMS Support for New Investigators**

The National Institute of General Medical Sciences (NIGMS) has established a number of procedures and funding policies to ensure that adequate numbers of new investigators are supported. This comes at a time when applications are increasing, with nearly 70 percent of the increase in new grant applications between 2001 and 2003 coming from new investigators (Hawkins, 2004). Under the new policies, an applicant's status as a new investigator is one of the criteria used in funding decisions made by the Institute. That is, NIGMS takes certain programmatic steps to provide special consideration for new investigators *after* consideration of their applications by the study section. In addition, NIGMS is making all its R01 grants to new investigators have a 5-year term (instead of the average 4-year award), providing new investigators with additional time to help establish their research careers.

Data provided to the committee by NIGMS suggest that these policies are already having an effect on the success of new investigators in applying for NIGMS support. New investigators are having greater success in receiving funding than are experienced investigators who have previously received NIH funding. For example, between 2001 and 2003, 36 percent of those submitting their first R01 application to NIGMS were funded; two-thirds of these awards were made to unamended applications in the first round of review, with most of the remaining awards going to amended applications submitted two review rounds later. This 36 percent for new investigators compares with a success rate of about 30 percent for previously funded investigators. When looking at *any* R01 (not only funding of the original or amended first application), about 45 percent of new investigators are funded within three years of their first R01 application to NIGMS.

These higher rates of funding success for new investigators occur despite worse priority scores obtained in peer review. New investigators with

difficult to obtain for researchers seeking to establish their independence and who do not already have an independent track record.

The number of true bridging awards is small. Foundations and the government fund fewer than 100 bridging awards each year, compared to tens of thousands of postdocs.

There is no comprehensive listing of awards of particular interest to new investigators. This leaves many potential applicants in the dark about the opportunities that do exist. Even within NIH, new investigators have had to navigate long listings of program announcements, requests for ap-

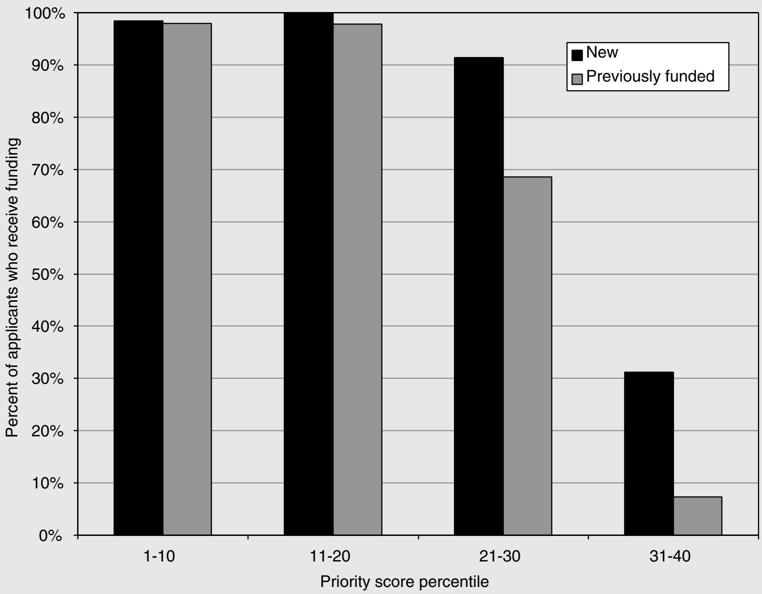


**FIGURE 2-13** Success rate for NIGMS R01 applications from new and previously funded investigators, by percentile score. New investigators have a higher success rate on submission of a revised proposal than previously-funded investigators. Source: NIGMS, NIH.

percentiles between 20-40 percent have over 20 percent higher funding rates than established investigators (Figure 2-13). Even new investigators with percentile scores between 40-50 percent have a 40 percent chance of being funded through revised applications.

plications, and institute-specific information to identify the small number of grant programs applicable to their situations. The committee applauds the NIH for compiling resources for new investigators on a single website.[6] This page not only provides links to grant opportunities, but provides historical context, help with applications, policies of individual institutes, and other resources.

[6]http://grants.nih.gov/grants/new_investigators/

## New Investigator Awards from NIH

The NIH has a history of programs targeted to new investigators and has looked into the issue internally several times. During the mid-1990s, the NIH working group on new investigators was charged with finding answers to two overarching questions: (1) How well have new investigators competed in the funding system? And (2) have the mechanisms designed to support new investigators been effective?

The most prominent among NIH new investigator mechanisms was the R29 First Independent Research Support and Transition (FIRST) award, a successor to the R23 New Investigator Research Award (NIRA) that was phased out in 1986. The nonrenewable R29 award provided total direct costs of no more than $350,000 over 5 years (with a maximum of $100,000 in any single year). The investigator had to be independent, spend at least 50 percent on research effort, have no more than 5 years' research experience after completing postdoctoral work, and could not hold a concurrent R01.

Alan Leshner, a former director of the National Institute on Drug Abuse, was a member of the NIH working group on new investigators in the mid-1990s. In his remarks at the committee's June 2004 workshop, he explained that the working group first looked at the numbers of new investigators applying for R01s and R23/R29s from 1980 to 1995. The numbers remained relatively constant, which suggests, at least, that the R23/R29s did not bring more investigators into the system. Next, the group looked at a series of mechanisms, with an initial focus on the R29 (FIRST) award. From 1980 to 1995, the success rate for R29s was consistently higher than that for the R01s (Figure 2-14). In other words, R29s were easier to get. Did this, then, equate to greater success when the R29 recipients subsequently competed with all other investigators for R01s?

To answer this question, the working group looked at the R01 success rates for those who received the highest scores (top three deciles) on their initial R01 or R29 and found that the probability of getting a subsequent R01 was lower for someone who had an R29 than for someone who had an R01. Some argue that these two groups are not cohorts—rendering the comparison invalid—because those who initially received R01s might have been of different quality than those who received R29s. Perhaps a better comparison would be between those who had received R29s and those who had received no prior funding. Finding equivalent cohorts is a significant problem.

In any event, R29 awards were not seen as prestigious as R01s and did not garner much respect in academia; they were generally given less serious consideration in tenure deliberations. This speaks to the role that academia plays in providing institutional recognition of NIH research

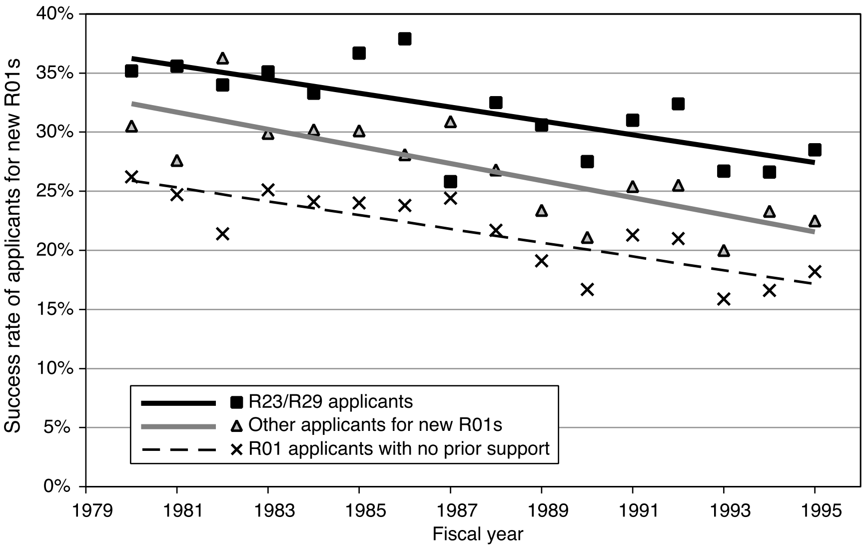


**FIGURE 2-14** Success rate of R01/R23/R29 applicants with no prior support and other applicants for new R01s. Source: http://www.nigms.nih.gov/news/reports/table10a.html.

awards. Further, the budgets allowed for R29 awards were generally not sufficient to establish and run a research laboratory. Since R29 recipients could not hold a concurrent R01, it was difficult to obtain supplemental funding from other sources.[7] The conclusion was obvious: the FIRST award was not a great success. The group recommended that NIH abolish the R29, provide a mechanism for identifying new investigators on the R01 application (resulting in the front-page checkbox; see Figure 2-5), and maintain the numbers and success rates for new investigators within the R01 system. The group also recommended that, in future efforts, NIH should provide more dollars, find ways to avoid stigmatizing investigators, and conduct formative analysis to evaluate the effectiveness of mechanisms from their initial implementation.

The working group also studied the outcomes for two other mechanisms: the K08 mentored career development award for MDs and the R03

[7]Before the R29 awards were eliminated, an NRC committee recommended that the maximum size of the 5-year R29 award be increased from $350,000 to $625,000, while maintaining the same total number of awards (NRC, 1994).

small research grant. The K08 did not fulfill its original purpose of bringing more MDs into the research pool, but it did highlight the important contribution of mentorship. Sixty-five percent of K08 awardees applied for a subsequent R01 or R29, and they realized a 50 percent success rate. In comparison, only 32 percent of MDs without a prior mentored award received R01 or R29 funding. The R03 grant was even less effective in fostering future R01 success. Only 7.5 percent of those who received the small ($75,000) R03 grant were awarded a subsequent R01.

Beyond the R01 and now-discontinued R29, the NIH offers other programs for new investigators. The K22 career transition award is offered by many of the NIH institutes and centers (ICs), although the requirements and characteristics differ significantly. In general, K22s are awarded for 1-2 years of mentored research to postdoctoral researchers who have not received prior independent support. The remaining 3-4 years of the 5-year award tenure is then provided in the first tenure-track independent position. As mentioned, the characteristics and amount of the award differ among ICs; for example, some require carrying out the postdoctoral period in an intramural NIH laboratory. (Chapter 5 recommends a new program that builds upon the strengths of the existing K22, but addresses its weaknesses.)

As mentioned above, the R03 small research grant offers up to 2 years of research support. Although the amount of support is small (limited to $50,000 per year), these awards do not require submission of preliminary data, which makes them especially attractive to new investigators. The R21 exploratory/developmental research grants also do not require submission of preliminary data and these awards are more generous than the R03 (up to $275,000 with a term of up to 2 years), but still below the budget and length of R01s. R21s are intended to promote research that may have risk but has the potential for high reward. Although the R03 and R21 awards often appeal to new investigators since they do not require preliminary data and are perceived as easier to obtain, these awards are not generally explicitly geared for new investigators; rather, ICs use them to encourage research in new areas, develop new research technologies or methodologies, or perform pilot studies.

Several other career development awards in the K series affect a more targeted group of applicants. The K01 mentored research scientist development awards are for those moving to a substantially new area of research or who have had a career hiatus. K02 independent scientist awards provide salary support only and require 75 percent protected time for research. The K08 mentored clinical scientist development awards and related K23 mentored patient-oriented research career development awards primarily support MDs engaged in clinical or patient-oriented research. The K25 mentored quantitative research career development awards are especially for scientists with quantitative backgrounds looking to pursue independent research in the biomedical sciences, and the K18 career enhancement awards support training in the use of stem cells. The characteristics and requirements for most K awards differ significantly by institute.

Finally, the NIH Director's Pioneer Award (NDPA) has recently been established "to identify and fund investigators of exceptionally creative abilities and diligence, for a sufficient term (five years) to allow them to develop and test far-ranging ideas."[8] Those selected to formally apply for the NDPA from those nominated do not submit a formal research plan since it is expected to evolve during the tenure of the grant. Because the specific scientific plan is not a review criterion, recipients are selected on the basis of their potential—including scientific innovation and creativity, motivation and enthusiasm, and potential for scientific leadership. Individuals at all career stages are eligible for the NDPA and "nominations from individuals at early stages of their career who demonstrate independence of their ideas from their mentors are especially encouraged." While the Pioneer Awards have great potential to encourage risk-taking by a small number of biomedical researchers, they will likely have little effect on more than a handful of new investigators. In particular, it is difficult for new investigators—who, by definition, have little track record—to have already demonstrated significant creativity and independence. Without even a research plan, the selection is largely based on the track records of the applicants and new investigators have little to show, at least as compared to their more senior colleagues. The outcome of the first round illustrates why the NDPA is unlikely to help new investigators: of the nine awardees (out of 1,300 applications)—all are men in their 40s and 50s, most are tenured professors at elite institutions, and seven of the nine already have current NIH grants (Mervis, 2004a).

## National Science Foundation

The National Science Foundation (NSF) administers one program especially targeted to those at the beginning of their careers. The Faculty Early Career Development (CAREER) Program, offered across NSF, targets those who plan to integrate research and education activities. CAREER awards provide at least $100,000 a year for 5 years to investigators in their first faculty positions. Recipients must be in tenure-track positions, but not yet have received tenure. The application requires an endorsement

[8] http://nihroadmap.nih.gov/highrisk/initiatives/pioneer/

from the department head and a career-developmental plan from the applicant that describes research and educational goals, the relevance to the applicant's own career goals, and a summary of prior research and educational accomplishments. Several of the most meritorious CAREER recipients are selected for the Presidential Early Career Awards for Scientists and Engineers (PECASE), although this designation does not include any additional award benefits. Twenty-five percent of the biological sciences directorate's young investigators are funded through CAREER each year, although the success rate is only 16 percent.

Overall, in 2003, the NSF funded 24 percent of research grants submitted by all principal investigators, 30 percent of research grants submitted by new principal investigators, and 20 percent of CAREER grant applications across the Foundation, according to Mary Clutter of the Biological Sciences Directorate in her presentation at the committee's June 16, 2004, public workshop.

NSF does not ask applicants their age, so "new" is defined by the number of years after receiving the PhD. When expressed as a percentage of total awards, awards to new investigators decreased significantly after investigators passed 11 years from PhD. This equates to approximately 40 years old, which is below the median age for receipt of new NIH awards. Because of its broad mission, NSF offers a comparison of biological sciences awards with those in other disciplines. A cross-disciplinary analysis shows the experiences of new investigators in biological sciences are similar to those in mathematics and the physical sciences. Only in computer science and engineering (by a significant margin) and social, behavioral, and economic sciences (by a slim margin) do new investigators have the greatest success in obtaining funding within 5 years after receiving their PhDs.

In addition to the CAREER program, NSF fosters independence in a number of ways:

- Review committees (akin to study sections) are asked to give "extra credit" to beginning investigators.
- Program officers are encouraged to have balance in their portfolios. As Dr. Clutter described at the workshop, NSF division directors make sure there are "a goodly number of beginners, as well as small institutions, different types of institutions, etc."
- The few postdoctoral awards that NSF offers are portable and include automatic starter grants (for approximately $50,000).

NSF is concerned about the next generation of scientists and, therefore, places extra emphasis on new investigators. In addition, NSF strives to integrate research and education.

## Other Federal Support for New Investigators

In addition to NIH and NSF, the Department of Defense provides another major source of federal funding for new investigators in the biomedical sciences. The Army's Breast Cancer Research Program offers a physician-scientist training award. This two-phase 5-year award can total up to $700,000. The award is given to MDs or MD/PhDs in their last year of oncology graduate training or in their first 3 years as a junior faculty member. The first, mentored phase of the award provides up to 3 years of salary support and medical school debt relief; the second phase adds direct research support. The Office of Naval Research also administers a Young Investigator Program designed to support the careers of academic scientists and engineers within 5 years of receiving their PhD. It offers up to $100,000 per year for 3 years for salary, graduate student support, supplies, and operating expenses and requires a letter of institutional support.

## Private Sector Programs for New Investigators

A number of programs for new investigators also exist in the private sector, especially at private foundations (see also ACS/BWF/HHMI, 2000).

### *Markey Scholar Awards in the Biological Sciences*

The Lucille P. Markey Charitable Trust created some of the first career transition awards, known as Markey Scholar Awards in the Biological Sciences. Established in 1983 as a 14-year limited-term trust, the Markey Trust distributed institutional and individual grants, including almost $60 million to 113 Markey Scholars (Lucille P. Markey Charitable Trust, 1996). Academic institutions were invited to nominate young investigators for the awards, which provided salary and research support for up to 3 years of postdoctoral training and for the first 5 years of the awardee's first faculty position. Support for the faculty phase declined in anticipation of the faculty member obtaining replacement funds from other sources. Among the characteristics that proved especially desirable in the Markey Scholars program were the flexibility in the awardees' use of the money, including no-cost extensions; the long tenure of the award; the resultant ability to focus on research without having to seek additional funding; and the networking opportunities with the other Scholars.

The National Academies is engaged in a multi-year study on the outcomes of grants and fellowships awarded by the Markey Charitable Trust in the biomedical sciences between 1982 and 1997. Among the outcomes of interest for fellowship recipients are publications, grants, and independent investigator status. These results will be helpful data in evaluating the success of career transition awards.

### *Burroughs Wellcome Career Awards*

The Burroughs Wellcome Fund (BWF) offers the Career Award in the Biomedical Sciences,[9] based upon the initial structure of the Markey Scholar Awards. The goal of this $500,000, 5-year award is to help postdoctoral scholars obtain faculty positions and achieve research independence. Applicants must have between 1 and 2 years of postdoctoral study and be nominated by their sponsor institutions. BWF requires 1 year of additional postdoctoral training unless, during the application process, the applicant has been offered a faculty position. Eighty percent of the recipient's time must be devoted to research. The award provides salary and research funding—up to 1 year of postdoctoral support and 4 years of faculty support. An investigator is not restricted from receiving additional awards from other sources. The BWF career awards program is one of the only programs that has had a formal assessment of its success and influence on the career trajectories of its awardees (Pion and Ionescu-Pioggia, 2003). Box 5-1 summarizes the evaluation.

BWF provides training to the awardees in areas not generally addressed during postdoctoral training, such as how to manage a laboratory and how to negotiate an academic-industrial collaboration. BWF also collaborates with the Howard Hughes Medical Institute (HHMI) to host the Laboratory Management Course (BWF and HHMI, 2004).[10]

### *National Multiple Sclerosis Society Career Transition Fellowships*

The National Multiple Sclerosis Society awarded its first three Career Transition Fellowships in 2003. These two-phase awards are given to those with 2-4 years of postdoctoral experience who are engaged in multiple-sclerosis-related research; the first phase includes salary and research support in the 2-year mentored postdoctoral phase, followed by $125,000 annually for salary, personnel, research, and indirect costs during the 3-year faculty phase.

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[9]BWF also offers an interdisciplinary Career Award at the Scientific Interface following a similar model.

[10]http://www.hhmi.org/labmanagement

*American Heart Association Fellow-to-Faculty Awards*

The American Heart Association offers a career transition awards program for MD and MD/PhD scientists pursuing independent research careers in areas relevant to its mission. Applicants for Fellow-to-Faculty awards may have no more than 5 years of postdoctoral research training and must work with a mentor to develop a plan for the training phase; the applicant also identifies a mentor for the faculty phase of the award. Awardees receive salary and research support during the training phase and salary, project support, and indirect costs during the faculty support phase. Mentors also receive $5,000 in compensation for their efforts. Applicants are expected to devote at least 80 percent of their time to research- and training-related activities.

*Keck Distinguished Young Scholars in Biomedical Research*

The W.M. Keck Foundation established the Distinguished Young Scholars in Biomedical Research Program in 1998. Although the program was originally meant to award only 5 years of Scholars, it was extended for another 5 years in 2003. Thirty institutions are invited to nominate promising early-career biomedical scientists who are in the second, third, or fourth year of their first tenure-track position. Awardees receive up to $1 million over 5 years for salary and research support. The review process is said to emphasize innovative ideas and to support "risky" projects for which funding may be hard to otherwise secure. Unlike several other awards for young investigators, the Keck Foundation does not place limits on teaching, administrative, or grant-writing responsibilities of the awardees, as it sees these skills as important for the careers of the Scholars.

*Packard Foundation Fellowships for Science and Engineering*

The David and Lucille Packard Foundation invites the presidents of 50 universities to nominate two professors who have held faculty positions for less than 2 years for their Fellowships in Science and Engineering. Nominees should be "unusually creative researchers" undertaking "innovative individual research" in the natural sciences, physical sciences, or engineering, focusing on areas that do not traditionally receive generous funding from other sources. Awardees receive $625,000 over 5 consecutive years and attend annual Packard Fellows meetings.

*Beckman Young Investigator Program*

The Arnold and Mabel Beckman Foundation established the Beckman Young Investigator Awards in 1991 and has made about 200 awards totaling over $40 million since that time. Awards are normally in the range of $240,000 over a 3-year award tenure. Applicants must be U.S. citizens or permanent residents who are pursuing careers in the chemical or life sciences and have held tenure-track positions for no more than 3 years. According to the Foundation, "Projects should . . . represent innovative departures in research rather than extensions or expansions of existing programs. Proposed research that cuts across traditional boundaries of scientific disciplines is encouraged."[11]

*Pew Scholars Program in Biomedical Sciences*

The Pew Charitable Trusts has given 20 rounds of awards through the Pew Scholars Program in the Biomedical Sciences, to support junior faculty members as they establish independent laboratories. The program encourages awardees to be "more venturesome in their research and future applications for support than would otherwise be likely." Faculty within the first 3 years of a full-time faculty appointment as assistant professor or independent researcher are eligible to be nominated by their institution. Scholars are awarded $60,000 per year for 4 years to use for personnel, equipment, supplies, and related travel. The amount for the Scholar's salary is capped at $10,000, and overhead is limited to 8 percent. Scholars are also expected to participate in an annual meeting to present their research and allow for collaboration and exchange with other Pew Scholars.

*Searle Scholars Program*

The Kinship Foundation offers the Searle Scholars Program to "support the independent research of exceptional young faculty in the biomedical sciences and chemistry." Searle Scholar Awards are made to selected academic institutions to support the independent research of outstanding individuals in the first or second year of their first tenure-track assistant professor appointments. Applicants pursuing independent research careers in biochemistry, cell biology, genetics, immunology, neuroscience, pharmacology, or related areas of chemistry, medicine, and the biological sciences can receive one of 15 grants, which offer $80,000 for each of 3 years.

[11] http://www.beckman-foundation.com/byiguide2.html

*McKnight Scholar Awards*

The McKnight Endowment Fund for Neuroscience offers its McKnight Scholar Awards for scientists in the early stages of their careers on disorders of learning and memory. Applicants should have already completed their doctoral degree and postdoctoral training and be in the first 4 years of establishing an independent laboratory and research career. Up to six scholars are selected each year for up to 3 years of support at $75,000 per year. Funds may be used in any relevant way to support the Scholar's research program, except for indirect costs.

*Damon Runyon Scholar Award*

The Damon Runyon Cancer Research Foundation grants five Scholar Awards each year to support outstanding scientists as independent investigators. Awardees, who must be within the first 3 years of an assistant professorship, must either be former Damon Runyon postdoctoral fellows or be nominated by their institution (if invited to do so). Damon Runyon Scholars receive $100,000 for each of 3 years that may be used for salary, technical support, equipment, or supplies. Scholars must submit a progress report in the first 2 years of the award as well as a one-paragraph summary of their research written for the lay public. The host department and institution must guarantee that 80 percent of the applicant's time will be devoted to research, with an accounting for the activities that make up the remaining 20 percent of time and effort specified in the application and progress reports.

*Sloan Research Fellowships*

The Alfred P. Sloan Foundation has spent nearly $100 million since 1955 to support the early careers of over 3,800 researchers as Sloan Research Fellows. Tenure-track assistant professors within 6 years of receiving their PhD may be nominated by their departments. The 2-year award of $40,000 provides support for the Fellow's research, including equipment, travel, or trainee support, but may not be used for salary augmentation or indirect costs. The field distribution has been established by the Foundation and currently awards 116 fellowships, including 16 in neuroscience and 12 in computational and evolutionary molecular biology.

*American Cancer Society Programs*

The American Cancer Society offers a number of research grants and mentored training and career development grants that support new investigators. In addition to research scholar grants for those in the first several years of independent research careers, several other programs for senior investigators encourage the inclusion of a faculty member at an early-career stage as a co-investigator.

*Institutional Independent Research Fellowships*

Several institutions provide highly prestigious and very flexible research fellowships to promising researchers at an early career stage. Most recipients are recent doctoral-degree recipients nominated by their research mentors or other prominent scientists. Awardees generally spend several years in residence at the host institution and receive both salary and research support. The fellowship period therefore allows these new investigators to establish an independent research program free from having to apply for external funding or fulfilling teaching or administrative responsibilities. Many of these programs were developed following the model of others, in an attempt to provide similar experiences at other institutions.

The Carnegie Institution of Washington has supported a small number of exceptional early-career scientists as staff associates in its Department of Embryology since 1979. Staff associates are independent junior faculty members who hold non-renewable faculty-level independent appointments for up to 5 years and are appointed in lieu of or just after completing a regular postdoctoral fellowship. Up to four staff associates at a time are provided with their own laboratory space and funding for research equipment, supplies, and usually a technician. Staff associates are considered to be independent PIs and are eligible to apply for external funding, though institutional resources are generally sufficient during the tenure at Carnegie. Although there is no formal association with an established Carnegie laboratory or PI, staff associates are encouraged to attend regular laboratory group meetings in addition to department-wide activities. The small size of the department and the commitment of its members to the program provide a collegial environment in which staff associates receive necessary guidance and mentoring, even without a formal mentoring system.

The Whitehead Institute for Biomedical Research accepts nominations of recent PhD, MD, and MD/PhD recipients for the Whitehead Fellows Program from candidates' research advisors or other distinguished scientists. The handful of fellows in residence at a time are provided with the space and resources to establish an independent laboratory and conduct an independent research program at the Whitehead Institute. Fellows generally receive support for their own salary, one or two technicians, and necessary equipment, supplies, and overhead. A 3-year appointment is initially made at selection with the expectation that it will be extended to 5 years. Fellows have the opportunity to serve as PIs and to take advantage of the facilities and interactions with colleagues at the Whitehead or neighboring Massachusetts Institute of Technology, free from financial constraints and formal teaching responsibilities.

The Fellows Program at the University of California, San Francisco (UCSF) has brought in a small number of promising early-career researchers through a 5-year fixed-term award. UCSF Fellows receive office space and a small laboratory, along with salary and a core research grant, and are eligible to serve as PI on external research grants. Fellows may sponsor postdoctoral researchers and co-sponsor graduate students with UCSF faculty. UCSF Fellows are nominated by prominent scientists, generally just after completion of their PhD or after brief postdoctoral periods. UCSF is also considering mechanisms for including physician-scientists in the program. Unlike most of the other models described here, formal mentorship is an important aspect of the program: UCSF Fellows are encouraged to set up a mentoring committee of three senior faculty members to provide guidance on topics including running a laboratory and hiring research personnel.

The University of California, Berkeley awards Miller Research Fellowships through The Adolph C. and Mary Sprague Miller Institute for Basic Research in Science to approximately 8-10 promising scientists at the time of—or soon after—receipt of a doctoral degree. Nominations are accepted from former Miller Fellows and Professors, UC-Berkeley science faculty, faculty advisors and department chairs of candidates, and a worldwide panel of experts. Fellows currently receive a stipend of $50,000 per year with an individual research fund of $10,000 for research, equipment, travel, and other expenses.

Harvard University selects about 10 "persons of exceptional ability, originality, and resourcefulness" as Junior Fellows in any field of study at an early career stage each year. Selected by the Harvard faculty who serve as Senior Fellows from nominations by previous research mentors, recipients spend 3 years in residence conducting independent research with few strings attached—other than attendance at weekly lunches and dinners. Junior Fellows currently receive a stipend of $55,500, but generally arrange support for research with members of the Harvard faculty or apply for internal research funds (Junior Fellows do not have PI status for applying for external funding).

Although the committee found these institutional independent pre-tenure-track fellowships to be beneficial, the committee did not feel that this model could be successfully adopted by the NIH. First, the fully independent positions require very substantial financial investment on the part of the institution,[12] usually providing a start-up equipment package to each fellow along with continuing research and salary support, even though the individuals may only stay at the institution for 3-5 years. Only the wealthiest institutions are likely to be able to provide these resources, and even for them there must be a significant internal reason to divert start-up funds from regular faculty to these special programs. In fact, there is some evidence that other institutions that have tried to adopt similar programs have had difficulty maintaining appropriate funding levels as other needs arise. Moreover, external support to establish or support such programs would essentially be institutional block grants. Although training grants may also be considered block grants, they tend to have a well-defined research focus and close oversight by faculty PIs, in addition to being much more modest in budget. The lack of oversight by NIH on such an institution-based program would make such a program unlikely to receive significant federal support.

Second, the fully independent fellowship positions often lack the opportunity for direct personal mentorship by a senior scientist with similar research interests that is the major academic benefit of the traditional postdoctoral period. Although it is desirable for scientists to become fully independent as quickly as possible, for many people assuming an independent position with the complete responsibilities of running a laboratory immediately after completing the PhD may be too soon. This emphasizes the importance of such programs having the full support and participation of senior faculty mentors.

### European Models

Finally, it is worth considering awards that support the independence of new investigators in Europe. The German Research Foundation (Deutche Forschungsgemeinschaft) offers several programs for early-career scientists including the Heisenberg Programme for individuals usually under 35 but no older than 39 with 5 years of salary and research support—and the Emmy Noether Programme, which supports training abroad followed by research and salary support in the first German faculty position.

The Volkswagen Foundation Lichtenberg Professorships provide support to outstanding scientists for up to 8 years. The goal is to provide young investigators the opportunity to independently pursue new and

[12]Estimates from some programs suggest that institutions devote on the order of $1 million over several years for each Fellow, including salary and research support, start-up costs, and necessary overhead and support services.

interdisciplinary research at an early stage in their careers. Applicants must be within 3 years of receiving their PhD and under age 35 with a proven research and publication record. Institutions must also submit a binding letter describing how the environment and focus of the department is appropriate for the applicant and committing to cost-sharing during the professorship and continuing support after the award's conclusion.

The European Molecular Biology Organization (EMBO) offers the Young Investigator Programme to young scientists in the first 3 years of establishing their own independent laboratory. In addition to €15,000 per year, EMBO provides an opportunity to network with other scientists at the European Molecular Biology Laboratory (EMBL). EMBO Young Investigators choose an EMBL mentor who provides advice on the awardee's research project and helps promote the mentee to relevant conferences.

The French National Institute for Health and Medical Research (INSERM) offers its Avenir Program for the Promotion of Young Researchers to encourage autonomy for promising young biomedical research scientists. Avenir awardees are provided with a fully equipped laboratory within an INSERM facility or French University Hospital. Applicants receive support of up to €60,000 per year for 3 years and, possibly, financial support to host a foreign postdoc or graduate student. Applicants may already hold a permanent research position at INSERM or other French research institute, university, or hospital; those without a permanent position may apply to develop an independent research project at a host institution.

## Conclusion

Few of these model programs for new or early-career investigators have collected data on their outcomes or the successes of their awardees. Conclusions on helpful elements of the awards come from the few programs that have been evaluated and from anecdotal feedback from recipients, program administrators, and other observers. The lack of rigorous feedback on these awards demonstrates the importance of collecting data on awardees—and an appropriate control group—to determine the effect of the award on the careers of those scientists. However, it is difficult to demonstrate a cause-and-effect relationship between the award and career success. For instance, many of the awards go to the same population of researchers, i.e., the same individuals may receive multiple such awards. Did the award help those selected to advance in their career or receive subsequent funding? Or would the individuals selected have been likely to succeed even without the award? These questions are difficult to answer.

# 3

# A Vision for 2010

Current policies and practices for funding and training postdoctoral biomedical scientists, and for funding, mentoring, and promoting the advancement of new investigators do not sufficiently address the challenge of fostering independent and innovative careers. This is a critical deficiency given the rapid pace of change and expanding scope of biomedical research. Multiple trends are changing the environment for biomedical research (NRC/IOM, 2003) including the need for better approaches to translate basic science discoveries into medical treatment, the threats of emerging infectious diseases and bioterrorism, the increased need for large-scale and trans-institution projects that require longer-term strategic planning and commitments, the emergence of "-omics" and its informatics and data requirements, the opportunity to employ interdisciplinary research to tackle many diseases, and, in view of these developments, the need to assure opportunities for the independent ideas and research of individual scientists.

Given these trends, we might ask, how will the biomedical research enterprise look in 2010 and how should it look? What policies and practices related to the preparation of new scientists might foster change and independence of thought? This chapter sets the stage for the recommendations made in the following chapters for changes that should be made over the next five years by the National Institutes of Health (NIH), academic research institutions, faculty, and the postdoctoral and research communities to help launch more productive research careers for more of the country's early-career researchers. The recommendations address the challenges confronting new investigators in a variety of different ways, with each designed to address a different segment of the research community or a specific challenge. Some of the changes can and should be implemented immediately; others will require large-scale policy decisions and adjustments in the academic culture.

The committee first looked ahead to 2010 to create a vision of where the training and nurturing of new investigators might lead and then developed more detailed recommendations for how to achieve those goals. While some of the visions might not be fully achieved by 2010, the 5-year deadline means that change must begin now. Setting a deadline further off would make it too easy to delay response in the belief that someone else will deal with it sometime in the future. But the need for attention and, especially, action is urgent and must be initiated immediately.

This chapter therefore presents a vision for the future in order to provide a scaffold for the recommendations and discussion that will be discussed in more detail in the remainder of the report: from optimizing the postdoctoral experience (Chapter 4), to facilitating the transition to a first independent position (Chapter 5), to establishing stable research programs (Chapter 6).

## NEW ALLOCATION STRATEGIES AND FUNDING MECHANISMS FOR SUPPORTING POSTDOCTORAL RESEARCHERS

NIH currently relies on four primary mechanisms to support postdoctoral researchers. A majority are supported on research grants held by their advisors; fewer are assigned to training grants awarded to institutions; still fewer have individual fellowships via National Research Service Awards (NRSAs); and a small number of senior postdoctoral scientists have mentored K-series transition awards. There are several ways in which NIH could reallocate funds and support postdoctoral researchers' efforts to achieve independence. The vision for the future distributes funding to support training and programmatic goals, rather than defining goals by funding opportunities. The recommendations of Chapter 4 describe this vision.

### Fostering Collaborative Research

Is the training of independent researchers outmoded? As collaborative, interdisciplinary research becomes increasingly valuable in answering some of biology's most difficult questions, what is the role of the independent researcher? As defined in Box 1-3, the new definition of "independence" does not mean that a researcher must work alone as long as the investigator enjoys independence of thought.

Collaborative research can be especially attractive to a new investigator because it thrives on the exchange of ideas and communication. Currently, NIH emphasizes research project support through the R01-type mechanism. Although this strategy has been very successful overall, it tends to isolate scientists both physically and intellectually. The vision for the future broadens funding policies and mechanisms in order to encourage applications that empower groups of scientists with diverse expertise to devise collaborative approaches to complex biological problems.

Possible new mechanisms would differ from current project and center grants by acknowledging multiple PIs, each with primary responsibility for a particular disciplinary component of the proposed study. In this way, both responsibility and credit could be allocated appropriately, providing new investigators with the recognition needed to advance their careers. Some of these mechanisms should be framed in such a way to encourage engineers, computer scientists, mathematicians, physicists, and chemists—as well as clinical and basic biomedical researchers—to join these research teams. Such an arrangement would permit those without explicit training in the biological sciences or medicine to enter the field. New investigators serving as PIs for parts of projects within these collectives would be encouraged to think independently as acknowledged experts in a given area, while having the advantages of operating within a collaborative group.

The committee's vision for collaborative research involves one in which independent researchers from different disciplines or with different sets of expertise come together as equals. In this way, the reach of a collaborative group can be more than just the sum of its constituent parts as independent researchers engage each other in questioning that spans traditional disciplinary boundaries. In fact, interdisciplinary collaborative research teams argue for increased independence as investigators in such teams must be able to fully trust those in different research areas as they work together to solve problems of common interest.

### New Investigators and the R01 System

The criteria for the R01 award deserve reconsideration. Currently, R01-type mechanisms and traditional study section behaviors are biased toward experienced investigators because of an emphasis on preliminary data and track record. The system has moved so far in this direction that most "new investigators" are over 40 years old and—counting their graduate studies—have already been working as practicing scientists for 12 to 15 years. The vision for the future would provide opportunities for postdoctoral researchers and other non-faculty to apply for their own research funding in order to establish independence earlier in their careers. The vision extends to providing opportunities for transitioning to independence and dedicating funds to new investigators and non-tenure-track researchers often left out of the funding system. These specific recommendations are discussed in detail in Chapters 5 and 6.

## CHANGES NEEDED IN ACADEMIC RESEARCH INSTITUTIONS

Academic institutions can do much to create an environment that promotes independence, recognizes the contributions of new investigators, and rewards scientists who choose a non-academic career path. The biomedical community would benefit from reconsidering who is brought into the enterprise, what positions they are brought into, when they are brought in, and how they are encouraged to stay and be productive. The social and cultural issues surrounding research career structures and issues such as tenure and credit are important ones that cannot be ignored. A complete analysis of this situation is beyond the scope of the present study; however, a more thorough national examination of the current environment, including recommendations for the future, would help the academic and research communities.

Department chairs face a number of challenges when hiring new people, especially assistant professors. Medical schools are especially constrained by the need to hire in areas with readily available funding since medical school faculty must often pay at least a portion of their salaries through external grants (Liu and Mallon, 2004). Currently, R01 funding is a virtual prerequisite for promotion to tenure or tenure-equivalent positions at research-intensive institutions. NIH study sections, therefore, almost serve as *de facto* tenure committees. In its vision for 2010, the committee sees additional criteria for hiring, advancement, and promotion that recognize and reward scientific creativity beyond the sole-investigator model and within the context of multi-investigator interdisciplinary groups. These criteria would acknowledge and support the skills necessary to work effectively in collaborative settings.

### Changing Attribution and Publication Policies

Once hired, new faculty must compete with more established investigators for recognition of their work. The most revered approach to gaining recognition is through publications. Biomedical researchers publish their findings in scholarly journals, adhering by tradition to an attribution structure in which the first listed author has carried out most of the experiments and the last author is the independent investigator who conceived the study and obtained primary funding. As such, one measure of independence for an investigator is being listed as the last author on a publication or an author list that does not include the research mentor.

However, many scientists can make valuable independent contributions to team efforts through essential skills and expertise that do not result in a first- or last-author listing on publications. By 2010, the vision includes a new system for attribution in publications in which the contributions of each author are explicitly stated and appropriately valued by promotion committees, study sections, and other evaluators. The biomedical research community can learn and adopt models from other scientific enterprises (e.g., high-energy physics research, the biotechnology industry), where large interdisciplinary teams of creative individuals are common and publication recognition is apportioned appropriately.

### Recognize and Reward Non-Tenure-Track Pathways

Finally, although the tenure-track faculty position is the dominant model for independent basic biomedical research in academia and is likely to remain so, this traditional pathway, by which life scientists achieve independent laboratory status through a "straight and narrow" route, is not as clear as it once was. On this pathway, graduate students move on to perform postdoctoral work, are hired as assistant professors, and obtain their own funding. But this pathway is not as common now and it is not the only route to creative and independent scientific research. The research community needs to retain the talents of scientists who do not pursue the tenure-track academic faculty pathway. In particular, the vision for 2010 includes respect and recognition for staff scientists, whose contributions to the research enterprise are critically important and who may conduct much of the biomedical research in the future.

In the vision for 2010, academia will establish and support new career tracks that recognize independent scientific thought and scholarly achievements outside the traditional tenure-track position. This issue is addressed in more detail in Chapter 6.

## NEED FOR FACULTY REFORM

In the current system of training and apprenticeship, faculty members are largely responsible for facilitating the transition to independence of trainees in their laboratories. Currently, standards and best practice for training and mentoring postdoctoral researchers are highly variable between—and even within—institutions. In fact, some faculty members are not comfortable or skilled as mentors, and few faculty have received any training and preparation for this important role. Indeed, because the majority of postdoctoral researchers are supported on individual research grants held by their advisors, there is no mandate or stated expectation for training, and the experience is sometimes treated primarily as a form of employment, with little or no serious educational component.

Postdoctoral researchers who emerge from this setting are typically narrowly focused, and many aspire to become "clones" of their advisors rather than to think boldly and independently. The areas of research for postdoctoral researchers usually center tightly on the work of their advisor. Further, their career opportunities are constrained by the dearth of tenure-track faculty positions for independent investigators, especially at research-intensive institutions.

Fortunately, recognition of these problems among some faculty and within certain professional societies is growing. In the 2010 vision, faculty groups within institutions, government and private funding agencies of biomedical research, and professional societies would acknowledge an educational imperative for postdoctoral researchers, defining and implementing policies for their training and mechanisms for fostering their independence. These issues are discussed in more detail in Chapter 4.

## NEED FOR DATA

As discussed in Chapter 2, there are very few available data on early-career researchers, making even simple questions—such as the number of postdoctoral scholars—very difficult to answer. The lack of data on postdoctoral researchers, staff scientists, and other non-tenure-track positions—as well as for tenure-track scientists[1] —makes it difficult to formulate informed programmatic and policy decisions. The few existing data sources exclude large segments of the biomedical research community (see Box 2-1); for example, the Survey of Doctorate Recipients excludes MDs and anyone earning a PhD outside of the United States.

The vision for 2010 includes a comprehensive integrated research personnel database that includes basic information on all federally-funded scientific researchers. This system would provide accurate counts and statistics on the research workforce and allow the kind of targeted and rigorous analysis needed for making informed programmatic and policy decisions. The need for accurate data is critical and is discussed in each of Chapters 4, 5, and 6.

[1]The Association of American Medical Colleges maintains a Faculty Roster that includes comprehensive information on faculty members at accredited U.S. medical schools. There are, therefore, some data on biomedical researchers at medical schools, but no similar source for biomedical researchers outside of medical schools.

# 4

# Optimizing Postdoctoral Training

Much has been written about the postdoctoral experience, including its value, length, and attractiveness, or lack thereof. Numerous reports have made recommendations to improve the quality and utility of this critical period of training (COSEPUP 2000; IOM 1990; NRC, 1998; ACS/BWF/HHMI 2000). All have recognized the importance of humanizing and expanding this experience to ensure the "continued success of the life-science research enterprise" (NRC 1998), and most have documented the declining appeal of the current mode of preparation for a career in science. For example, a 1994 National Research Council (NRC) report noted that "young investigators are not merely apprentices for future positions but a crucial source of energy, enthusiasm, and ideas in the day-to-day research that constitutes the scientific enterprise" (NRC, 1994, p. 2). A 1998 report commented that young scientists caught in the postdoctoral experience while searching for independence are increasingly frustrated and that the postdoctoral period has become too much of a "holding pattern" for many young scientists (NRC, 1998). Some postdoctoral researchers are poorly matched with mentors and some feel exploited, while others may be well-matched and respected but feel trapped by being unable to secure independent positions.

Federal agencies have discussed what to do about the situation for years, and have made adjustments in grant funding and stipends. But the number of postdoctoral scientists has continued to increase while the opportunities for independence remain limited. Clearly, many of the obstacles to launching independent careers do not merely relate to the amount or type of money available; rather, cultural and social factors are just as important to the quality of the training experience. In his opening remarks to the committee at its June 2004 workshop, Elias A. Zerhouni, director of the National Institutes of Health (NIH), noted "lack of money and lack of lab space are manageable; the thing that is not manageable is a culture where young investigators are discouraged from either entering the field or once in the field, get discouraged about taking risks and bringing science in the new directions it needs to go. The worst thing that can happen is the risk averseness that you see in many postdocs today. It's not a good idea to have a scientific talent pool that's afraid of risk."

Given the amount of concern that has persisted for so many years about the postdoctoral experience, it is notable that not all institutions have agreed even on a single definition of a postdoctoral researcher.[1] The committee endorses the definition[2] adopted by the Committee on Science, Engineering, and Public Policy (COSEPUP, 2000), also found in Box 4-1, and wishes to stress and expand on several of its elements because they provide points of leverage for improving the postdoctoral experience.

First, the postdoctoral appointment is temporary. Several reports, including COSEPUP (2000), have recommended restricting the total duration of postdoctoral training to 5 years so as to not suspend postdoctoral scientists in indefinite periods of dependency. Second, the apprenticeship model emphasizes the requirement for quality mentorship by more senior investigators. In particular, the mentorship must evolve over the period of postdoctoral tenure from initially greater oversight to increasingly greater independence of the postdoctoral researchers (i.e., affording the postdoc with additional responsibility and freedom). Third, this period of training incorporates the development of skills beyond technical laboratory competencies to include training in areas such as laboratory management, business and budgeting, communication, and overall management. These activities are not separate from full-time research and scholarship, but rather integral to the experience.

In this chapter, the committee makes recommendations to improve the likelihood that postdoctoral researchers will have the opportunity to launch an independent career. It also provides an urgent recommenda-

[1]In fact, some institutions can have as many as 15 or more different titles for postdocs (COSEPUP, 2000), including postdoctoral scholar, research associate, laboratory instructor, contract employee, research fellow, or visiting scholar (Klotz, 2000). Institutions may classify postdocs as employees, trainees, associates, faculty, students, or staff.

[2]This definition closely mirrors those of others, including the Association of American Universities (http://www.aau.edu/reports/PostDocRpt.html), Association of American Medical Colleges GREAT Group (http://www.aamc.org/members/great/postdoc_definition.htm), and the Federation of American Societies for Experimental Biology (FASEB) (http://www.faseb.org/opa/post_doc_def.html).

**BOX 4-1**
**Defining the Postdoctoral Position**

Postdocs have sometimes been called the "invisible university." With the rapid growth and importance of the postdoctoral population, some institutions are attempting formal definitions using some or all of these criteria:[a]

- The appointee has received a PhD or doctorate equivalent.[b]
- The appointment is viewed as an apprenticeship—a training or transitional period preparatory to a long-term academic, industrial, governmental, or other full-time research career.
- The appointment involves full-time research or scholarship.[c]
- The appointment is temporary.
- The appointee is expected to publish (and receive credit for) the results of research or other activities performed during the period of the appointment.

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[a]This definition draws on criteria suggested by the American Association of Universities (AAU, Committee on Postdoctoral Education, *Report and Recommendations*, Washington, DC, March 31, 1998) and by Vanderbilt University School of Medicine (presented by Roger Chalkley at COSEPUP's December 1999 workshop on the postdoctoral experience).

[b]e.g., the MD, DDS, DVM, or other professional degrees in science and engineering.

[c]However, in some disciplines, such as mathematics, the postdoctoral experience commonly includes a major teaching element. Also, some postdoctoral experiences, such as the National Academies' and AAAS Fellowships, introduce the postdoc to the field of public policy.

Reproduced from: COSEPUP, 2000.

tion that NIH improve its data collection and evaluation activities about this most critical human resource.

## LENGTH OF THE POSTDOCTORAL APPOINTMENT

The postdoctoral period should be a temporary apprenticeship and not extend beyond the time needed for training. However, because postdoctoral researchers have more experience and often generate more novel ideas than graduate students or technicians, the "cost" (financial and time investment) to the PI is lower than hiring non-postdoctoral personnel. This makes postdocs attractive laboratory personnel, resulting in appointment terms sometimes lasting 6 to 10 years. In too many instances, "postdoctoral training"—when a young scientist is learning new approaches and techniques towards independence—has turned into "postdoctoral employment"—with the postdoc remaining at the same professional rank with little advancement or additional training (NRC 1998). In addition to the negative consequences of this trend for postdoctoral researchers themselves (e.g., increasing the age of independence), this cycle is ultimately problematic for the scientific community as a whole. It can result in disillusioned postdoctoral scholars working side-by-side with and providing discouraging advice to graduate and undergraduate students contemplating a career in science (Russo, 2003).

Between 1980 and 1998, the number of postdoctoral researchers at academic institutions doubled (COSEPUP, 2000, with data from Survey of Graduate Students and Postdoctorates in Science and Engineering). Almost 75 percent of this increase was in the life sciences, likely a result of the interplay between a growing NIH budget and advances in biology. Concurrent with this growth, the average tenure for a postdoctoral appointment increased. In the early 1970s, 61 percent of the total biomedical doctorates spent 2–4 years as postdoctoral researchers; this increased to 76 percent by the late 1980s (COSEPUP, 2000, with data from Survey of Doctorate Recipients). Only 21 percent of doctorates spent more than 4 years as postdoctoral scientists in the early 1970s compared with 40 percent in the late 1980s. In the biological sciences, the median time spent by scientists with U.S.-earned PhDs in a postdoctoral appointment is more than four years,[3] as compared to a median overall time of 2.5 years for other disciplines (COSEPUP, 2000).

NIH and many academic institutions and scientific organizations have recognized the need to set a limit on the length of postdoctoral appointments, with 5 years as the generally recommended limit. In fact, a 2001 NIH report stated:

> The NIH supports the concept that federal funding from any combination of NRSA [National Research Service Award] and/or research grants should not exceed . . . five years for postdoctoral training. Universities should consider conversion of all individuals in postdoctoral training to staff or faculty appointments at the earliest possible opportunity. Certainly, by five years of postdoctoral training experience, training should be completed and individuals who are being retained at the institution should be converted to non-training positions that provide appropriate levels of income and a benefit package that includes such items as retirement, leave, and health insurance. The increased costs associated with such positions have been and will continue to be allowable under NIH research grants. Principal Investigators are encouraged to build such costs into the budget request for future competing grants (NIH, 2001).

[3]It should be noted that the range of PhD tenure is quite broad.

But enforcement of term limits varies highly. NIH only requires adherence to the recommended limits for those supported on NRSAs and does not even mention the limit for R01-supported postdocs. Although NIH agrees with the limit and encourages actions by institutions, it has done nothing to enforce this desire, despite announcing a plan to do so:

> The NIH supports the concept that universities should encourage the earliest possible completion of graduate and postdoctoral education and training. To foster this objective, the NIH proposes to limit the use of federal dollars from any source for the support of graduate training that exceeds six years and postdoctoral training that exceeds five years. (NIH, 2001)

The majority of institutions do not have a policy to limit postdoctoral tenure. According to an informal survey conducted by the National Postdoctoral Association in 2004, only about one-third of institutions have a term limit for postdoctoral appointments; those that do are generally consistent with the 5-year recommendation. A survey of the members of the Graduate Research, Education, and Training (GREAT) Group of the Association of American Medical Colleges (AAMC) showed that about half of respondents have a term limit on postdoctoral appointments; however, the response rate was quite low and likely biased toward institutions with well-developed postdoctoral programs more likely to have such policies in place. Moreover, even when such time limits do exist, they may regularly be ignored or waived at many institutions (AAU, 1998). This means that PIs generally decide on the term limit—if any—for their own postdoctoral researchers.

The only mention of term limits for postdoctoral appointments in NIH guidelines is in the fine print following a table that shows discrete levels for 8 years of postdoctoral support in salary guidelines for the Ruth L. Kirschstein National Research Service Awards (NRSAs).[4] Although the note clarifies that "the presence of eight discrete levels of experience should not be construed as an endorsement of extended periods of postdoctoral research training," the listing of 8 levels provides a different impression. And, despite an implied desire to limit the length of federal support for postdoctoral training to 5 years (NIH, 2001), there is no policy for postdoctoral scientists supported on research grants—which are the majority of NIH-supported postdocs—and the issue is not even mentioned in the R01 guidelines.

[4]http://grants2.nih.gov/grants/guide/notice-files/NOT-OD-05-032.html

The 5-year limit needs to be enforced as a maximum for *all* NIH-supported positions.

**4.1 NIH should enforce a 5-year limit on the use of any funding mechanism—including research grants—to support postdoctoral researchers. The nature of the position, including responsibilities and benefits, should change for those researchers who transition to staff scientist positions after 5 years.**

NIH should require and enforce that a person can only be classified as a "postdoctoral researcher"—regardless of what the position is officially called at an institution—for no longer than 5 years total (whether at one or multiple institutions), regardless of the type of award. That is, the time limit should apply equally to postdoctoral researchers supported with individual NRSAs, training grants, or R01s. In circumstances where a postdoc requires an extra year beyond the 5 years to complete an already-started job search, a professional development plan should be submitted to NIH indicating the need for a single extra year to achieve career success and independence. This recommendation has been made by others including COSEPUP (2000), FASEB (2001), and endorsed by the NIH (2001) itself; the committee stresses the importance of applying it equally to *all* postdoctoral researchers, regardless of funding source.

Five years is meant to be the *maximum* duration of a postdoctoral position, with the *expected* duration much shorter. A postdoctoral tenure should last only as long as needed to prepare the investigator for the next career stage. The committee hopes that the normal length of postdoctoral training is closer to 3 years, whether in one or multiple environments. This is consistent with an overall training period—including graduate and postdoctoral tenure—of no more than 10 years.

In some cases, a postdoctoral researcher might choose to remain in the same laboratory beyond the 5-year postdoc appointment. This choice should entail a change in career direction and a new title, and must be accompanied by compensation and benefits appropriate to a full-time employee of the institution. Researchers opting to make such a switch would then be *in* a career and no longer *training* for a career. Moreover, the staff scientist would become an employee of the institution—not a trainee—subject to the same pay scales and benefits packages as other institutional staff. External support from NIH or elsewhere could, of course, be used to support such positions (see also Chapter 6 for recommendation on maintaining the independence of non-tenure-track researchers). While universities take on the responsibilities of an employer, external sponsors could take on the costs of research.

The new position is not merely a continuation of the postdoc with a new name, but a new career path. This type of staff scientist appointment must be a respected career option essential to carrying out the scientific goals of the nation and of the institution. (These positions and the necessary support are described in more detail in Chapter 6.)

Enforcement of this policy will obviously require enhanced data collection by NIH and reporting of supported personnel by PIs. Many postdocs are paid from a variety of sources over a postdoctoral tenure, including NIH, institutional, and other public and private funds. While the possibility of multiple funding sources introduces an additional administrative burden, the burden should not interfere with the career progression of postdoctoral researchers. The data collection and reporting mechanisms discussed later in the chapter can help provide the kind of information that will help enforce these term limits.

## REALLOCATE NIH RESOURCES FOR POSTDOCTORAL SUPPORT

The use of the R01 as the predominant mechanism to support postdoctoral researchers is problematic; an estimated 80 percent of postdoctoral researchers are paid from a PI's research grant (Singer, 2004). These postdocs may thereby be required to spend 100 percent of their time on the research plan described in the PI's R01, stifling the ability of postdocs to pursue independent research. Postdoctoral researchers would benefit more if they received their own support through individual awards or training grants. At the same time, innovation and discovery in American biomedical science would be stimulated by postdoctoral scholars having more of a role in designing, conducting, and evaluating their own research projects, while still under the mentorship of more senior investigators (see Recommendation 4.4 for a more complete discussion of such mentoring relationships).

The NIH's Ruth L. Kirschstein National Research Service Awards (NRSA) provide support for both predoctoral and postdoctoral trainees via individual fellowships and institutional training grants. Although the NRSA award type includes both pre- and postdoctoral researchers, there are obvious differences between the specific programs geared to each population. This report focuses on biomedical researchers beginning with the postdoctoral period and on the success of those individuals in establishing an independent research career. As such, the committee addresses only the individual postdoctoral NRSAs (F32) and the NRSA postdoctoral training grants (T32) in the context of an individual's career development.

The NRSA Individual Postdoctoral Fellowship (F32) provides the standard of excellence because study sections review applicants for their accomplishments and scientific promise. Applicants must put a great deal of thought into a proposal, the preparation of which is in itself an educational process that will serve the applicants well both for their immediate projects and for their future careers. Under the guidance of a sponsor or mentor (see below for a discussion of the role for such a mentor), the F32 is designed to help a postdoctoral scholar receive the combined didactic and supervised research experiences needed to become well trained in any field within the biomedical, behavioral, and population sciences. After NRSA support, NIH expects the recipients to continue to contribute to science.

NRSA awards—and career development K awards—provide postdoctoral fellows with independence not afforded under R01 awards. The related NRSA postdoctoral institutional training grants (T32) also provide the postdoctoral trainee with a degree of financial independence from their PI; thus, they have more freedom to pursue research outside of the already-funded research in the host laboratory. In addition, because programs or institutions are awarded training grants—instead of only individual PIs—they share responsibility for providing appropriate research training and career development.

**4.2 Postdoctoral researchers should be more independent and less dependent on the research grants of PIs. NIH should reallocate some of the resources for postdoctoral support away from the R01 and toward individual awards and training grants.**

This realignment in mechanisms of support for postdoctoral researchers would increase accountability and oversight for mentorship and training responsibilities, while facilitating collaborative research. The proposed increase in the number of awards made to individual postdoctoral researchers would encourage postdocs to take ownership of the conceptualization, design, and scientific direction for their research. Such a refocus of support for postdoctoral researchers is not a new idea. In fact, as Figure 4-1 shows, close to a 1:1 balance between biomedical postdocs supported on research grants and those supported on individual fellowships and traineeships was the norm 30 years ago. Related shifts in the funding of graduate student trainees have been recommended previously by several NRC committees (e.g., NRC, 1998, 2000). The objective is not to restrict the R01, but to shift some support for postdoctoral researchers toward awards that provide the postdocs with independence or focus explicitly on training. Moreover, it helps to provide a separation between the scientific relationship between postdoc and PI and employment.

Although the committee was in agreement with such shifts in funding for postdoctoral scholars, others have come to a different conclusion (e.g., NRC, 2005).[5] Some have been concerned about the effect on univer-

[5]Recommendation 4.8 calls for an independent evaluation of postdoctoral programs that will help provide much-needed evidence for the relative effectiveness of various programs.

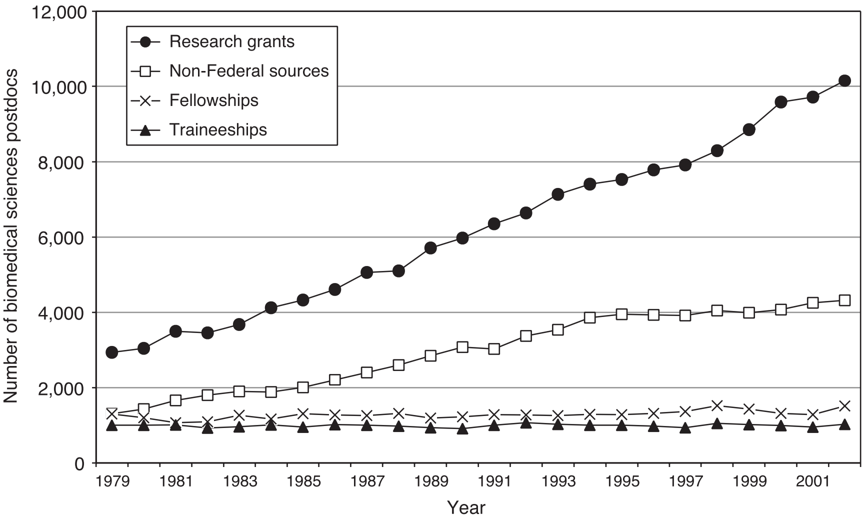


**FIGURE 4-1** Sources of support for biomedical sciences postdoctoral scholars at academic institutions. While fellowship and trainee support has remained relatively constant over the last 20 years, there has been a dramatic increase in postdocs supported on research grants or private sources. Source: Survey of Graduate Students and Postdoctorates in Science and Engineering via WebCASPAR, NSF. NOTE: Fields included are Anatomy; Biochemistry; Biology; Biomedical Engineering; Biophysics; Cell and Molecular Biology; Genetics, Microbiology, Immunology, and Virology; Nutrition; Pathology; Pharmacology; Physiology; Zoology; and Other Biosciences.

sity budgets with significant differences in indirect cost recovery between research and training awards (though there is no reason that such rates could not be altered). Others have been concerned about a possible mismatch between research funding of PIs and the workforce needed to conduct that research. But the viewpoint of this committee is that postdocs are not simply workers, but scholars with their own ability to contribute that must be nurtured. This committee's focus on the quality of biomedical research training to foster independence causes it to conclude that funding of postdocs through individual awards and training grants is preferable to funding on PI research awards. Furthermore, if eligibility for postdoctoral training support is expanded to include non-U.S. citizens, as recommended below, then the size of the applicant pool could double.

One challenge will be to ensure that postdocs supported by such individual or training awards really do have some degree or independence and autonomy (see also Chapter 6). Another will be to ensure that postdocs find willing mentors and laboratory space for projects that may not as closely relate to the existing interests within the host laboratory. And it will be important that postdocs supported in this way are distributed in different laboratories with PIs in various career stages, instead of concentrating in the large laboratories of a small number of prominent researchers.

The committee recognizes that significant shifts of funding from research to training would require Congressional action, as research and training budgets are separately enumerated in NIH allocations. For this reason, the committee has not set a target distribution nor suggested the amount of research resources reallocated to individual awards and training grants in support of postdoctoral researchers. However, NIH is encouraged to take steps to rebalance the distribution of support for postdoctoral researchers and to take this recommendation into account when submitting its budget requests.

One difficulty of an increased reliance on NIH training awards is their restriction to U.S. citizens and permanent residents (Box 4-2). Yet the number of postdoctoral biomedical scientists in the United States on temporary visas has increased dramatically in the last 20 years so that today, more than half the biomedical postdoctoral researchers in this country hold non-U.S. citizenship (Figure 4-2). Many researchers on temporary visas stay to contribute to U.S. research for years to come and many subsequently become U.S. citizens.

There are no reliable data on stay rates for non-U.S. citizens who conduct postdoctoral research here, largely because of the lack of data on those with PhDs earned outside the United States (see Chapter 2). However, Finn (2003) has used income and Social Security tax records to estimate the stay rates of those who received U.S. doctorates. For example, of those foreign-born individuals who received their life science PhDs at U.S. institutions on temporary visas in 1999, 74 percent were still here 2 years later (Finn, 2003). Moreover, of those who earned life science PhDs in 1996, 62 percent were still in the United States 5 years later, suggesting that many of these individuals stay for more than just a few years of postdoctoral work (Finn, 2003). While this analysis does not consider the growing number of those with PhDs earned outside the United States who perform postdoctoral work, it does provide some indication that even researchers on temporary visas are likely to stay for years. It is difficult to consider the U.S. biomedical research enterprise without acknowledging the critical role played by scientists from outside the U.S. In fact, these scientists are disproportionately represented among those making exceptional contributions to U.S. science, including membership in the National Academy of Sciences and authoring highly-cited papers (Levin and Stephan, 1999; Stephan and Levin, 2001). Since these scientists make sig-

**BOX 4-2**
**Citizen Eligibility Requirements for Ruth L. Kirschstein National Research Service Awards for Individual Postdoctoral Fellows (F32)**

"Citizenship. By the time of award, candidates for the postdoctoral fellowship award must be citizens or non-citizen nationals of the United States, or must have been lawfully admitted to the United States for Permanent Residence (i.e., possess a currently valid Alien Registration Receipt Card I-551, or other legal verification of such status). Non-citizen nationals are generally persons born in outlying possessions of the United States (i.e., American Samoa and Swains Island). Individuals on temporary or student visas are not eligible. Individuals may apply for the F32 in advance of admission to the United States as a Permanent Resident recognizing that no award will be made until legal verification of Permanent Resident status is provided."

Source: http://grants1.nih.gov/grants/guide/pa-files/PA-03-067.html

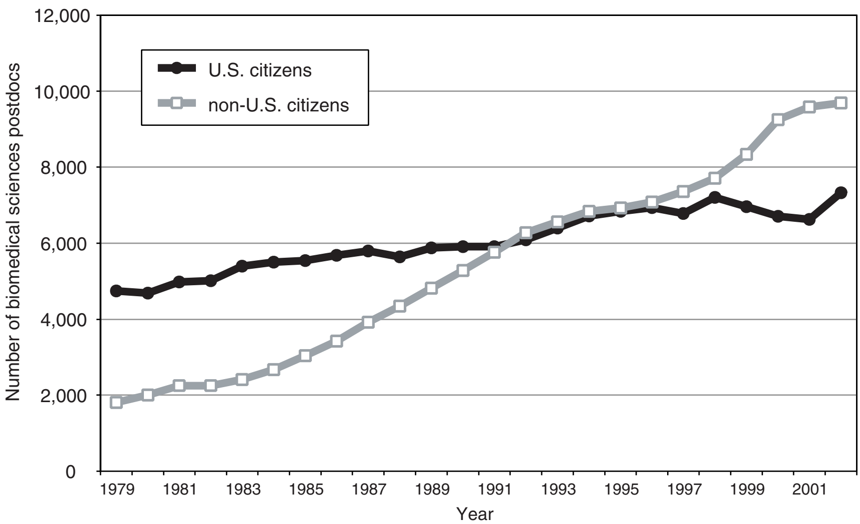


**FIGURE 4-2** Citizenship of biomedical sciences postdoctoral scholars at academic institutions. Non-U.S. citizens now make up the majority of biomedical sciences postdoctoral scholars at academic institutions. Source: Survey of Graduate Students and Postdoctorates in Science and Engineering via WebCASPAR, NSF.

nificant contributions to the U.S. biomedical research enterprise, they must have equivalent opportunities for independent postdoctoral training, including those preferred in Recommendation 4.2. In addition, as biomedical research opportunities increase outside of the U.S., competition for the more promising researchers worldwide will become even more intense.[6]

**4.3 In order to provide equal opportunities for non-U.S. citizens, the citizenship requirement for NRSAs and related postdoctoral training awards should either be modified, or alternative and equivalent mechanisms of support should be available for those who are not U.S. citizens or permanent residents.**

Making NRSAs and other postdoctoral training awards available to those who hold temporary visas would greatly increase the competition for such awards since it could potentially double the pool of eligible applicants. The committee does not take this issue lightly, since there is already too much competition for the small number of training awards. But the best interest of biomedical research and biomedical researchers calls for effective training opportunities for all conducting such research in the United States. Moreover, these effects would be mitigated in concert with recommendation 4.2 that calls for increased support for individual fellowships and training grants overall. Making federal support available to those who are not U.S. citizens or permanent residents can be controversial (e.g., Mervis, 2004b). It is important to recognize, however, that those who would receive such training awards are likely *already* supported on research grants and are, in fact, critical to the advances in U.S. biomedical research.

This is not a new idea and consistent with earlier recommendations. In fact, in response to an NRC (2000) recommendation that international postdoctoral trainees receive a similar level of support and training environment as U.S. citizens, the NIH has already committed to it:

> The NIH supports the continued funding of research training opportunities for graduate students and postdoctorates from foreign countries. The NIH endorses the recommendation that the training environment and the level of support for international students and postdoctoral trainees should be identical to that offered to domestic students and postdoctoral trainees. (NIH, 2001)

[6] The National Academies Committee on Science, Engineering, and Public Policy will release a 2005 report on the policy implications of international graduate students and postdoctoral scholars in the U.S. that will consider the desire to recruit the best talent from both domestic and international sources and concerns that the presence of international students may discourage domestic talent from entering science and engineering careers.

The NIH has launched its first training program that will support non-U.S. citizens in addition to U.S. citizens and permanent residents by combining training and research funds. The Training for a New Interdisciplinary Research Workforce (T90) program allows U.S. citizens and permanent residents to be supported with NRSA training funds and non-U.S. citizens to be paid out of the research budget in the same program (Mervis, 2004b). The committee is encouraged by this program and hopes that it will be expanded to include all training grant and individual NRSA postdoctoral awards. Moreover, the committee hopes that the evaluation of this program will help convince skeptics of the value of such openness and lead to greater flexibility in the use of training funds for non-U.S. citizens.

## INDEPENDENT FUNDING

In order to further promote increasing independence for postdoctoral researchers, the NIH should create targeted mechanisms that allow them to receive individual research grants. They would conduct this research in the laboratory of an identified mentor.

> **4.4 A new research award is needed at NIH to provide postdoctoral researchers with the opportunity to conduct an independent project under the mentorship of a senior investigator. This postdoctoral independent research award would complement but not replace the existing NRSA.**

The NRSA mechanism has been extremely beneficial and should be increased, as discussed in recommendation 4.2. These awards proposed here would not replace NRSAs, but provide an additional mechanism to allow for the most outstanding postdocs to achieve a greater degree of independence for specific research projects.

The new award would constitute a research grant to the postdoctoral researcher for a particular project conducted with an identified mentor. The project proposed by the postdoctoral applicant should be clearly and verifiably different from the ongoing research of the mentor. While the project would obviously be related to the general interests in the laboratory, it should be outside of the main thrust of the lab's focus. Moreover, the proposed project would be under the direction of the postdoctoral independent researcher. These 4-year awards would be portable to enable recipients to continue the research even if the present postdoctoral position ended. As such, the recipient could identify a new mentor or retain the balance of the award without an identified mentor in an independent position. The award would provide sufficient resources for the institution to provide benefits—as well as salary—for the postdoctoral scholar. Funds would be included in the new award for supplies, travel funds and all other monies necessary to successfully carry out the research project.

Research mentors at the host institution would provide the space and equipment needed for the proposed research. Mentors could also receive a small portion of the budget in recognition of their responsibility for mentoring the supported postdoc and the time that they are expected to devote to mentoring. The mentor would provide guidance to the postdoc on all aspects of the project, including by offering advice on the grant proposal, helping formulate research questions, appropriate experimental approaches, feedback on publications, etc. This mentorship would be in the form of guidance and advice and not as PI directing an employee. In return, the host laboratory would get exposure to new techniques and expertise, and expand its research focus into a new area. Peer review of such awards should take into account whether the named mentor is well-positioned to provide appropriate mentoring, and might include consideration of the number of other postdocs and graduate students mentored in the laboratory. Finally, as a research award, indirect costs could be recovered by the host institution in compensation for the space and other institutional needs of the supported research.

The proposed awards would encourage independence for postdoctoral researchers by offering them control in determining the subject and course of their research interests. Because they could take extensions of the project with them, the odds of achieving successful independence are enhanced.

The committee believes that 20 to 50 4-year awards each year would provide a large enough cohort to measure success should it occur. Since most of the applicants would otherwise be funded through R01s given to their research PI, additional funds would not necessarily be required. Recipients—and an appropriate control group of non-recipients—should be monitored for at least 5–10 years past receipt of the award to assess the success of this program in leading to independence.

## CLARIFYING THE MENTORSHIP RESPONSIBILITIES OF PIs

The R01 is currently by far the predominant mechanism by which biomedical postdoctoral researchers receive support (see Figure 4-1). This use of the R01 has resulted in the dependence of PIs on trainees to produce work for their publications and grant renewals as well as the dependence of trainees on their PIs for support. Even though all postdoctoral researchers would benefit from enhanced training from their mentors, this training is not considered in review of R01 proposals; as such, training only tends to occur at the discretion of the PI. The R01 application and review process should be modified to correct these deficiencies.

**4.5 NIH should modify the application for R01s so that requests for postdoctoral research positions include a description of how the postdoc will be prepared for an independent career (training) and a description of the elements of the proposed project in which the postdoctoral researcher will be involved. PIs should provide basic information for all current postdocs and those supported within the last 10 years to include name, time in the laboratory, and their current title and institution.**

PIs should be encouraged to implement a plan to assist the postdoc in achieving independence. Thus, the R01 submission should include an individual mentoring statement for each postdoctoral research position requested (similar to that used now for the F32 individual NRSA award). In cases where specific postdoctoral researchers have not been identified at the time of application, the mentoring statement should discuss a general training and mentoring plan for any supported postdoc. Adding these requirements to any R01 proposal that requests support for postdocs would reinforce to faculty the responsibility they have toward the postdoctoral researchers whom they supervise, not as employers, but as educators and mentors. It would also emphasize the critical interconnection between research and training and that, in fact, effective training enhances research.[7] This would constitute a new component in the review of new R01 applications, and it would be an especially crucial component for the review of competitive renewals. However, it is critical not to disadvantage new PIs who do not have a history of training postdoctoral researchers.

While some could see this as one more administrative burden for PIs and administrators, it only makes explicit what should always have been implicit: that is, all trainees should benefit from mentoring to allow them to achieve the goals of their training. Therefore, no additional funding should be requested for fulfilling these mentoring responsibilities. Just *asking* for up-to-date information about present and past postdoctoral researchers might help PIs recognize the realities of the current environment for biomedical careers. Moreover, NIH and peer reviewers should

[7]Since the release of this report in prepublication form, Sigma Xi has released the results of its Postdoc Survey (http://postdoc.sigmaxi.org/). Among other findings, postdocs who developed research and career development plans with their PIs were not only more satisfied with their postdoc experience and had fewer conflicts with their advisor, but also authored a greater number of peer-reviewed publications per year. More detail on the survey is provided later in this chapter.

endeavor to determine the extent to which PIs have appropriately trained previously-supported trainees.

The information to be requested for postdoctoral researchers is very similar to that already requested when applying for predoctoral institutional training grants, so the mechanisms for reporting and collecting such information should be familiar to many institutions. What would have to be clarified by NIH is exactly how reviewers should assess this additional component of the R01. What measures could help follow up on whether a successful training experience actually resulted (see discussion below about data collection)? These issues are already addressed in the review of predoctoral training grant applications, which could serve as a model for consideration of training components of R01s.

It should be noted that the external reviews of *intramural* NIH investigators currently include conversations with a PI's postdoctoral researchers. These outside boards have the ability to at least recommend that PIs with poor mentoring records not take on additional postdocs. Thus, consideration of mentoring for NIH-supported scientists is already part of investigator review for intramural researchers. A suggestion to make mentoring a formal requirement for receipt of all NIH awards was made by participants in the October 23-24, 2003, NIH meeting on "Post Docs: Training and Opportunities in the 21st Century." The National Science Foundation (NSF) has been encouraged to place a similar priority on mentoring through its "second criterion" on the "broader impacts" of proposed research, using it to emphasize mentoring and the success of previous postdocs in the review of applications that request support for postdoctoral researchers (NSF, 2003).[8]

## BROADEN EDUCATIONAL OPPORTUNITIES

All parts of academia need to accept responsibility for developing training programs explicitly designed for postdoctoral scholars (COSEPUP, 2000; NSF, 2003). Many of the skills required of PIs and faculty members are not well taught—or possibly never mentioned—to postdoctoral researchers. Instead, PIs and postdocs spend almost all of their time on research without acknowledging the kinds of complex issues that faculty members and PIs confront. Courses and workshops specifically designed to address these issues can provide the necessary exposure and allow institutions and individual faculty to meet their responsibilities in this realm. Offsite courses and workshops also serve an

[8]These issues have been reinforced as recently as November 2004 at an NSF-sponsored workshop (NSF, 2004).

important function, by providing postdocs with the opportunity to discuss these important issues freely. Finally, programs should recognize that different individuals have different interests and career objectives. Thus, institutions and programs should provide a variety of opportunities offering training and experience in different skill sets. In fact, the committee encourages institutions to collect and make available information about the career outcomes of recent postdoctoral scholars (see NRC [2003] for a discussion of career outcomes related to doctoral education).

**4.6 Postdoctoral researchers should receive improved career advising, mentoring, and skills training. Universities, academic departments, and research institutions should broaden educational and training opportunities for postdoctoral researchers to include, for example, training in laboratory and project management, grant-writing, and mentoring. NIH should take steps to foster these changes, including by making funds available to facilitate these endeavors.**

Funding should be made available for institutions or groups of institutions to develop career guidance and professional development courses (e.g., mentoring, grant writing, laboratory management, budgeting, publishing and authorship, conducting collaborative science, and project management). These activities could include workshops by experts from outside of the institution. The committee recognizes that in these times of fiscal constraint, new funds might not be readily available, but it urges NIH to release funds from other programs to support this critical aspect of the NIH mission, either as stand-alone programs or as supplements to existing awards like training grants. The resource needs will be modest and have the potential to impact a large number of postdoctoral researchers from each program. Institutions or consortia of institutions should define their vision of how their proposal will assist with independence and training, including an evaluation component.

NIH should consider launching such a program on a pilot basis and comparing success of postdocs at awardee institutions with those at institutions without such programs. The advisory council of the National Institute of Biomedical Imaging and Bioengineering (NIBIB) and NIBIB leadership have identified poor grant-writing skills as a difficulty for new investigators and have suggested that individual institutions or even NIH itself offer workshops for new investigators or training grants to teach grant-writing (Laas, 2005). There are also many model programs that could be emulated, including at universities (see Box 4-3 for an example) and even within NIH itself (such as that described in Box 4-4).

**BOX 4-3**
**Career Development Programs for Postdoctoral Scholars at the University of North Carolina at Chapel Hill[a]**

The mission of the University of North Carolina's (UNC) Office of Postdoctoral Services (OPS) is to enhance, support, and promote postdoctoral scholars while they are at UNC, and to prepare them for successful careers after they leave UNC. The office is jointly funded by the provost, vice chancellor, and School of Medicine and serves postdocs in all disciplines. The director has formal training and 10 years of experience as a career counselor. A research-focused faculty advisor consults on program planning, advises postdocs, conducts individual grant reviews with postdocs, and—critical to success—creates buy-in among UNC faculty.

The OPS director has taken a developmental approach to facilitating postdoctoral growth by creating a stage model, which works with discrete postdoc entry and exit points. A postdoctoral scholar typically moves through the following four stages: (1) adjustment (year 1); (2) skill enhancement (years 2 and 3); (3) search for positions (years 4 and 5); (4) and transition to independence (by year 5). These stages are fluid, and the amount of time actually spent in each stage depends on the individual's specific skills, discipline, work environment, and mentor.

It is important for postdoctoral scholars to establish healthy patterns and behaviors, in order to achieve long-term success. Accordingly, during the first stage, postdocs can attend workshops in time management, personal finance, and communication, to name a few. The workshops are offered in different formats (i.e., daylong, semester-long, and symposia) to ensure all are able to access them. In addition, the office provides individual counseling and advising.

During the second stage, postdocs attend workshops such as "Bring Your Science to the Classroom" and "Bench Mentoring Skills for Scientists" as well as symposia on grant-writing and management skills. They also participate in individual grant reviews.

To assist postdocs in finding positions during stage 3, the office has developed workshops on writing curriculum vitae, interviewing, and negotiating job offers. A career symposium allows current UNC postdocs to hear the experiences of former UNC postdocs. The majority of UNC's postdocs move into research-intensive careers, but the office works hard at meeting the needs of those destined for non-bench careers as well.

The university also offers services for faculty—in particular, a mentoring workshop—in response to a growing awareness of the impact faculty have on the work life and satisfaction of postdocs.

The model appears to be successful in that UNC has seen job success in its postdoctoral population and positive outcomes in terms of skill development through its program evaluations.

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[a]http://postdocs.unc.edu/

**BOX 4-4**
**Office of Fellows' Career Development at NIEHS[a]**

The NIH's National Institute of Environmental Health Sciences (NIEHS)—located in Research Triangle Park, NC—has had to establish its own career development activities because it is located too far from the main NIH campus in Bethesda, MD. The grassroots NIEHS Trainees Assembly (NTA) drafted a proposal for an office that would handle the career development needs of NIEHS fellows that could not be met by the NTA; the Office of Fellows' Career Development (OFCD) was established within the NIEHS Director's Office in the spring of 2003.

The OFCD brings career/professional developmental information to fellows in varied forms, including workshops, seminars, and brown-bag discussion lunches. It also acts as a liaison between the NIEHS fellows' community and administration, and cooperates with outside organizations focused on enhancing postdoctoral training. OFCD programs complement those sponsored by the NTA, including the NTA's "flagship" event: the annual Career Fair, which regularly has about 300 attendees from the local area. Some events organized by the OFCD include a Survival Skills workshop series covering issues such as job-hunting and teaching skills, seminars on management and networking skills, and brown-bag lunches featuring former NIEHS fellows discussing careers in biotech and the reality of being a new assistant professor. In partnership with Sigma Xi, the Scientific Research Society headquartered nearby, the OFCD developed and now cosponsors an annual weeklong grant-writing skills workshop.

Besides developing events, OFCD also disseminates information to fellows on employment opportunities, funding resources, career development resources, and non-NIEHS events. In order to determine ongoing needs of NIEHS fellows, the OFCD conducts informal information gathering and short surveys and administered the national Sigma Xi Postdoc Survey for NIEHS. In response to requests by both fellows and PIs, the OFCD is developing a web site, expanded recruitment and orientation materials, and informational materials for PIs, and is helping to recruit new fellows. All of the OFCD activities are coordinated by one part-time administrator, who continues to do part-time research concurrently.

By disseminating career and professional developmental activities to groups of fellows and serving as a central point of contact on the NIEHS campus, the OFCD has freed both PIs and fellows from independent individual searches for professional development information.

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[a]http://www.niehs.nih.gov/ofcd/home.htm

## NEED FOR BETTER DATA AND PROGRAM EVALUATION

Postdoctoral researchers have become a large component of the scientific workforce. Yet very limited data on this contingent hampers the ability of decision makers to analyze the effectiveness of scientific programs and funding mechanisms (Kelly et al., 2004; NRC, 1998, 2000; COSEPUP, 2000; National Postdoctoral Association, 2003; NSF, 2003). The current best source of data on the postdoc population is the longitudinal Survey of Doctorate Recipients (SDR) conducted by the NSF (see Box 2-1 for a description). However, this survey only includes about 8 percent of those who received their PhD from a U.S. institution, and it does not include the many postdoctoral scientists who have received their PhD elsewhere. Almost 45 percent of doctorate holders working in the life sciences are foreign-born (National Science Board 2004, with data from 2000 U.S. Census) and many of those received their PhDs outside the United States; the SDR does not include them. Foreign-educated researchers hold about two-thirds of all postdoctoral positions in academic institutions and an unknown number in other sectors (NRC, 2005).

The SDR also does not include those with MDs from either U.S. or international institutions. Data need to be collected for both U.S.-degree holders and those who obtained their doctoral degrees elsewher. Further, the SDR does not currently include questions specifically targeted to the postdoctoral experience (other than respondents identifying themselves as such).[9]

The Sigma Xi Postdoc Survey[10] will provide valuable information about the postdoc experience at individual campuses nationwide, by allowing institutions to benchmark their postdoctoral training with other institutions. Among the data it will provide are information about mentoring experience, development of professional skills, degree of independence, and ability to apply for independent research support. However, the survey is aimed at providing about 50 participating institutions with data about postdocs locally—as well as benchmarking with other participating institutions. As such, it will not provide a statistical portrait of the postdoctoral community at all institutions nationwide.

Despite the large size of the NIH-supported postdoctoral population, insufficient data are available on this group, with almost no data available on postdoctoral researchers funded through R01s (despite the predominance of this funding mechanism for postdoctoral researchers). Although

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[9]The SDR included a special module on postdocs in its 1995 survey and another is planned for 2006.

[10]http://postdoc.sigmaxi.org/

NIH (2001) has agreed with the need for such enhanced data collection, steps to implement the plan have been slow.

> **4.7 NIH should develop enhanced data collection systems on postdoctoral researchers to include all NIH-supported postdoctoral researchers, regardless of specific funding mechanism. This will allow NIH to track the effectiveness of its programs and thereby make more informed programmatic decisions.**

NIH needs to gather data on postdoctoral researchers supported through R01s and other mechanisms and track these individuals as they progress to their first independent award. Data should be collected annually on all individuals supported by NIH funds, not only as a requirement for initial application. The initial person budgeted may leave during the period of the grant, replaced by a new researcher; both postdocs should therefore be reflected in the annual reports for the time of their tenure in the laboratory.

Such data are likely to inform NIH leadership about the relative successes of various funding mechanisms and programs in fostering independence. Moreover, data should be disaggregated to detect different trends among different demographic and other groups. In gathering these data and conducting analyses, it will be necessary to better characterize the postdoctoral researcher and all of the possible titles associated with the position. Standard terminology should be developed and used by R01 and other applicants to describe each type of employee/trainee.

The committee suggests that the NIH work with other federal agencies and private sector funders that support postdoctoral researchers to enable cross-agency data collection on at least the postdoctoral population, but possibly including other research personnel. This could provide a common set of definitions and measures that would enable cross-agency comparisons. With increasing electronic grant submission and reporting, tracking of all federally funded research personnel across agencies should be simplified.

Maintaining updated personal profiles online could facilitate data collection. Such profiles could be a requirement for receipt of NIH funds and allow NIH to track individuals as they move from graduate student and postdoctoral positions into independent research positions. The information in the profiles would also serve to complement the information provided by PIs on their current and past postdocs as described in Recommendation 4.5.

Once it has collected information on postdocs, NIH could conduct a rigorous independent analysis of its programs.

**4.8 NIH should commission an independent evaluation of the different models of postdoctoral support.**

As data on postdoctoral programs and support become available, NIH should commission an independent review of different postdoctoral funding mechanisms to evaluate the relative merits and successes of each approach. This study could help answer questions related to the effectiveness of various postdoc programs that could address issues of balance between research, training, and individual support, as discussed in relation to Recommendation 4.2 above.

This review could compare postdoctoral researchers funded through, for example, R01s, individual NRSAs, NRSA institutional postdoctoral training grants, and NIH and other career transitions awards. The common set of definitions and measures described above would also allow comparisons to NSF programs, private research fellowship programs, and other mechanisms of support. The goal should be not only to address research achievements, but also to examine the process of postdoctoral training. As such, it should include consideration of mentoring, degree of independence and responsibility, and receipt of awards by PIs and institutions. The review should consider the subsequent positions of supported postdoctoral researchers to help gauge the effectiveness of different postdoc programs for different career objectives and the appropriate number of awards to give.

The next chapter focuses on ways to improve the transition to first independent position.

# 5

# Transition to First Independent Position

The grants system of the National Institutes of Health (NIH), built on the principles of peer review, merit-based funding, and transparency of processes, in many ways represents a paradigm for U.S. government funding, and it has served the nation well. Yet, there is room for improvement. One area in particular involves the experiences of postdoctoral researchers as they look to the future. As described in the previous chapter, postdocs do not always receive the mentoring and training required to successfully pursue a variety of careers. In addition, there are challenges to conducting independent research during postdoctoral tenures.

Over the past 20 years, scientists have been receiving their first NIH grants at increasingly older ages (see Figure 1-2). The average age at which investigators receive their first independent research support is creeping upward. The average age at which biomedical researcher receive their first faculty appointment is also increasing, but there is still a 4–7 year lag from becoming a faculty member to receiving a first R01 (Chapter 2).

The growing number of postdoctoral researchers who report themselves as risk-averse is also disturbing (Mervis, 2004a), as they adhere to restrictive definitions of "success." Many postdocs feel that they need to author one of more papers in high-impact journals in order to have any chance at a desirable position in academia or in receiving grant funding. Both NIH and academic institutions have contributed to the growing expectations that researchers must meet. Even new investigators are held to the standards of previously funded investigators who are required to produce preliminary results that show they can perform a particular set of experiments at a high-quality level. As a consequence, new investigators who have not had time to "establish" themselves in the specific area they wish to explore—despite perhaps brilliant postdoctoral work—are excluded from funding. Also generally excluded are scientists who may introduce new ideas and conduct important research—but do so outside of the tenure track. Talented scientists lost from the research community are a critical loss for the scientific enterprise. This chapter considers the transition from postdoctoral work to independence, whether as a tenure-track principal investigator or as a research faculty member or staff scientist, and makes recommendations for easing that transition.

## CAREER TRANSITION RESEARCH GRANTS

The transition from postdoctoral researcher to independent scientist is perhaps the most difficult step in a research scientist's career (National Postdoctoral Association, 2003). Yet, very few funding opportunities assist in crossing that bridge to independence, provided by either the federal government or private foundations (see Box 5-1 for an example in the private sector). By comparison, the NIH supports tens of thousands of postdoctoral fellows each year. This ratio is in need of adjustment, consistent with the recommendation of a previous NRC committee (NRC, 1998) and the National Postdoctoral Association (2003). The present committee reiterates the call for enhancing the number of "career-transition" grants for senior postdoctoral fellows with a well-defined program to help the most promising researchers make a transition to independent research and independent careers.

> **5.1 NIH should establish a program to promote the conduct of innovative research by scientists transitioning into their first independent positions. These research grants, to replace the collection of K22 awards, would provide sufficient funding and resources for promising scientists to initiate an independent research program and allow for increased risk-taking during the final phase of their mentored postdoctoral training and during the initial phase of their independent research effort. The program should make 200 grants annually of $500,000 each, payable over 5 years.**

Although the current K22 serves a career-transition function, it faces significant challenges that limits its effectiveness (see Chapter 2 for an introduction to the K22 award). Listed below are characteristics of this proposed program that the committee feels would contribute to the success in fostering the independence of new investigators:

**BOX 5-1**
**Success of Career Transition Awards, Burroughs Wellcome Fund**

The Burroughs Wellcome Fund (BWF) offers a career transition award in biomedical sciences,[a] the initial structure of which was developed by the Markey Foundation. The bulk of BWF's funding is directed to this program: to date it has given 195 awards for a $90 million investment in the careers of young scientists. The program is very competitive—of the 175 to 200 applications received per year, it funds only 8 to 10 percent.

The goal of this $500,000, 5-year award is to help postdoctoral fellows obtain faculty positions and achieve research independence. The award provides money for salary and research—up to 2 years of postdoctoral support and the balance as faculty support. An investigator may hold other concurrent awards. Recipients are allowed no-cost extensions of unused money through the tenure review process and beyond.

Individuals at BWF track the progress of the program, examining the faculty position itself, the independence of the scientist, and the institution (Pion and Ionescu-Pioggia, 2003). The tracking data allow BWF to determine if the program makes a difference in the quality of science for those individuals who were funded compared with those who were not. Eighty-four percent of awardees believe the award helped them develop an independent research program, and 69 percent believe the award allowed them to pursue risky or novel research.

Of the incumbent awardees eligible for tenure-track positions, 98 percent currently have them, with many at the top NIH-funded institutions. The mean amount of time from the last doctoral degree to the faculty position is 6 years, and the average age at the first faculty appointment is 35. The awardees receive start-up funding at levels at or above national averages. The average age for receiving an initial R01 is 36. Of 33 awardees in the two early BWF classes (1996 and 1997), 12 are now associate professors, 1 is a full professor, and 10 are assistant professors. Approximately 60 percent of career awardees receive their degrees from institutions ranked in the top 25 institutions based on NIH funding. On average, awardees are 33 years old (slightly older for MDs) and have completed 41 months (slightly less for MDs) of postdoctoral work at the time of award.

In addition to formal studies of recipients (Pion and Ionescu-Pioggia, 2003), BWF conducts an annual survey and encourages feedback from the awardees. This feedback has helped change the structure of the award over time.

[a]http://www.bwfund.org/programs/biomedical_sciences/

a) Provide postdoctoral training support for a maximum of 2 years for the awardee to develop an independent research program and 3 years of support once a fully independent research position has been obtained. Individuals would apply for these career transition research grants during years 1 through 3 of their postdoctoral appointment and would, of course, adhere to the maximum 5-year tenure in postdoctoral positions (see Recommendation 4.1). Individuals could apply without a sponsoring institution while in a "mentored" research position. Those awardees not receiving an independent research position at the end of the postdoctoral period could reserve the independent support for 1 additional year until an independent research position is obtained.

b) The award would support awardees to continue in a mentored position for approximately 1 year following receipt of the award, although no minimum mentored postdoctoral period is required. As the purpose of the proposed award is to facilitate *transitions* to independent awards, individuals already accepted into independent positions would be expected to apply for the new investigator R01s described in Chapter 6.

c) The award would support the transition to an independent position that is either tenure-track or considered career-path (e.g., research faculty or staff scientist), serving as the first research grant in these positions.

d) The award would include sufficient resources to provide at least partial salary support (at competitive salary levels) and funds for research and career development activities (e.g., participation in scientific conferences and in career development workshops on laboratory management or similar topics).

e) Flexibility should be incorporated into the award conditions regarding time spent on research in the first independent position to comply with a hiring institution's policies for new faculty or staff (e.g., a minimum of 50 percent time spent in research to allow time for teaching or clinical responsibilities rather than the greater research time commitment now required).

f) The award should have uniform requirements and conditions across all NIH institutes. These grants would replace the current collection of K22 awards, which differ from institute to institute. They should *neither* limit the award to NIH intramural candidates nor require that the postdoctoral training phase be carried out at an NIH intramural laboratory.

g) The award would allow individuals from other disciplines to engage in mentored research in the biomedical sciences before setting off on independent careers. For example, it would be appropriate for those with a background in chemistry, physics, engineering, computer science, mathematics, psychology, or other disciplines to apply for these career transition research grants with the mentored period conducted in a biomedical research group.

h) The receipt of such a grant should not prohibit the investigator from applying for and receiving additional R01s—on an equal basis with everyone else.

i) The funds should be drawn from a separate account to eliminate competition between new and previously funded investigators. As a research award, it should allow for full indirect cost recovery during the independent second phase.

NIH is encouraged to provide staff to guide applicants through the application and award process. The staff should encourage applicants to submit plans for higher-risk research and provide study sections with explicit guidance for these projects during scientific review.

Although some NIH institutes use the current K22 mechanism in ways consistent with the above proposed guidelines, treatment varies greatly.[1] For example, of the 12 institutes that had active K22 awards in 2003, only four did not require that the applicant spend the early years of the award (anywhere from 18 months to 3 years) as an *intramural* postdoctoral researcher. The requirement for intramural postdoctoral training may be unattractive to many senior postdoctoral candidates who need more flexibility in their career path. For some institutes, a tenure-track position itself is required rather than the possibility of an equivalent position, a condition that does not match well with the current statistics on academic employment patterns. One NIH institute restricted eligibility to its own NRSA trainees and fellows (or other NRSA recipients working in relevant areas) and two others allow individuals to apply for only the faculty portion of the award.

Others have suggested this kind of award, including the National Research Council (1998) and National Postdoctoral Association (2003); it draws upon the strengths of existing award programs including the existing NIH K-series awards, the Burroughs Wellcome Fund Career Awards in the Biomedical Sciences (see Box 5-1), the discontinued Markey Scholar Awards, and the National Multiple Sclerosis Society Career Transition Fellowship. Although the spirit of the career transition award is similar to previous recommendations (especially NRC, 1998), the specificity of implementation seeks to address the possible challenges with the K22 programs as currently configured.

[1]Based on a preliminary analysis of the K22 program announcements posted on the NIH training opportunities website.

Anecdotal and limited empirical data, including discussion at the workshop and the BWF outcome study (Pion and Ionescu-Pioggia, 2003), suggest that these career transition programs may assist in the development of an independent research program by:

- providing the ability to develop independent research while still in postdoctoral training;
- facilitating movement into tenure-track or independent research career paths (e.g., prestige of award and funds);
- providing stable resources and protected time to establish a laboratory;
- enhancing the ability to pursue novel directions and more risky research avenues; and
- obtaining preliminary data and testing the feasibility of research study designs and/or plans for future grant applications.

The importance of the proposed new mechanism is its potential to increase the possibility of achieving independence and promoting risk-taking. For example, it might help recipients to obtain a first faculty position—even causing the creation of positions. The additional funds necessary for this program should be modest if NIH reconfigures the current K22 programs in accordance with the above recommendation.

The committee recognizes that this proposal faces numerous challenges. First, even with extramural support from NIH, sufficient resources are still required by the hiring institutions and mentors to enact this program (e.g., laboratory space, equipment). In addition, questions remain as to whether the indirect cost rate typically assigned to career development awards is appropriate here. As these awards support the first years of an independent position, at least those portions of the awards should include recovery of full indirect costs, consistent with R01 and other research awards. Finally, an expansion in NIH career transition awards may persuade private foundations to reduce their contribution in this area.

The committee recommends that NIH award 200 5-year grants annually of $500,000 each. These grants would only be one pathway to independence and would only affect a relatively small number of eligible individuals in postdoctoral positions. But the 200 awardees each year could represent a significant percentage of those entering faculty positions; for instance, Federation of American Societies for Experimental Biology (FASEB) President Paul Kincade suggested that there are about 800 tenure-track jobs filled in the biomedical sciences each year.[2] Thus, the pro-

[2]Remarks at the 173rd meeting of COSEPUP on November 20, 2003, based upon the percentage of new PhDs assuming faculty positions (Survey of Doctorate Recipients).

gram would support about one-quarter of those entering biomedical faculty positions each year. Other chapters in this report address a number of other approaches to career transitions; no single program provides a global solution to the problem. This award amount and tenure is modeled on that of the BWF Career Award.

## PROGRAM ASSESSMENT

Ongoing evaluation and assessment are critical for calibrating the number of awards. Systematic assessment of previous K22 recipients, for example, can identify whether the intended outcomes have occurred. In particular, a sample of K22 awardees, their faculty mentors, and institutional administrators should be interviewed to garner feedback that could be used to improve the program. This assessment should also involve some reasonably simple data collection (e.g., tracking of grantees as to the type of independent position) and use of IMPAC II[3] data (how many applied for and received subsequent research project grant funding). Ideally, this effort should be carried out in collaboration with other agencies and private foundations that have similar programs in order to obtain comparable data on a core set of outcomes. Additional data collection would be necessary to assess other desired outcomes (e.g., "innovation" or other external research support). It also would be useful to correlate outcomes with the different award conditions (e.g., intramural versus extramural postdoctoral training) to examine the relationship between outcomes and award characteristics.

More rigorous assessment of expected outcomes should be conducted for recipients of the proposed career transition awards, including the use of appropriate comparison groups if possible. Such planning "up front" on data needs and useful types of comparison groups significantly increases the likelihood of obtaining meaningful information on outcomes and on the important variables related to these outcomes.

**5.2 NIH needs to develop enhanced data collection systems on staff scientist and other non-tenure-track researchers to include all NIH-supported researchers, regardless of specific funding mechanism. This will allow NIH to track the effectiveness of its programs and thereby make more informed programmatic decisions.**

[3]Information for Management, Planning, Analysis, and Coordination (IMPAC) II is NIH's internal database with confidential information on grant applications and awards.

It is essential that such data collection be appropriately disaggregated to detect any differences between demographic and other groups.

### Non-Tenure-Track Scientists

It is important to collect data on individuals in *non-tenure* track staff scientist research positions at academic institutions. Because of its experience in research on scientific and engineering personnel and the overall research enterprise, such data collection efforts may be best coordinated by the National Science Foundation (NSF) and funded by NSF, NIH, and other federal agencies that sponsor scientific research. Important questions to answer include:

- Who is in "other academic" category from the Survey of Doctorate Recipients?
- How long do appointments last?
- To what extent are these positions "stepping stones" to faculty and other independent employment positions?
- What are the current models of laboratory space assignment for non-tenure-track individuals?
- Are individuals in these positions *able* to apply for independent NIH grants? To what extent *do* individuals in these positions apply for NIH grants? Of those who apply, what are their success rates?
- How do schools handle start-up costs for research assistant professors/staff scientists?
- To what extent are scientists on "soft money" able or allowed to train graduate students?

In sum, we need a greater understanding of the factors that influence a transition to a successful career, either as a tenured faculty investigator or as a staff scientist involved in large-scale collaborative efforts or independent exploration. This need will become greater if the career transition program recommended in this chapter is implemented.

The next chapter focuses on mechanisms to facilitate the establishment of stable research programs.

# 6

# Establishing Stable Research Programs

Over the past 20 years, scientists have been receiving their first grants from the National Institutes of Health (NIH) at increasingly older ages, as discussed earlier. The proportion of NIH grant recipients under age 35 has fallen dramatically, down to 4 percent in 2001; the average age of award of an investigator's first independent NIH grant is now 42 for PhD recipients and 44 for MD and MD/PhD recipients (see Chapter 2). The general lengthening of graduate and postdoctoral training periods, the scarcity of faculty positions in biomedical research, and NIH's policies and practices all contribute to this trend. New investigators are held to the standards of established scientists and are expected to have already obtained preliminary results that show they can perform a particular set of experiments at a high-quality level. As a consequence, many new investigators—who have not had time to "establish" themselves independently despite perhaps brilliant postdoctoral work—must wait for NIH funding.

The number of traditional tenure-track assistant professorships has remained level or even declined, while the number of PhDs competing for these positions has increased substantially (see Chapter 2). Consequently, the number of research positions outside normal tenure-track faculty appointments has grown. As such, the fastest-growing categories of *post*-postdoctoral appointment academic scientists are non-tenure-track positions, with titles such as staff scientist, research associate, lecturer, and research assistant professor. Scientists in these positions no longer work as trainees under a mentor's supervision, yet many of them have not yet obtained independent financial support.

As each institution submits grant applications on behalf of its researchers, institutional policy plays an important role in deciding who may apply for a grant. Receipt of research funding is an essential credential in the scientific community and is necessary for even continuation of most "soft-money" positions. NIH permits grant applications from scientists without tenure-track positions, but it also requires that their proposals have institutional backing. One indicator of the problematic status of most non-tenure-track scientists is the fact that many universities are reluctant to allow them to apply for their own research funding. Some institutions do not allow certain classes of non-tenure-track researchers to apply for external funding at all, refusing to commit the laboratory space and resources necessary to conduct the proposed research to individuals outside the tenure track.

Non-tenure-track positions that depend solely on "soft money" are not always considered desirable careers, given their almost complete dependency on uncertain federal research dollars and the resultant job insecurity. But this does not necessarily differ from the situation for tenure-track faculty, especially in medical schools. For example, a study by the Association of American Medical Colleges (AAMC) indicated that tenure did not carry any financial guarantee for basic science appointments at 30.8 percent of medical schools in 2002, up from 24.4 percent just three years earlier (Liu and Mallon, 2004).

Clarifying the roles and possibilities available to non-tenure-track academic scientists and finding ways to make the best use of their talents and training presents a challenge to the leadership of the nation's research enterprise. This chapter makes recommendations on creating more stable research opportunities for new investigators, both tenure-track and non-tenure-track.

## R01s FOR NEW INVESTIGATORS

For some time, NIH and the broader biomedical research community have been concerned about the ability of new investigators to obtain research grants, even those researchers who have attained tenure-track positions. The application and interview process for most tenure-track academic positions is so competitive that the successful applicant is not only an "above-average" scientist, but one near the very top of early-career-stage scientists. Given this level of vetting, the best interests of U.S. biomedical science require funding more of these individuals. The special mechanisms instituted by NIH over the past 15 to 20 years did not increase the number of new investigator applicants and these programs were eliminated (see Chapter 2), in part because promotion and tenure committees only value the "R01" designation. Creating opportunities for increased scientific independence therefore requires a variety of arrangements that do not stigmatize a particular type of award and that are palatable not only to the investigator but also to his or her institution.

After NIH abolished the R29 award, it developed a one-page sheet that provides guidelines for reviewing applications from new investigators (see Box 2-3 and related discussion). If these guidelines were followed in a robust and uniform manner, some of the problems faced by new investigators in applying for funds would be ameliorated. But the distribution of study section scores to new investigators (see Figure 2-12) and the experience of reviewers show otherwise.

As explained in Chapter 2, study sections currently review an application in terms of the significance of the project, its approach or methods, the innovation of its concepts, the investigator's qualifications, and the probability of success due to environment. Applications can be deferred (rarely), unscored, or scored. An unscored application is one that is deemed noncompetitive, and a scored application is one that has enough likelihood of funding that it merits further discussion. Having a proposal unscored ("triaged") appears to be a particularly discouraging event, as evidenced by the lower rates of resubmission for unscored proposals than for unfunded—but scored—proposals. This may be especially discouraging for new investigators who do not have a history of grant applications and grant success.

Leaving a new investigator's application unscored deprives him or her of valuable feedback on the proposal and harms morale. Data provided by the National Institute of General Medical Sciences (NIGMS) suggests the importance of allowing new investigators the opportunity to revise and resubmit their applications after complete feedback, including assignment of a priority score (see Box 2-5).

U.S. biomedical science would benefit if beginning PIs were encouraged to follow opportunities distinct from the area of their postdoctoral project, and even important areas not much pursued by anyone. Yet the current reliance on preliminary results further discourages branching out into high-risk, high-reward areas.

**6.1 NIH should establish and implement uniformly across all of its institutes a New Investigator R01 grant. The "preliminary results" section of the application should be replaced by "previous experience" so as to be appropriate for new investigators and to encourage higher-risk proposals or scientists branching out into new areas. This award should include a full budget and have a 5-year term. NIH should track new investigator R01 awardees in a uniform manner including success on future R01 applications.**

This award should have the following characteristics:

a) The grant should be designated an "R01," with the "new investigator" status indicated by a checkbox on the first page of the application.

b) The "Preliminary Results" section should be replaced by "Previous Experience."[1] Previous experience need not necessarily be in the same subfield as the proposed research.

c) The budget should be in the same range as for other R01s, currently $250,000 per year.

d) The term of these grants should be 5 years, allowing investigators the opportunity to establish a laboratory and train personnel without concern about renewing research support immediately. In addition, short duration awards further discourage investigators from pursuing new areas of research (NRC, 1994).

e) The receipt of a New Investigator R01 should not prohibit additional NIH funding, although additional R01 applications would not be eligible for "new investigator" status.

f) As an R01, these grants should be reviewed by regular study sections, which have the appropriate depth of expertise, but evaluated in a contiguous "new investigator session" and introduced with clear instructions from staff. A previous NRC committee (1994) proposed this mechanism for review of R29 awards.

g) All of these applications should be given full review and priority score, with none unscored. Applicants could also benefit from prompt return of reviews to enable them to prepare a resubmission in the next study section round.

h) Funding for this program should be allocated separately from those of previously funded investigators so that new investigators do not compete against those with more experience. This will assure that an appropriate number of new investigators will be funded in each study section.

Considering the modest number of new investigator proposals currently left unscored by a typical study section, the additional workload entailed by the implementation of this recommendation is not onerous. An open issue is eligibility for these awards: Who is considered a "new investigator"? The preferred policy would exclude those with significant

[1]This is consistent with an earlier NRC committee's recommendation for consideration of new investigator proposals without requiring preliminary data from new investigators (NRC, 1994).

*renewable* sources of funding. As such, receipt of career transition awards (e.g., K22, BWF) would not disqualify an applicant, because they are non-renewable. However, being the sole PI on a renewable grant from another source (public or private) would disqualify the applicant. NIH institutes must have the same definition of eligibility.

To allow evaluation of the impact of this program, NIH should track applicants for this New Investigator R01 with respect to their success in future R01 applications and in competitive renewals of their first R01.

## SUPPORT FOR NON-TENURE-TRACK SCIENTISTS

### Independent Grant Support for All Researchers

Very few postdoctoral scholars obtain a tenure-track position in academia, and the number of tenure-track positions has been constant over time. However, many postdocs still remain in the academic sector; the number of postdocs who pursue other academic positions has dramatically increased, from approximately 1,000 in 1985 to nearly 17,000 in 2001 (Garrison et al., 2003). Some of these individuals work as part of a team in big science projects, and it is appropriate to fund them through grants awarded for these projects. Others might work alone as independent investigators. The career track of staff scientists/research track faculty should be legitimized (Marincola and Solomon, 1998a, 1998b; Gerbi, et al. 2001) by offering salaries appropriate to the position and the opportunity to compete for federal grants. Although biomedical research is entering an era of increasingly big science, a broad platform of independent research projects will still yield benefits.

**6.2 NIH should establish a new renewable R01-like grant program for small science projects (e.g., $100,000 direct costs per year), open to researchers who do not have PI status on another significant research grant, including "soft-money" staff and research-track scientists. This program should receive its own set-aside funding from the NIH budget.**

The committee has chosen to spell out details of this new award program to ensure that it meets the desired aim of fostering the independence of new investigators rather than serving as another source of funds for already-funded researchers. Applicants for these grants should provide a statement describing their independence (especially if housed within the laboratory of a mentor). These funds would go to applicants who work as independent investigators but have positions other than the traditional tenure-track faculty appointments. By recommending this grant program, the committee does not intend to encourage the creation of additional "soft-money" positions; rather, the grant recognizes the reality of the growing number of these researchers and provides them with increased opportunities for independence.

Scientists with PI status on another research grant would normally not be allowed to apply. NIH staff could determine whether scientists with a small amount of funding as a result of Co-PI status on another research grant, participation in a training grant, or other small amounts of support remain eligible. Funds from the small grant would allow the staff scientist/research-track faculty member to have a salary commensurate with their training and experience, thereby endorsing the career track they are pursuing as honorable and independent and one that contributes to the research enterprise. While other small grants are available (for example the R03 award), they are normally nonrenewable and often too restricted in funding levels. Moreover, those other awards are available to all researchers, while the proposed new award would be restricted to those without other significant sources of support.

As research awards, sponsoring institutions could recover indirect costs.

### Providing for Enhanced Job Security

The number of tenured and tenure-track faculty in research universities and institutions has remained approximately constant over the last decade, while the ranks of non-tenure-track scientists have swelled. These investigators have many titles, including research assistant professor, senior scientist, lecturer, research associate, and instructor—and, in a few cases, they are still called postdoctoral associates. It is time to develop policies to protect the careers of these individuals, who provide a valuable resource to the current and future research enterprise.

In recent years, universities increasingly have used non-tenure-track positions to expand their faculty without making a permanent commitment. At research universities, faculty-level jobs lacking the possibility of tenure have risen from 55 percent of new hires in 1989 to 70 percent today (presented by Paula Stephan, using data from National Center for Educational Statistics). The large number of applicants for each position offers a "buyer's market" and allows institutions to attract talented researches to non-tenure-track positions. These trends have intensified job competition among young scientists.

Such non-tenure-track scientists are generally completely dependent on external grant support. They rarely have any job security or protection and may have to take on teaching or clinical responsibilities that further inhibit their chances at independence. Nonetheless, these individuals have made a commitment to research and to their institutions; their institutions should return that commitment by providing some means of job security and protection against a single unfunded grant proposal. Moreover, NIH should provide bridge support for the most highly deserving applicants who do not have additional funding.

**6.3 Non-tenure-track "soft-money" researchers should have a budgetary "safety net" that provides time to reapply for grant support if their funding lapses. This safety net should be a joint responsibility of the NIH and the host institution: NIH should expand the Shannon Award to provide merit-based bridge awards for those without other sources of support and host institutions should offer multi-year renewable contracts to its staff scientists that guarantee space, salary, and minimal research support even in the absence of external funding.**

NIH's James A. Shannon Director Award (R55) currently provides a small number of PIs whose grant applications fall just below the payline with $100,000 of bridge funding over 2 years to allow them to strengthen the proposal for resubmission. This program should be expanded to incorporate a special program of merit-based bridge funding that will be awarded to the most promising researchers who do not have other means of support. That is, NIH should examine whether applications that fall just below the payline are submitted by "soft-money" researchers who have no other source of support. Since the positions held by these applicants may be put in jeopardy by a funding lapse, a small bridging award will allow them to revise and strengthen a grant proposal for resubmission.

This recommendation is not intended to establish a *de facto* form of tenure for non-tenure-track researchers, but to provide a minimal means of job security. At present, institutional commitment to "soft-money" researchers seems almost entirely tied to external funding; that is, if the funding is lost, so is the position, often before the applicant has the chance to even submit a revised proposal. If the institution is willing to commit to the individual by sponsoring their funding application, it should honor some level of commitment even if the grant application is not funded. The committee encourages institutions to offer multi-year renewable contracts to its non-tenure-track researchers so that they have some means of security and are protected from a single unfunded proposal.

The committee has found it difficult to find examples of institutions that have an announced, transparent policy to provide a safety net to "soft-money" researchers. While many institutions and departments will assist individual researchers, they seem reluctant to publish a policy that would commit them to any action. The university may have pages of regulations for tenure-track researchers, but barely a mention of non-tenure-track, even as these scientists are becoming increasingly prevalent in the research community. Recommendation 6.3 is very far removed from the current situation, but one that is vital to the continued success of the research enterprise.

Non-tenure-track scientists and physicians should be eligible—by both institutions and the NIH—to apply for grants, including the New Investigator R01, and the NIH should review such applications without prejudice regarding their "soft-money" status. One challenge will be to ensure that these applications really do represent an independent research project from the applicant and not merely an opportunity for an established investigator to extend his or her funding through a junior colleague.

Finally, to allow evaluation of the impact of such grants, NIH should monitor non-tenure-track applicants for R01 grants with respect to their funding rate and their success in future R01 applications—both new grants and competitive renewals.

## DATA COLLECTION

As with postdoctoral and other researchers, NIH needs informative data on all segments of the scientific workforce, including tenure-track and non-tenure-track researchers.

> **6.4 NIH should develop enhanced data collection systems on all NIH-supported researchers, regardless of specific funding mechanism. This will allow NIH to track the effectiveness of its programs, make more informed programmatic decisions, and monitor the career progression of supported researchers.**

These data should include information about position, responsibilities, and support on those receiving NIH support. For instance, what percentage of time do funded investigators spend on research? Teaching? Clinical responsibilities? Is salary support provided by the host institution or is some of it obtained through external grants? How does this distribution correlate with the position held by the investigator? Moreover, data should be disaggregated to detect different trends among different demographic and other groups.

In sum, creating a more stable environment for new investigators will encourage productivity and innovation early in their careers as they choose a long-term path. Great uncertainty is non-productive and can lead to risk-averse behavior, an anathema to good science.

# 7

# Conclusion

The career structure of academic biomedical research is, in many ways, a byproduct of the funding programs offered by the National Institutes of Health (NIH) and of imbalances in biomedical labor markets to which NIH may contribute. As the major source of support for biomedical research in the United States, the NIH has great influence in defining not only the specific research projects that are conducted, but also the environments in which that research is conducted and the scientists who conduct it. As NIH implements the NIH Roadmap, it must ensure that the vision outlined in the Roadmap can be sustained with a successful group of independent investigators to carry biomedical research into the future.

Although the current NIH system has very successfully stimulated groundbreaking biomedical research, there are growing concerns that it may not do as much as it could to foster the development of the next generation of investigators to conduct this research. In particular, scientists are now usually into their 40s before they have an opportunity for independent thought and the freedom to direct their own research. This delay runs the risk of discouraging promising young scientists from pursuing careers in biomedical research as they see greater opportunities for independence in other sectors. Moreover, new investigators may be less likely to engage in higher-risk research projects since they do not have the freedom to blaze their own path and must satisfy study sections that have an inherent bias toward research programs with a greater probability of success.[1] These challenges affect not only the new investigators themselves, but also threaten the health and vitality of the entire biomedical research enterprise.

There is need to act now. Not only can postdoctoral researchers and new investigators be impacted immediately, but the long-term effect on the biomedical workforce may only be fully manifest after a significant time. It may take 12–14 years for scientists to move from undergraduate years to an independent position. This is but one reason to have a continual source of current data on the scientific workforce to measure the ongoing effect of any efforts made to address these challenges. To that end, data collection on the biomedical workforce and how all individuals move through the grants system must be enhanced significantly. It is impossible to make informed programmatic decisions without accurate numbers of who is being supported, by what mechanism, and with what impact.

In this report, the committee has considered three different stages of biomedical careers—postdoctoral training, the transition to independence itself, and the establishment of stable research programs—and it offers recommendations appropriate to each career stage (Figure 7-1). The steps focus on fostering investigator independence and positioning investigators to continue that independence throughout their research career. "Independence" means not only independence of funding, but independence of thought; this broadening of the definition takes into account the new realities of biomedical research, including the development of large research teams and the growth of non-tenure-track research positions.

The committee has considered recommendations from previous reports made on these issues and examined the challenges that have prevented successful implementation. As such, many of the recommendations presented in this report have largely already been subjected to at least one round of testing and revision. The committee has also examined existing programs and models inside and outside the NIH to identify elements that appear to meet with success. The recommendations presented here incorporate these ideas.

In conclusion, this report presents an overview of biomedical research careers and strategies for recruiting, retaining, and supporting new investigators in biomedical research. While recognizing the realities of the present situation, it offers a vision for the future that will help ensure the continued vitality of the biomedical research enterprise and its workforce.

[1]A trend away from higher-risk, higher-reward research programs is, of course, not limited to new investigators, but out-of-the-box thinking may be especially common among those at the beginning of their careers.

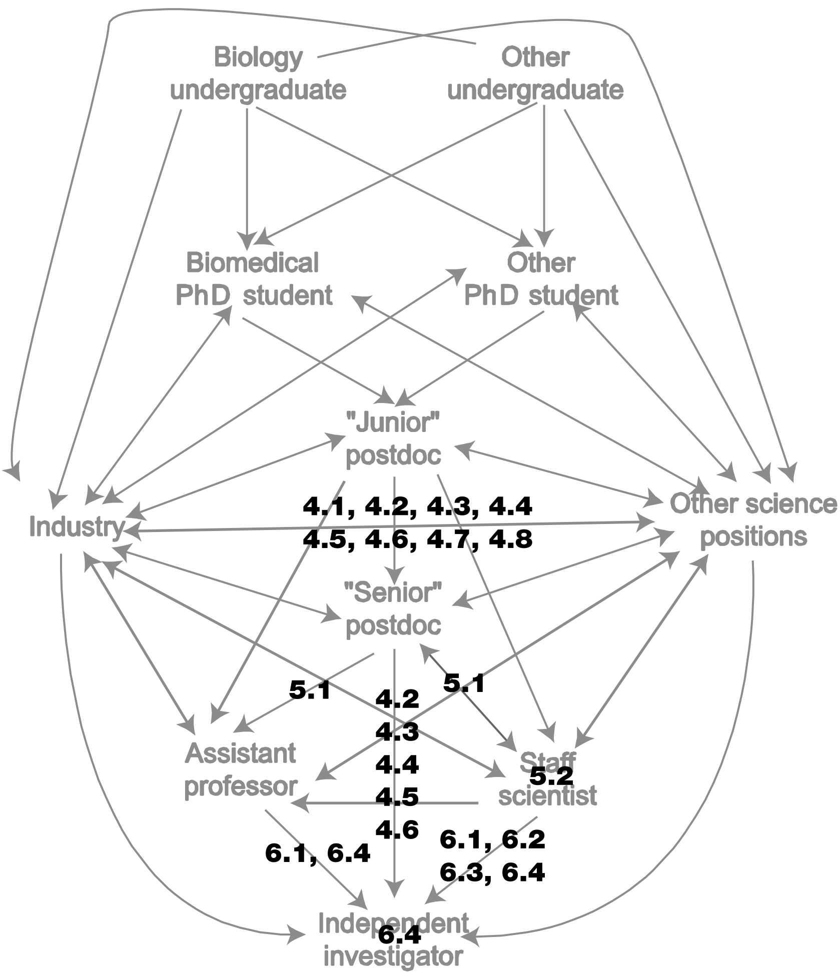


**FIGURE 7-1** Transition and career stages addressed by recommendations in the report. While biomedical career pathways are still quite complicated, the report helps to move researchers from postdoctoral positions to that of independent investigator.

The recommendations are bold, but realistic and practical. Their successful implementation relies not only upon the actions of the NIH, but also on the participation of all stakeholders in biomedical and academic research. Working together, the stakeholders can meet their responsibility to provide a bridge to independence by helping to foster the independence of new investigators in biomedical research.

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# Appendix A

# Committee Statement of Task

The National Academies will convene a workshop as the principal data-gathering event of a study to explore issues related to fostering the independence of early-career scientists (postdoctoral researchers and young faculty) in order to enhance the vitality of the biomedical research enterprise and its workforce. This workshop will build upon an October 23–24 meeting held at the National Institutes of Health (NIH) that addressed training and opportunities for postdoctoral scientists and on previous reports on postdocs and young faculty issued by the National Academies and others (e.g., *Enhancing the Postdoctoral Experience for Scientists and Engineers* [2000] and *Trends in the Early Careers of Life Scientists* [1998]). The proposed workshop will focus on the transition to independence of postdoctoral researchers and entry-level faculty with particular emphases on mechanisms to enhance the quality and effectiveness of postdoctoral training and the ability of young faculty to receive independent research funding. Previous recommendations from other studies will be considered and participants will be asked to identify and consider means to address the impediments that have prevented many of these recommendations from being put into practice. The workshop will consider whether existing programs within NIH could be expanded (e.g., K awards) and will include discussion of some of the successful programs and models being used outside NIH and to determine which features of these programs might be transferable to NIH and other large research sponsoring organization settings.

The workshop will seek to address questions related to the implementation of recommendations for fostering the independence of early-career investigators. Among the questions that might be considered are:

- Are previous recommendations still appropriate and relevant?
- To what degree have they been implemented?
- What are the challenges to implementing previous recommendations?
- Which non-NIH models have been successful in fostering the independence of early-career scientists and how might their most important elements be incorporated into NIH programs?
- How might support of postdoctoral fellows through research grants be used to foster their independence and reduce any tendencies to stifle their creativity?
- What is the role of the NIH study section and peer review system in creating the current situation for the funding of young scientists?
- To what extent can the objectives be achieved by specific instruction to study sections and/or by increasing discretion of Program Officers?

A report will be prepared identifying the challenges and presenting ideas for enhancing the opportunities for young investigators to gain independent research funding. The report will also make recommendations on those topics where consensus can be reached. The study will focus on mechanisms for fostering independent funding in the life sciences, but it may also identify challenges or recommend solutions for dealing with the larger biomedical research and academic structures.

# Appendix B

# Workshop Information

**Agenda**

**BRIDGES TO INDEPENDENCE: FOSTERING THE INDEPENDENCE OF NEW INVESTIGATORS IN THE LIFE SCIENCES**

**Keck Center of the National Academies, Room 100**
**500 Fifth Street, NW, Washington, DC 20001**

**Wednesday, June 16, 2004**

8:30 am Welcome and Introductions
*Thomas R. Cech (Committee Chair)*

9:00 am Charge from Sponsor
*Elias A. Zerhouni, Director, National Institutes of Health*

9:30 am Data on funding of new investigators

- Overview of data on NIH funding to new investigators
  *Norka Ruiz Bravo, Deputy Director for Extramural Research, NIH*
- Unpacking the data: Factors contributing to the increasing age of first grant
  *Paula Stephan, Professor of Economics, Andrew Young School of Policy Studies, Georgia State University*
- Questions and discussion

10:15 am Break

10:30 am Current opportunities for funding new investigators

- Overview of NIH programs and the history of R29 FIRST Awards
  *Alan I. Leshner, Chief Executive Officer, American Association for the Advancement of Science*
- NIH study section and review process
  *Brent B. Stanfield, Acting Director, Center for Scientific Review, NIH*
- NSF experience (why does it differ from NIH?)
  *Mary E. Clutter, Assistant Director for Biological Sciences, NSF*
- Success of career transition awards
  *Martin Ionescu-Pioggia, Senior Program Officer, Burroughs Wellcome Fund*
- Questions and discussion

11:40 am A University President's Perspective
*James R. Gavin III, President, Morehouse School of Medicine*

12:20 pm Introduction to breakout sessions

12:30 pm Box lunches available

12:45 pm Breakout sessions during lunch (please sign up at registration table; topics enclosed)

1:45 pm Reporting back on breakout sessions

2:15 pm Academic panel addressing impact of funding on hiring decisions; startup packages; institutional commitment to unfunded researchers; challenges for new faculty, staff scientists, and postdoctoral fellows:

- *David Hirsh, Executive Vice President for Research, Columbia University*
- *Robert D. Goldman, Stephen Walter Ranson Professor and Chair, Department of Cell & Molecular Biology, Feinberg School of Medicine, Northwestern University*
- *William G. Kelly, Assistant Professor of Biology, Emory University*
- *Peter Espenshade, Assistant Professor of Cell Biology, Johns Hopkins University School of Medicine*
- Questions and discussion

3:20 pm Break

3:35 pm Fostering success of new investigators

- Career development programs for postdoctoral fellows
  *Melanie Sinche, Director, Office of Postdoctoral Services, University of North Carolina at Chapel Hill*
- Junior faculty mentoring programs
  *Dorothy F. Bainton, Vice Chancellor for Academic Affairs and Professor, University of California, San Francisco*
- Laboratory management skills: BWF/HHMI Lab Management Course
  *Peter J. Bruns, Vice President for Grants and Special Programs, Howard Hughes Medical Institute*
- FASEB Individual Development Plan
  *Philip S. Clifford, Associate Dean for Postdoctoral Education and Professor of Anesthesiology and Physiology, Medical College of Wisconsin*
- Questions and discussion

4:30 pm Summary

5:00 pm Adjourn for reception in the foyer

## BREAKOUT GROUP TOPICS

1. In Tom Cech's opening remarks, a proposal for revised R01 grant application and review policies for beginning investigators was put forth. Would these revisions be useful, and what other revisions would you suggest? How would not considering preliminary data for new investigators encourage researchers to seek new areas of investigation or be willing to pursue riskier lines of research?

2. What types of awards would enable transitions to independence? What are the benefits and drawbacks of career transition awards (e.g., R29, BWF, NMSS)? Are there different issues for different populations of scientists? For example, are there special concerns regarding the transition to independence for women? For international postdocs? For faculty at medical schools as compared with arts and science faculty? For clinical research as compared with basic research faculty?

3. Should certain postdocs or non-tenure-track scientists be allowed to compete for R01 grants? What would be the ramifications of having senior postdocs, staff scientists, and non-tenure-track faculty apply for independent awards for universities? for NIH? Would it encourage new areas of investigation or riskier lines of research?

4. How can we better prepare postdocs to be successful independent investigators? What skills and competencies are important for successful transitions to independence? How can training in these skills be offered? What are the responsibilities and opportunities of the various stakeholders (funding agencies, institutions, mentors, senior faculty, junior faculty, postdocs)?

5. What data should be gathered with regard to transition for independence to help guide policy decisions? Which already exists and how can other data be collected? Which specific questions or issues need data collected?

## SPEAKER BIOGRAPHIES

**Dorothy F. Bainton** is vice chancellor, academic affairs and professor of pathology at the University of California, San Francisco. In 1963 she came to UCSF as a fellow in the Department of Pathology, has been a member of the faculty since 1972, and was chair of the department from 1987–1994, when she became vice chancellor. Dr. Bainton is recognized for her research on the structural and functional relationships of hematopoietic cells in bone marrow. She is a member of the Institute of Medicine and the American Academy of Arts and Sciences, and a fellow of the American Association for the Advancement of Science. As vice chancellor of academic affairs she works with the deans of the various schools, and has been responsible for the planning and review of all teaching programs at UCSF. She chairs the Chancellor's Council on Faculty Life and has had a long-term commitment to mentoring junior faculty.

**Peter J. Bruns, PhD**, is the vice president for grants and special programs at the Howard Hughes Medical Institute (HHMI). He manages the largest privately funded science education program in U.S. history, with a grant program of over $100 million annually. A native of Syracuse, New York, he received his bachelor's degree from Syracuse University and his doctorate from the University of Illinois before joining the Cornell University faculty as an assistant professor of genetics in 1969. His research is in the genetics and molecular biology of the one-celled pond organism *Tetrahymena thermophila*, with a special interest in its chromosomal organization. He has been active in numerous professional organizations and as a reviewer for scientific journals. Dr. Bruns has earned a national reputation for his efforts to improve science education for students at all levels. He established the Cornell Institute for Biology Teachers, which brings New York State high school teachers together each summer for lectures, field trips, hands-on laboratories, and computer training to improve their teaching. He also took the lead in expanding opportunities for Cornell students interested in doing original laboratory research in biology and related disciplines.

**Philip S. Clifford** is associate dean for postdoctoral education and professor of anesthesiology and physiology at the Medical College of Wisconsin. His interest in postdoctoral issues began while he was a postdoctoral fellow at the University of Texas Southwestern Medical School in Dallas and continued as he became an advocate for postdoctoral fellows in his own laboratory. He was tapped by the Medical College of Wisconsin to create the Office of Postdoctoral Education in 2001 just prior to the publication of the COSEPUP report *Enhancing the Postdoctoral Experience*. He has participated in discussions on postdoctoral training as a member of the Advisory Board of the National Postdoctoral Association, the AAMC GREAT Group Committee on Postdoctoral Issues, and FASEB's Science Policy Committee on Training and Careers. In surveys by *The Scientist* in 2003 and 2004, the Medical College of Wisconsin ranked as one of the top 10 institutions for postdoctoral training. Dr. Clifford heads an active research program investigating the physiological mechanisms regulating skeletal muscle blood flow during exercise. His research laboratory has been funded by the NIH since 1988 and has received additional funding from the American Heart Association and the Department of Veterans Affairs. He is a fellow of the American Heart Association and the American College of Sports Medicine and serves on the editorial boards of several physiological journals. He is also a consultant in the medical device industry.

**Mary E. Clutter** is assistant director of the National Science Foundation (NSF). She is responsible for the Biological Sciences Directorate that supports all major areas of fundamental research in biology. Dr. Clutter came to NSF from the department of biology at Yale University to be program director of developmental biology. She has held a number of positions at NSF including division director of cellular biosciences, senior science advisor to the director, and acting deputy director, NSF. Dr. Clutter is the U.S. chair of the U.S.-European Commission Task Force on Biotechnology, a member of the Board of Trustees of the international Human Frontiers Science Program, a member of the Board of Regents of the National Library of Medicine, chair of the Biotechnology Subcommittee of the Committee on Science of the National Science and Technology Council (NSTC), co-chair of the Subcommittee on Ecological Systems of the Committee on Environment and Natural Resources/NSTC, co-chair of the NSTC Committee on Science's Interagency Working Group on Plant Genomes and sits on the National Interagency Genomics Sciences Coordinating Committee. She is also a member of numerous professional societies, and has served on the Board of Directors of the American Association for the Advancement of Science (AAAS). She is a Fellow of the AAAS and the Association for Women in Science. Dr. Clutter received the bachelor of science degree in biology from Allegheny College and her master's and doctoral degrees from the University of Pittsburgh. She received honorary doctorates of science from Allegheny College and Mount Holyoke College and the Bicentennial Medallion of Distinction from the University of Pittsburgh. She has received numerous Senior Executive Service Awards, including the Meritorious and Distinguished Executive Presidential rank awards from President Ronald Reagan, President George H.W. Bush and President William Clinton.

**Peter Espenshade** graduated from Princeton University in 1990 with a degree in molecular biology. Following a year as a research technician, he began a PhD at Massachusetts Institute of Technology with Dr. Chris Kaiser. Upon completion of his doctorate in 1997, he joined the laboratory of Dr. Michael Brown and Dr. Joseph Goldstein at UT-Southwestern Medical Center in Dallas where his research focused on the mechanisms of cholesterol homeostasis. In 2002, Dr. Espenshade joined the department of cell biology at Johns Hopkins University School of Medicine as an assistant professor, where his laboratory uses fission yeast as a genetic model for understanding sterol homeostasis in mammalian cells. During his career, his studies and research have been supported by NSF predoctoral and NIH postdoctoral fellowships. Currently, his research is funded by a Career Award in the Biomedical Sciences from the Burroughs Wellcome Fund and the National Institutes of Health, R01 HL-77588.

**James R. Gavin III, MD, PhD,** graduated from Livingstone College in Salisbury, North Carolina, in 1966 with a degree in chemistry. He earned his PhD in biochemistry from Emory University in 1970 and his MD degree from Duke University School of Medicine in 1975. Dr. Gavin began his current position as president of the Morehouse School of Medicine on July 1, 2002. Prior to that, he was senior scientific officer at the Howard Hughes Medical Institute (HHMI) from 1991–2002 and director of the HHMI-National Institutes of Health Research Scholars Program from 2000–2002. Before joining the senior staff of HHMI, he was on faculty at the University of Oklahoma Health Sciences Center as a professor and as chief of the Diabetes Section; acting chief of the Section on Endocrinology, Metabolism and Hypertension; and William K. Warren Professor for Diabetes Studies. He previously served as associate professor of medicine at Washington University School of Medicine in St. Louis. He was a lieutenant commander in the U.S. Public Health Service (USPHS) from 1971–1973 and continues to serve as a reserve officer in the USPHS. He has published more than 180 articles and abstracts. Among the many honors Dr. Gavin has received are the Daniel Hale Williams Award, the E.E. Just Award, the Herbert Nickens Award, the Daniel Savage Memorial Award, the Emory University Medal for Distinguished Achievement, the Banting Medal for Distinguished Service from the American Diabetes Association, the Distinguished Alumni Award from the Duke University School of Medicine, and the Internist of the Year from the National Medical Association.

**Robert D. Goldman** is the Stephen Walter Ranson Professor and chair of the department of cell and molecular biology at Northwestern University's Feinberg School of Medicine in Chicago. He received his PhD at Princeton University and has spent his entire career in the field of cell biology. His specific interests are focused on the structure and function of cytoskeletal systems, emphasizing the role of intermediate filaments in regulating both cytoplasmic and nuclear architecture. He has been an active member of the Corporation of the Marine Biological Laboratory where he has served as a member of the board of trustees, director of the physiology: cell and molecular biology course, co-director of the Science Writer's Fellowship Program, and now serves as director of the Whitman Center for Visiting Scientists. Goldman has also served as a member of the Council of the American Society for Cell Biology, the board of directors of the American Association for the Advancement of Science, and as president of the Anatomy, Cell Biology and Neuroscience Chairpersons Association. He was the founder of the Public Information Committee of the American Society for Cell Biology, and is a member of the Committee on the Public Understanding of Science and Technology of the American Association for the Advancement of Science and the Juvenile Diabetes Foundation Stem Cell Advisory Board. He is presently funded by grants from the National Institutes of Health and the Muscular Dystrophy Foundation.

**David Hirsh** is the executive vice president for research at Columbia University. From 1990 until 2003, he was chairman of the department of biochemistry and molecular biophysics in the College of Physicians and Surgeons of Columbia University. He served as interim dean for research in the Faculty of Medicine from January 2000 to February 2001. Prior to Columbia he served as executive vice president and director of research at Synergen, Inc., and held an academic appointment at the University of Colorado, Boulder. He received his BA from Reed College and his PhD from Rockefeller University in 1968, and was a postdoctoral fellow at the

MRC laboratory of Molecular Biology in Cambridge, England. He was one of the first investigators to use *C. elegans* as an experimental organism to answer basic molecular genetic questions. His early studies identified the close sequence homology between genes of *C. elegans* and vertebrates. These findings led to studies on the arrangement of genes within the *C. elegans* genome, their timing of expression, and their tissue specificity. More recently, his research has been in the area of innate immunity in mammals and the regulation of the activity of the pro-inflammatory cytokine, interleukin-1, during inflammation and infection. Dr. Hirsh is a member of the boards of Rockefeller University and the Agouron Institute, is a director of Zymogenetics, Inc., and chairs the Lifesciences Advisory Board of Warburg Pincus.

**Martin Ionescu-Pioggia** joined the Burroughs Wellcome Fund in September 1994 and is responsible for Career Awards in the Biomedical Sciences, and for initiatives in outcome evaluation, postdoctoral, and faculty career development, reproductive science, and the history of medicine. Dr. Ionescu-Pioggia received his PhD in clinical psychology from the University of North Carolina at Chapel Hill in 1985. He completed his pre- and postdoctoral research fellowships at McLean Hospital and Harvard Medical School, where he served as associate project director for substance abuse research. He taught psychology at the University of North Carolina at Chapel Hill from 1980 to 1983. From 1983 to 1994, he worked at the pharmaceutical firm Burroughs Wellcome Co. as a clinical research scientist in the neurosciences and as a medical liaison to marketing, and worked primarily on the clinical development of bupropion, an antidepressant. Dr. Ionescu-Pioggia currently holds faculty appointments at McLean Hospital-Harvard Medical School and Duke University Medical School and serves on the advisory board of *Science*'s Next Wave. Interested in practical and policy-level career development issues, he collaborated with the Howard Hughes Medical Institute and AAAS to launch the Career Development Center, an online resource for postdocs and junior faculty on the *Science* Next Wave web site (http://nextwave.sciencemag.org/cdc/). Most recently, with HHMI, he co-developed and co-directed the BWF-HHMI Comprehensive Course in Laboratory Management for Advanced Postdocs and New Faculty. A publication summarizing the course is available online (http://www.hhmi.org/labmanagement/).

**William G. Kelly** is an assistant professor in the biology department at Emory University in Atlanta and has been so for 4 years. He maintains an active lab (currently 4 grad students, 3 post-docs, and 2 technicians) in addition to participating in undergraduate and graduate teaching. Prior to this position, Dr. Kelly was a postdoctoral fellow in the laboratory of

Dr. Andrew Fire at the Carnegie Institution of Washington Department of Embryology in Baltimore (6 yrs). His PhD work was in Dr. Gerald Hart's lab in the Department of Biological Chemistry at the Johns Hopkins School of Medicine. He also has an MS in biology from the University of Maryland Baltimore County and a BS in biology from Belmont Abbey College in North Carolina.

**Alan I. Leshner** is chief executive officer of the American Association for the Advancement of Science (AAAS) and executive publisher of its journal, *Science.* From 1994–2001, Dr. Leshner was director of the National Institute on Drug Abuse at the National Institutes of Health (NIH), and from 1988–1994 he was deputy director and acting director of the National Institute of Mental Health. Prior to that, he spent 9 years at the National Science Foundation, where he held a variety of senior positions, focusing on basic research in the biological, behavioral, and social sciences; on science policy; and on science education. Dr. Leshner began his career at Bucknell University, where he was professor of psychology. His research has focused on the biological bases of behavior, particularly the role of hormones in the control of behavior. Dr. Leshner has been elected a member of the Institute of Medicine of the National Academies of Science, and a fellow of AAAS and the National Academy of Public Administration. He has received numerous awards form both professional and lay groups for his national leadership in science, mental illness and mental health, substance abuse and addiction, and public engagement with science. He received an AB in psychology from Franklin and Marshall College and MS and PhD in physiological psychology from Rutgers University.

**Norka Ruiz Bravo** was appointed NIH deputy director for extramural research in November 2003. She started at NIH in 1990 as a scientific review administrator in the National Institute of General Medical Sciences (NIGMS). Since then, she has held a number of positions such as program director for the NIGMS Division of Genetics & Development Biology, deputy director and then acting director for the Division of Cancer Biology at the National Cancer Institute, and most recently associate director for extramural activities at NIGMS. After earning a PhD in biology from Yale University, Dr. Ruiz Bravo completed an NIH postdoctoral fellowship in biochemistry and molecular biology at M.D. Anderson Cancer Research Center. Before coming to NIH, Dr. Ruiz Bravo was an assistant professor in the departments of urology and cell biology at Baylor College of Medicine.

**Melanie Sinche** has served as director of the Office of Postdoctoral Services (OPS) at the University of North Carolina at Chapel Hill since the office opened in October 2001. Ms. Sinche prepares postdocs for successful careers through individual counseling sessions and group seminars on career-related issues. Ms. Sinche has also assisted in developing a university postdoc policy, designed a campus-wide database to track UNC postdocs, established a postdoc orientation program, developed an online employment survey for outgoing postdocs, and provided services to faculty, including a training program on effective mentoring. Prior to serving postdocs, Ms. Sinche worked closely with graduate students as assistant director of university career services at UNC. She has also served as a recruiter for a diversity recruiting firm. Ms. Sinche earned a bachelor's degree from Colgate University and a master's degree from the University of Michigan. In 2004, she will complete a second master's degree in counseling at North Carolina State University and will work towards a Licensed Professional Counselor (LPC) credential.

**Brent B. Stanfield** is presently the acting director of the National Institutes of Health Center for Scientific Review (CSR). Dr. Stanfield received the BS degree in biological sciences from the University of California, Irvine in 1973, and the PhD degree in neurobiology from Washington University, St. Louis in 1978. After a period of postdoctoral training, first at Washington University, then at the Salk Institute for Biological Studies, he was appointed to the faculty in the Developmental Neurobiology Laboratory at the Salk Institute in 1981 and, in addition, appointed assistant adjunct professor in the Department of Neurosciences at the School of Medicine, University of California, San Diego in 1982. In 1987 Dr. Stanfield moved his lab to the intramural program of the National Institute of Mental Health (NIMH) where he ran the Unit on Developmental Neuroanatomy in the Laboratory of Neurophysiology. In 1996 Dr. Stanfield worked in the Office of Science Policy at NIH and later that year was appointed acting deputy director of the Division of Intramural Research in NIMH. In 1997 he briefly moved to the CSR, where he helped implement the reorganization of the study sections that review NIH neuroscience grant applications. Dr. Stanfield moved back to NIMH in March 1998 to serve as director of the Office of Science Policy and Program Planning. He has been deputy director of CSR since July 2000, and was appointed acting director in October 2003.

**Paula E. Stephan** is professor of economics at the Andrew Young School for Policy Studies, Georgia State University. Dr. Stephan graduated from Grinnell College with a BA in economics and earned both her MA and PhD in economics from the University of Michigan. Her research interests focus on the careers of scientists and engineers and the process by which knowledge moves across institutional boundaries in the economy. Her other interests include technology transfer and the role that immigrant scientists play in U.S. science. Her research has been supported by the Alfred P. Sloan Foundation, the Andrew Mellon Foundation, the Exxon Education Foundation, the National Science Foundation, NATO, and the U.S. Department of Labor. Dr. Stephan has served on several National Research Council committees, including the Committee on Dimensions, Causes and Implications of Recent Trends in the Careers of Life Scientists; Committee on Methods of Forecasting Demand and Supply of Doctoral Scientists and Engineers; and the Committee to Assess the Portfolio of the Science Resources Studies Division of NSF. Dr. Stephan is a regular participant in the National Bureau of Economic Research's meetings in higher education and has testified before the U.S. House Subcommittee on Basic Science. She currently is serving a 3-year term as a member of the Social, Behavioral and Economic Advisory Committee, National Science Foundation. She has published numerous articles in journals such as the *American Economic Review*, *Science*, *Journal of Economic Literature*, and *Social Studies of Science.* Dr. Stephan co-authored with Sharon Levin *Striking the Mother Lode in Science*, published by Oxford University Press, in 1992.

**Elias A. Zerhouni** began his tenure as the 15th director of the National Institutes of Health On May 20, 2002. Dr. Zerhouni initiated the creation of a new research vision for the NIH, which focuses the attention of the biomedical research community on new pathways of discovery, research teams for the future, and the re-engineering of the clinical research enterprise. Among his noteworthy achievements since becoming director, Dr. Zerhouni named directors for five institutes: National Institute of Mental Health (Thomas R. Insel, MD), National Institute on Alcohol Abuse and Alcoholism (Ting-Kai Li, MD), National Institute on Drug Abuse (Nora D. Volkow, MD), National Institute of Neurological Disorders and Stroke (Story C. Landis, PhD) and National Institute of General Medical Sciences (Jeremy M. Berg, PhD). He also named a new NIH deputy director (Raynard S. Kington, MD, PhD), a new director of the Office of Technology Transfer (Mark L. Rohrbaugh, PhD, JD), a new deputy director for extramural research (Norka Ruiz Bravo, PhD), a new associate director for budget (Richard Turman) and a new associate director of communications (John T. Burklow). He has also overseen the completion of the doubling of the NIH budget. Prior to joining the NIH, Dr. Zerhouni served as executive vice dean of Johns Hopkins University School of Medicine, chair of the Russell H. Morgan Department of Radiology and Radiological Science, and Martin Donner Professor of Radiology and professor of biomedical engineering. His research in imaging led to advances in Computerized Axial Tomography (CAT scanning) and Magnetic Resonance Imaging (MRI) that resulted in 157 peer-reviewed publications and 8 patents. Since 2000, he has been a member of the National Academy of Sciences' Institute of Medicine. He served on the National Cancer Institute's Board of Scientific Advisors from 1998–2002.

## REGISTERED WORKSHOP PARTICIPANTS[1]

Ahmed Abdullai
Alexandra Achen, Science Technician, Division of Science Resource Statistics, NSF
Barbara M. Alving, Acting Director, National Heart, Lung, and Blood Institute, NIH
Irwin M. Arias, National Institute of Child Health and Human Development, NIH
Cindy Arrigo, Postdoctoral Fellow, Department of Biochemistry and Molecular Biology, UMDNJ-New Jersey Medical School
Suresh Arya, Senior Investigator & Program Director, National Cancer Institute, NIH
Constance Atwell, Office of Extramural Research, NIH
Jim Austin, North American Editor, *Science*'s Next Wave
Joel Bader, Assistant Professor of Biomedical Engineering, Johns Hopkins University
Dorothy F. Bainton, Vice Chancellor of Academic Affairs, University of California, San Francisco
Robin Barr, Deputy Associate Director, Office of Extramural Affairs, National Institute on Aging, NIH
James Battey, Director, National Institute on Deafness and Other Communication Disorders, NIH
Shannon Bayer, Recruiter/Coordinator of PostDoctoral Programs, Dana-Farber Cancer Institute
Beryl Benderly, *Science*'s Next Wave
Jeremy M. Berg, Director, National Institute of General Medical Sciences, NIH
Diane Bernal, Executive Officer, National Institute of Nursing Research, NIH
Yudhijit Bhattacharjee, *Science* Magazine
Henning Birkedal-Hansen, Acting Deputy Director, National Institute of Dental and Craniofacial Research, NIH

[1]This list includes those registered to participate in the workshop and may differ slightly from the actual workshop participation. Affiliations are as provided by participants at the time of the workshop.

Barney Bishop, Assistant Professor of Chemistry & Biochemistry, George Mason University
Terry Bishop, Training and Careers Program Director, National Institute of Diabetes and Digestive and Kidney Diseases, NIH
James Biswas, Medications Research Grants Branch, National Institute on Drug Abuse, NIH
Chris Blagden, Postdoctoral Fellow, Molecular Neurobiology, NYU School of Medicine
Brendan Bradley, Board on Life Sciences, The National Academies
Eileen Brantley, Postdoctoral Fellow, Biological Testing Branch, NCI-Frederick, NIH
Phil Brantley, Professor and Director of Education, Pennington Biomedical Research Center
Kerry Brenner, Board on Life Sciences, The National Academies
Kenneth Bridbord, Director, Division of International Training and Research, Fogarty International Center, NIH
Peter J. Bruns, Vice President for Grants and Special Programs, Howard Hughes Medical Institute
Cherie Butts, Postdoctoral Fellow, National Institute of Mental Health, NIH
Thomas R. Cech, President, Howard Hughes Medical Institute
Ida Chow, Executive Officer, Society for Developmental Biology
Philip S. Clifford, Associate Dean for Postdoctoral Education and Professor of Anesthesiology and Physiology, Medical College of Wisconsin
Mary E. Clutter, Assistant Director for Biological Sciences, National Science Foundation
Timothy Coetzee, Director, Research Training Programs, National Multiple Sclerosis Society
Debbie Cohen, Office of Intramural Training and Education, NIH
Sandra Colombini-Hatch, Medical Officer, National Heart, Lung, and Blood Institute, NIH
Michael Commarato, Health Scientist Administrator, National Heart, Lung, and Blood Institute, NIH
Joshua Corbin, Assistant Professor of Neuroscience, Georgetown University
Belinda Davis, Intramural Administrative Specialist, National Eye Institute, NIH
Mary DeLong, Director, Graduate Partnerships Program, NIH
Daniel Denecke, Director of Best Practices, Council of Graduate Schools
Claude Desjardins, Dean for Research, University of Illinois Medical Center

Nancy Desmond, Director, Research Training & Career Development Office, National Institute of Mental Health, NIH
Aaron DiAntonio, Assistant Professor, Department of Molecular Biology and Pharmacology, Washington University School of Medicine
Yuliya Dobrydneva, Eastern Virginia Medical School
Janice G. Douglas, Professor of Medicine and Physiology & Biophysics, Case Western Reserve University
Sidney Draggan, Senior Science and Science Policy Advisor, U.S. EPA
Peter Espenshade, Assistant Professor, Department of Cell Biology, Johns Hopkins University School of Medicine
Chris Espy, Manager, LTE Programs, Pacific Northwest National Laboratory
Adam P. Fagen, Board on Life Sciences, The National Academies
Di Fang, Manager of Demographic and Workforce Studies, Association of American Medical Colleges
Maryrose Franko, Senior Program Officer, Howard Hughes Medical Institute
Crina Frincu, Georgetown University
Howard Garrison, Director, Office of Public Affairs, Federation of American Societies for Experimental Biology
James R. Gavin III, President and Professor of Medicine, Morehouse School of Medicine
Susan A. Gerbi, George Eggleston Professor of Biochemistry, Department of Molecular Biology, Cell Biology & Biochemistry, Brown University
Robert D. Goldman, Stephen Walter Ranson Professor and Chair, Department of Cell & Molecular Biology, Feinberg School of Medicine, Northwestern University
Walter Goldschmidts, Acting Research Training Officer, NIH
Michael Gottesman, Deputy Director for Intramural Research, NIH
Bettie Graham, Associate Director, National Human Genome Research Institute, NIH
Eric Haag, Assistant Professor, Department of Biology, University of Maryland, College Park
Laure Haak, Committee on Science, Engineering, and Public Policy, The National Academies
Shirley Haley, *Washington Fax*
Terri Hall, University of Notre Dame
Iqbal Hamza, Assistant Professor of Animal & Avian Sciences, Cell Biology & Molecular Genetics, University of Maryland, College Park
Della Hann, Director, Office of Science Policy & Program Planning, National Institute of Mental Health, NIH

Kevin Hardwick, Office of International Health, National Institute of Dental and Craniofacial Research, NIH
Sandra Hatch, Medical Officer, National Heart, Lung, and Blood Institute, NIH
Peter Henderson, Director, Board on Higher Education and Workforce, The National Academies
David Hirsh, Executive Vice President for Research, Columbia University
Sharon Hrynkow, Acting Director, Fogarty International Center, NIH
Zoe Huang, Health Scientist Administrator, National Heart, Lung and Blood Institute, NIH
Martin Ionescu-Pioggia, Senior Program Officer, Burroughs Wellcome Fund
Sunita Jones, Postdoctoral Fellow, Department of Urology, Stanford University School of Medicine
Jocelyn Kaiser, *Science* Magazine
Sheila Keilholz, National Institute of Neurological Disorders and Stroke, NIH
William G. Kelly, Assistant Professor of Biology, Emory University
Henry Khachaturian, National Institute for Biomedical Imaging and Bioengineering, NIH
Ruth Kirschstein, Senior Advisor to the Director, NIH
Cheryl Kitt, Director of Extramural Programs, National Institute of Arthritis and Musculoskeletal and Skin Diseases, NIH
Susan Knoblach, Research Assistant Professor, Georgetown University Medical Center
Peter J. Kozel, The National Academies
Lisa Kozlowski, Assistant Dean of Postdoctoral Affairs and Recruitment, Thomas Jefferson University
Charlotte Kuh, Deputy Executive Director, Policy and Global Affairs, The National Academies
June M. Kwak, Assistant Professor of Cell Biology & Molecular Genetics, University of Maryland
Story Landis, Director, National Institute of Neurological Disorders and Stroke, NIH
Natalie Lenard, Postdoctoral Fellow, Louisiana State University Health Sciences Center-Shreveport
Alan I. Leshner, Chief Executive Officer, AAAS and Executive Publisher, *Science*
Bruce R. Levin, Samuel Candler Dobbs Professor of Biology, Emory University
Evangeline Loh, Executive Secretary, GREAT Group, Association of American Medical Colleges

Linda MacArthur, Research Assistant Professor, Georgetown University Medical Center
Carol L. Manahan, Postdoctoral Fellow, Department of Cell Biology, Johns Hopkins University School of Medicine
Richard McGee, Director of Graduate Student Affairs, Graduate Partnerships Program, NIH
Shelia McClure, Health Scientist Administration, National Center for Research Resources, NIH
Sidney McNairy, Director, Division of Research Infrastructure, National Center for Research Resources, NIH
Keith Micoli, Postdoc, University of Alabama-Birmingham
Helena O. Mishoe, Associate Director for Minority Health Affairs, National Heart, Lung, and Blood Institute, NIH
Susan R. Morrissey, Associate Editor, *Chemical & Engineering News*
Milton Muldrow, Board on Life Sciences, The National Academies
Garry Myers, Staff Scientist, Microbial Genomics Group, The Institute for Genomic Research
Neal Nathanson, Associate Dean, University of Pennsylvania School of Medicine
Maile Neel, Assistant Professor, University of Maryland, College Park
Sarah Parks, Office of Research on Women's Health, NIH
Mary Frances Picciano, Office of Dietary Supplements, NIH
Georgine M. Pion, Research Associate Professor, Department of Psychology & Human Development, Peabody College, Vanderbilt University
Joseph Pitula, Assistant Professor, Department of Natural Sciences, University of Maryland Eastern Shore
Jonathan D. Pollock, National Institute on Drug Abuse, NIH
Laura Pomerance, Reporter, Research USA
Mahboob Rahman, Assistant Professor of Medicine, Case Western Reserve University
Louise Ramm, Deputy Director, National Center for Research Resources, NIH
Michele Rankin, Postdoc, National Institute of Neurological Disorders and Stroke, NIH
Samara Reck-Peterson, Postdoctoral Fellow, University of California, San Francisco
Alyson Reed, Executive Director, National Postdoctoral Association
Robert Rich, Program Officer, Office of Research Grants, American Chemical Society
Emilda Rivers, Division of Science Resources Statistics, National Science Foundation

Dean Rosenthal, Associate Professor, Department of Biochemistry and Molecular Biology, Georgetown University
Joyce Rudick, Director, Programs and Management, Office of Research on Women's Health, NIH
Norka Ruiz Bravo, Deputy Director for Extramural Research, NIH
Wendy Sanders, Johns Hopkins Medical Institutions
William Sansalone, Associate Director, Research Development; Adjunct Professor of Biochemistry, Georgetown University Medical Center
Walter Schaffer, Acting Director, Office of Extramural Programs, NIH
Joan P. Schwartz, Assistant Director, Office of Intramural Research, NIH
Yvette Seger, Committee on Science, Engineering, and Public Policy, The National Academies
Rekha Seshadri, The Institute for Genomic Research
Fran Sharples, Director, Board on Life Sciences, The National Academies
Zaki Sherif, Assistant Professor of Biochemistry and Molecular Biology, Georgetown University
Susan Shetzline, Postdoctoral Fellow, University of Pennsylvania
Cynthia Simbulan-Rosenthal, Assistant Professor of Biochemistry and Molecular Biology, Georgetown University School of Medicine
Melanie Sinche, Director, Office of Postdoctoral Services, University of North Carolina at Chapel Hill
Patricia Sokolove, AAAS/NIH Science Policy Fellow, Office of Science Policy & Public Liaison, National Institute of Biomedical Imaging and Bioengineering, NIH
Susan Spence, National Cancer Institute, NIH
Robert Star, National Institute of Diabetes and Digestive and Kidney Diseases, NIH
Brent B. Stanfield, Acting Director, Center for Scientific Review, NIH
Paula E. Stephan, Professor of Economics, Andrew Young School of Policy Studies, Georgia State University
Susan Streufert, Extramural Policy Officer, National Institute of Child Health and Human Development, NIH
Andrea Stith, Science Policy Analyst, Federation of American Societies for Experimental Biology
Jane M. Sullivan, Assistant Professor, Department of Physiology and Biophysics, University of Washington School of Medicine
Sandra Talley, National Institute for Biomedical Imaging and Bioengineering, NIH
W. Fred Taylor, Health Scientist Administrator, Division of Research Infrastructure, National Center for Research Resources, NIH
Olga Tcherkasskaya, Professor of Biochemistry and Molecular Biology, Georgetown University School of Medicine
Michael Teitelbaum, Program Director, Alfred P. Sloan Foundation

Julie A. Theriot, Assistant Professor, Department of Biochemistry, Stanford University School of Medicine
Kenetia Thompson, Program Associate, National Postdoctoral Association
Gonzalo Torres, Research Associate, Duke University
Monique van Hoek, George Mason University
James Voytuk, Board on Higher Education and Workforce, The National Academies
Shengchun Wang, Natural Resources and Landscape Architecture, University of Maryland
Steven Wendell, Postdoc, University of Pittsburgh
Jonathan Wiest, Associate Director for Training and Education, National Cancer Institute, NIH
David Wilde, Medical Officer, Division for Clinical Research Resources, National Center for Research Resources, NIH
Martin Wu, The Institute for Genomic Research
Keith R. Yamamoto, Professor of Cellular and Molecular Pharmacology and Executive Vice Dean, School of Medicine, University of California, San Francisco
Laurie Yelle, Freelance Writer and Editor
Dong Yu, Princeton University
Elias A. Zerhouni, Director, National Institutes of Health
Eleni Zika, Board on Science, Technology, and Economic Policy and Science, Technology, and Law Program, The National Academies
Eric Zimmerman, Committee on Science, Engineering and Public Policy, The National Academies

# Appendix C

# Acronyms and Abbreviations

| | |
|---|---|
| AAMC | Association of American Medical Colleges |
| AAU | Association of American Universities |
| ACS | American Chemical Society |
| ASCB | American Society for Cell Biology |
| BWF | Burroughs Wellcome Fund |
| CAREER | NSF Faculty Early Career Development Program |
| COSEPUP | Committee on Science, Engineering, and Public Policy, The National Academies |
| CSR | Center for Scientific Review, NIH |
| EMBL | European Molecular Biology Laboratory |
| EMBO | European Molecular Biology Organization |
| F Awards | NIH Fellowship Programs |
| F32 | NIH Ruth L. Kirschstein National Research Service Award for Individual Postdoctoral Fellows |
| FASEB | Federation of American Societies for Experimental Biology |
| FIRST | NIH First Independent Research Support and Transition Award (R29) |
| GREAT | Graduate Research, Education, and Training Group, Association of American Medical Colleges |

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|---|---|
| HHMI | Howard Hughes Medical Institute |
| | |
| ICs | NIH Institutes and Centers |
| IMPAC II | Information for Management, Planning, Analysis, and Coordination II (NIH internal database on grant applications and awards) |
| INSERM | Institut national de la santé et de la recherché medicale (French National Institute for Health and Medical Research) |
| IOM | Institute of Medicine, The National Academies |
| | |
| K Awards | NIH Career Development Programs |
| K01 | NIH Research Scientist Development Award–Research & Training |
| K02 | NIH Research Scientist Development Award–Research |
| K04 | NIH Modified Research Career Development Award (not currently in use) |
| K08 | NIH Clinical Investigator Award |
| K12 | NIH Physician Scientist Award (Program) |
| K18 | NIH Career Enhancement Award |
| K22 | NIH Career Transition Award |
| K23 | NIH Mentored Patient-Oriented Research Career Development Award |
| K25 | NIH Mentored Quantitative Research Career Development Award |
| | |
| NAS | National Academy of Sciences, The National Academies |
| NCI | National Cancer Institute, NIH |
| NDPA | NIH Director's Pioneer Award |
| NIBIB | National Institute of Biomedical Imaging and Bioengineering, NIH |
| NIEHS | National Institute of Environmental Health Sciences, NIH |
| NIGMS | National Institute of General Medical Sciences, NIH |
| NIH | National Institutes of Health |
| NIRA | NIH New Investigator Research Award (R23) |
| NPA | National Postdoctoral Association |
| NRC | National Research Council, The National Academies |
| NRSA | NIH Ruth L. Kirschstein National Research Service Award |
| NSF | National Science Foundation |
| NTA | NIEHS Trainees Assembly (see Box 4-4) |
| | |
| OFCD | NIEHS Office of Fellows' Career Development (see Box 4-4) |

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|---|---|
| PECASE | Presidential Early Career Awards for Scientists and Engineers |
| PHS | United States Public Health Service |
| PI | Principal Investigator |
| | |
| R Awards | NIH Research Programs |
| R01 | NIH Research Project (traditional investigator-initiated research award) |
| R03 | NIH Small Research Grant |
| R15 | NIH Academic Research Enhancement Award (AREA) |
| R21 | NIH Exploratory/Developmental Grant |
| R23 | NIH New Investigator Research Award (not currently in use) |
| R29 | NIH First Independent Research Support and Transition (FIRST) Award |
| R37 | NIH Method to Extend Research in Time (MERIT) Award |
| R55 | NIH James A. Shannon Director's Award |
| | |
| SDR | Survey of Doctorate Recipients, National Science Foundation (see Box 2-1) |
| SRA | Scientific Review Administrator, Center for Scientific Review, NIH |
| | |
| T Awards | NIH Training Programs |
| T32 | NIH Institutional National Research Service Award (training grant) |
| T90 | NIH Training for a New Interdisciplinary Workforce Program |
| Type 1 | NIH new grant application |
| Type 2 | NIH competing continuation (renewal, recompeting application) |
| | |
| UCSF | University of California, San Francisco |
| UNC | University of North Carolina |

# Appendix D

# Committee Member Biographies

**Thomas R. Cech, PhD,** *Committee Chair*, is president of the Howard Hughes Medical Institute, succeeding Purnell Choppin in January 2000. He is also Distinguished Professor of Chemistry and Biochemistry at the University of Colorado at Boulder. He received his BA degree in chemistry from Grinnell College and his PhD degree in chemistry from the University of California, Berkeley. His postdoctoral work in biology was conducted at the Massachusetts Institute of Technology. Dr. Cech is a strong advocate for science education at all levels and has worked to improve the career development and mentorship of young scientists. Dr. Cech is a member of the National Academy of Sciences, Institute of Medicine, and American Academy of Arts and Sciences. Among the honors he has received are the Lasker Award, the National Medal of Science, and the 1989 Nobel Prize in Chemistry.

**Aaron DiAntonio, MD, PhD,** is currently assistant professor of molecular biology and pharmacology at Washington University School of Medicine in St. Louis. Dr. DiAntonio's research interests focus on the molecular mechanisms that regulate synapse size and strength during development. His studies combine genetics, electrophysiology, and neuroanatomy to characterize the plasticity of neural circuits in both *Drosophila* and mouse. Dr. DiAntonio received an A.B. in biochemistry and molecular biology from Harvard in 1988, an MPhil in biochemistry from Cambridge University in 1989, an MD from Stanford University School of Medicine in 1995 and a PhD in molecular and cellular physiology in 1995 from the same institution. He previously held a postdoctoral fellowship within the department of molecular and cellular biology at the University of California, Berkeley (1995–1999). Some of his many honors and awards include the Keck Foundation Young Scholars Award, McKnight Scholar Award (2002–2005), Sloan Research Fellow (2001–2003), Whitehall Foundation Award (2000–2003), HHMI Faculty Development Award (2000–2002), and the Burroughs Wellcome Career Award in the Biomedical Sciences (1998–2003).

**Janice G. Douglas, MD,** is currently professor of medicine, physiology and biophysics and professor of pharmacology at Case Western Reserve University School of Medicine. She was formerly the director of the Hypertension Division and vice chair for academic affairs for the Department of Medicine. Dr. Douglas is internationally renowned as a physician-scientist and conducts studies on cellular and molecular mechanisms of blood pressure regulation with a focus on the kidney and the renin angiotensin system and racial/ethnic diversity in the pathophysiology of essential hypertension. She has extensive authorship of medical publications and is (or has been) a member of editorial boards, publication committees and/or associate editor (guest editor) for a number of prestigious medical journals including the *Journal of Clinical Investigation*, the *American Journal of Physiology*, *Circulation*, *Hypertension*, the *Journal of Laboratory and Clinical Medicine*, *Ethnicity and Disease*, and the Endocrine Society, to name a few. Dr. Douglas has been elected to membership in the most prestigious organizations for physician scientists, which include the American Society for Clinical Investigation, the Association for American Physicians, Fellow of the High Blood Pressure Council of the American Heart Association, the Association for Academic Minority Physicians, the Central Society for Clinical Research, and the Institute of Medicine of the National Academy of Sciences. She has served on the Board of Directors of the ABIM. Dr. Douglas has served on numerous policy and review committees for the National Institutes of Health and other organizations. National Academies experience includes membership on the Committee on National Needs for Biomedical and Behavioral Scientists (1997–2000) and the Committee on Career Paths for Clinical Research (1991–1993). Dr. Douglas received her BA from Fisk University, Nashville (1964) and her MD from Meharry Medical College, Nashville (1968).

**Susan A. Gerbi, PhD,** is currently the George Eggleston Professor of Biochemistry and founding Chair of the Department of Molecular Biology, Cell Biology and Biochemistry at Brown University. Current research interests include regions and sequences of DNA synthesis initiation, further exploration of the interplay between regulation of replication and transcription, and rRNA biogenesis. Among her honors, she received the State of Rhode Island Governor's Award for Excellence in Research. She received her PhD from Yale (1970). Previous positions include a 2-year spell as a NATO and then Jane Coffin Childs Postdoctoral Fellow at the Max Planck Institute in Germany, and as an assistant and associate professor at Brown University. Dr. Gerbi has been a member of the American Society of Cell Biology (ASCB) for over 30 years and while ASCB president, Gerbi formed the International Affairs Committee and the ASCB Archives. Gerbi has served on ASCB Council, as a chair of women in Cell Biology, and also on the Advisory Panel for Biomedical Research for the Association of American Medical Colleges (AAMC). She is a founding member and past chair of the AAMC Graduate Research Education and Training (GREAT) Group. She has been active, in collaboration with the Federation of American Societies for Experimental Biology (FASEB), in considering the education and employment of biomedical scientists in the United States.

**Bruce R. Levin, PhD,** is currently the Samuel Candler Dobbs Professor in the Department of Biology at Emory University. He received his BS in zoology, his MS and PhD in genetics, all from the University of Michigan. The research performed in his laboratory includes theoretical and empirical studies of the population and evolutionary dynamics of infectious diseases and their control. Their theoretical work involves the development and analysis of mathematical and computer simulation models. Their empirical studies include *in vitro* and *in mouseo* experiments with *E. coli* and other bacteria and their plasmids, phage, and transposons. Dr. Levin has taught at Brown University (1967–1971) and the University of Massachusetts, Amherst (1971–1992). Since 1992, he has been at Emory University. He has also been the Tage Erlander Guest Professor at Lund University and Uppsala University (1998). Dr. Levin has organized an array of conferences and symposia, including the first Microbial Population Biology Gordon Conferences in 1985. He has served and/or currently serves on the editorial boards of *Evolution*, *Theoretical Population Biology*, *Evolutionary Ecology Research*, *The American Naturalist*, *Trends in Ecology and Evolution*, and *Emerging Infectious Diseases*. He served on the National Research Council's Committees on Pesticide Resistance and Trends in Early Careers of PhDs in the Biological Sciences and is a past member of the NRC's Board on Biology. Dr. Levin is a member of the American Academy of Microbiology and a Foreign Member of the Royal Swedish Academy of Sciences.

**Carol L. Manahan, PhD**, is currently an American Association for the Advancement of Science (AAAS) Science and Technology Policy Fellow placed at the National Science Foundation. She is in the Division of Science Resources Statistics (SRS) working on the Postdoc Data Project. This project is a multi-year process to determine the feasibility and design for ongoing data collection on postdoctorate researchers (foreign as well as domestic) in the United States. Prior to the National Science Foundation, she was a postdoctoral fellow at Johns Hopkins School of Medicine in the laboratory of Dr. Peter Devreotes, director of the Department of Cell Biology (2000–2004). Her research focused on determining the mechanisms of adaptation to chemotactic signals in the social amoeba, *Dictyostelium discoideum*. While at Johns Hopkins, she was president (2002–2003) and treasurer (2001–2002) of the Johns Hopkins School of Medicine Postdoctoral Association (JHPDA). Dr. Manahan is one of the founders of the National Postdoctoral Association and was chair of the Executive Board (2002–2004). In addition, she has served as chair of the Executive Director Selection Committee, member of the Board Development and Finance Governance Committees, and member of the AAMC GREAT Group Postdoctoral Committee.

**Georgine M. Pion, PhD,** is a research associate professor in the Department of Psychology and Human Development at Vanderbilt University and senior research associate in the Center for Evaluation Research and Methodology, Vanderbilt Institute for Public Policy Studies. Dr. Pion's research has focused on career development and human resource policy, particularly as it pertains to the education, training, and employment of scientists and clinical personnel. Much of her work has focused on issues surrounding the education and employment of doctoral-level personnel, including those trained in research or clinical/professional fields. She recently directed a customer satisfaction survey of R01 applicants and an evaluation of their predoctoral work. Additionally, she also performed a large-scale evaluation of predoctoral research training programs in the biomedical and behavioral sciences for the National Institutes of Health. Her survey work at the NIH earned her a Merit Award in 1999. In collaboration with Vanderbilt special education faculty, she has completed two national surveys of doctoral students and recent doctoral recipients from graduate programs in special education in order to address issues related to the imbalance between faculty supply and demand in this field. She has served as chair of the Technical Advisory Committee for the Survey of Earned Doctorates, a member of the National Research Council's Panel on the Career Outcomes of Men and Women Scientists and Engineers, and a review group member for NSF's Science Policy and Indicators Research Program. At present, she is a member of the National Research Council's Advisory Group on the Evaluation of the Lucille S. Markey Charitable Foundation, the National Research Council's Committee on the Training Needs of Health Professionals in Domestic Violence, the National Science Foundation's Doctoral Data Advisory Committee, and the Center for Mental Health Services Human Resource Data Committee. Dr. Pion obtained her PhD from Claremont Graduate School in 1980.

**Dagmar Ringe, PhD,** is Lucille P. Markey Professor of Biochemistry and Chemistry at Brandeis University. She received her BA degree in chemistry from Barnard College, Columbia University and her PhD in organic chemistry from Boston University. After postdoctoral work at the University of Munich and MIT, she joined the staff at MIT and moved to Brandeis in 1990. She has served as the chair of the biophysics program at Brandeis and as the program director for biophysics at the National Science Foundation. She has also investigated funding models for scientific research. Dr. Ringe's research interests are in the areas of structure and function of proteins, enzyme mechanisms, protein-drug interactions, time-resolved protein crystallography, synthesis of enzyme inhibitors, and control of cofactor chemistry by protein structure. She has published over 160 journal articles in the areas of her research interests. Dr. Ringe was co-chair of the Gordon Conference on Enzymes, Coenzymes and Metabolic Pathways and has participated in the Conferences on Proteolytic Enzymes and Their Inhibitors, Quantitative Structure and Activity Relationships, Metals in Biology and Microbial Stress Response. Her awards include a Guggenheim Fellowship and the Biophysical Society Margaret Oakley Dayhoff Award for Outstanding Performance in Research.

**Julie A. Theriot, PhD,** received her PhD from the University of California, San Francisco, and is now associate professor of biochemistry and of microbiology and immunology at the Stanford University School of Medicine. Dr. Theriot is studying the transformation of chemical energy to mechanical energy in cell movement. Her work focuses on understanding the mechanisms of actin-based movement of the intracytoplasmic pathogenic bacteria *Listeria monocytogenes* and *Shigella flexneri*. She is investigating these systems at the molecular level, to yield insights into the mechanisms of whole-cell actin-based motility, as well as bacterial pathogenesis. Other research interests include establishment and maintenance of bacterial polarity, quantitative videomicroscopy, and image and motion analysis. Honors include a Whitehead Fellowship and a Packard Fellowship for Science and Engineering. Dr. Theriot recently received The School of Medicine Award for Graduate Teaching and was named a 2004 MacArthur Fellow.

**Keith R. Yamamoto, PhD,** is professor of cellular and molecular pharmacology and executive vice dean of the School of Medicine at the University of California, San Francisco. He has been a member of the UCSF faculty since 1976, serving as director of the PIBS Graduate Program in Biochemistry and Molecular Biology (1988–2003), chair of the Department of Cellular and Molecular Pharmacology (1994–2003), vice dean for research (2002–2003), and was made executive vice dean in 2004. Dr. Yamamoto's research focuses on the mechanisms of signaling and gene regulation by intracellular receptors, which mediate the actions of several classes of essential hormones and cellular signals. Dr. Yamamoto was a founding editor of *Molecular Biology of the Cell*, and serves on numerous editorial boards and scientific advisory boards, and national committees focused on public and scientific policy, public understanding and support of biomedical research, and science education. Dr. Yamamoto has played a key role in recent changes to the grant peer review process at the National Institutes of Health, most recently serving as chair of the Advisory Committee to the NIH Center for Scientific Review (CSR) (1996–2000) and a member of the CSR Panel on Scientific Boundaries for Review (1998–2000). Dr. Yamamoto was elected as a member of the American Academy of Arts and Sciences in 1988, the National Academy of Sciences in 1989, the Institute of Medicine in 2003, and as a fellow of the American Association for the Advancement of Sciences in 2002.