

Postdoctoral Appointments: Roles and Opportunities

A Report on an NSF Workshop

MAY 11-13, 2003

NATIONAL SCIENCE FOUNDATION
ARLINGTON, VIRGINIA

Sponsored by

National Science Foundation

Division of Chemistry and the Office of Multidisciplinary Activities,
Directorate for Mathematical and Physical Sciences

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Acknowledgment

The workshop described in this report was supported by the National Science Foundation under Grant No. CHE-0324824. Any opinions, findings, or conclusions are those of the authors and do not necessarily reflect the views of the National Science Foundation.

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Executive Summary

THIS REPORT SUMMARIZES DISCUSSIONS during a workshop convened to examine and discuss the current state and role of the postdoctorate, the period following completion of the doctorate and before the start of a full-time professional position. The workshop had two major goals. The first was to illuminate the processes, characteristics and outcomes of the postdoctoral appointment. The second was to identify concepts, opportunities and priorities for activities by the National Science Foundation (NSF) uniquely at the postdoctoral level to strengthen science, mathematics and engineering in the United States and the human resources required to maintain scientific leadership. The workshop envisioned larger outcomes of NSF-supported activities at the postdoctoral level as well. These outcomes include establishment of a better prepared and more diverse United States workforce in the chemical sciences in a global environment; enhancement of the numbers, capabilities and diversity of workforce leadership in the chemical sciences; identification of opportunities other than or in addition to research training that can be met at the postdoctoral level; and identification of additional research possibilities (including interdisciplinary research) to extend and fill gaps in the understanding and knowledge of the postdoctorate.

Workshop attendees represented a range of constituencies, largely but not exclusively in the chemical sciences, and included leading scientists and hosts of postdoctoral appointees; employers from academic, industrial, and governmental sectors; newly minted scientists, both with and without postdoctoral experience; current postdoctoral appointees (“postdocs”); public and private funders of postdoctoral positions; representatives of professional organizations; and representatives of organizations directed toward communities underutilized in science, including women, minorities, and people with disabilities. The workshop consisted of plenary presentations and panel discussions, each followed by breakout group discussions that were summarized for the entire assembly. Candor and a willingness to articulate deep-seated concerns and possible ways to address them characterized the workshop. Participants discussed expansions on the “traditional” research-only postdoctorate, acknowledging the underlying importance of research at the postdoctoral level. Additionally, several attendees and presenters described valuable postdoctoral appointments that did not incorporate research. The workshop made clear as well the need for more and better data to

inform policy and program decisions. Embedded throughout the entire workshop was the notion that scientific and scholarly excellence and leadership are intimately intertwined with diversity. Indeed, the workshop explicitly identified and addressed enhanced participation of women, African-Americans, Latinos, American Indians, and persons with disabilities in the scientific and technical workforce and its leadership.

The workshop did not seek to achieve consensus on programmatic recommendations, nor was it able to speak to all the underlying questions. Rather, its intent was to identify those aspects of the postdoctorate that are worthy of attention as new programs are considered or existing ones reviewed. Among these are

- better guidance from multiple sources, including professional associations, in choosing and preparing for careers, beginning at the graduate-student level;
- more-energetic and focused recruitment of underserved communities into postdoctoral appointments;
- better mentoring during the postdoctorate by the advisor, the institution, and professional associations;
- the need for clarity and explicitness in expectations of the postdoctoral appointment among postdoc, advisor, institution, and funder;
- documentation of previous mentoring of and successes by postdocs in renewal proposals for funding;
- provision of adequate pay and benefits, and enhancement of institutional status;
- creation of and participation in “hybrid” postdoctoral programs or ones that are not restricted to research;
- broader assessment of the impact of the postdoctorate beyond research output, including tracking of the careers of younger scientists to gauge specific benefits of postdoctoral appointments.

Hybrid programs and ones that do not include research elicited attention, both for the potential to provide new postdoctoral venues and for their implications for career pathways, especially in research-intensive universities.

An auxiliary outcome of the workshop was the recognition that many of the themes presented there apply also at other career stages, including undergraduate and graduate study, and during full-time employment. Indeed, all the stages of “life-long learning” seamlessly overlap and share common elements. Addressing these elements at any stage benefits all levels of career development and progress and promotes the goal of achieving scientific excellence and leadership.

Foreword

IN RECENT DECADES, POSTDOCTORAL APPOINTMENTS immediately following completion of the doctorate and before the start of a full-time professional position have become a *de facto* requirement for many jobs in academia and industry. The numbers of postdoctoral scientists (“postdocs”) on the nation’s campuses have grown substantially, to the point that postdocs now perform a significant fraction of the nation’s scientific research. Yet this great expansion of the postdoctorate has occurred with little planning, scrutiny, or institutional supervision.

While the roles and significance of these appointments for professional advancement can and do vary by discipline, they share a few common elements. Chief among these, in contrast to graduate study, is the general full-time focus on research. Most postdocs have little or no participation in teaching when in an academic setting or management when in an industrial or government setting. A few teaching postdoctoral positions exist, as do some positions in industrial and national laboratories, but these are in a minority.

Driven initially by concerns about employment opportunities, a number of professional, non-profit, and governmental organizations have focused attention on the postdoctorate. Working environments, benefits, demographics, institutional responsibilities, and career preparation at the postdoctoral level have all come under scrutiny. However, no major studies have assessed the added value of postdoctoral work for creating career opportunities or have compared career outcomes of scientists with and without postdoctoral experience. This last issue can be especially important in addressing the goal of diversifying the scientific workforce and leadership with respect to underserved communities, including women, African-Americans, Latinos, American Indians, and persons with disabilities.

Available studies and experience suggest that postdoctoral appointments serve one or more of the following purposes that benefit the postdoc, the supervisor, or both:

- continuing education leading to new skills or new knowledge;
- strengthening of scientific credentials through publications and scientific visibility;
- support for placement in permanent positions;

- network building with advisors and supervisors and with peers and contemporaries, leading to integration into the profession;
- provision of research laboratory staffing;
- productive employment while awaiting desirable full-time positions.

To strengthen and diversify the scientific and technical workforce and leadership in the United States, three broad questions regarding the postdoctorate must be addressed:

- Are the historical purposes and structures of postdoctoral appointments still adequate?
- Can the components of the postdoctorate be broadened or modified without diminishing its role as a means of enhancing scientific and technical skills and knowledge?
- Alternatively, should the notion of the postdoctorate extend beyond its current focus on entry into scientific and technical careers and embrace non-scientific activities?

These questions, bolstered by available studies, lead to an additional set of questions:

- How is a successful postdoctoral experience defined?
- Does or can a postdoctoral appointment serve also as a barrier to professional advancement? In particular, does the configuration, support, or practice of the postdoctorate act to discourage United States citizens underrepresented in science?
- Which laboratories (“gatekeepers”) generate the largest numbers of postdoctoral appointees, and why? What factors—e.g., laboratory setting, supervisor, institution—determine the quality of the postdoctoral appointment?
- Which laboratories serve the most diverse array of postdoctoral scientists, and why? How can diversity be encouraged and enhanced at the postdoctoral level?
- Can a postdoctoral position afford opportunities to explore alternatives to the single-investigator model for doing research, including collaborations across disciplines and institutions, broader use of shared facilities, and other structures?
- Can a postdoctoral appointment be broadened to include development or enhancement of other capabilities in addition to those required for research, such as communication, teaching, or management skills?
- What are the real costs and financial returns of postdoctoral appointments in the short and long term? Do the long-term returns

that postdocs afford the advancement of science and science education justify the short-term costs?

- Are or should postdoctoral appointments be “jobs” or be continuing education? What are the corresponding implications for salaries and benefits for postdocs?
- Can the enhancement of science and engineering leadership in the United States be addressed in new ways at the postdoctoral level?
- To what extent do national security issues need to be considered in creating and filling postdoctoral positions? What are the corresponding implications for participation and leadership by the United States in the internationalization and globalization of science?
- To what extent can or do postdoctoral appointments enhance both short- and long-term employment “flexibility and agility”¹ in a rapidly changing and more professionally diverse marketplace?
- In addition to research-intensive universities, where the vast majority of postdoctoral appointments exist, can other settings (e.g., industries, national laboratories, non-doctoral colleges and universities) be used more effectively to benefit both the postdoc and the host institution?

On May 11-13, 2003, motivated by these issues, the Division of Chemistry and the Office of Multidisciplinary Activities of the National Science Foundation (NSF) sponsored a workshop in Arlington, Virginia, to examine the past, present, and future of the postdoctorate. Approximately 80 participants with a wide range of backgrounds in industry, education, government, and non-profit organizations came together to analyze the experiences of postdocs and to explore how those experiences can be enhanced. The group included college and university faculty members and administrators, government officials and analysts, industrial executives, scientists and administrators at national laboratories and other research institutions, leaders of professional organizations, and current postdocs. Through plenary sessions, breakout groups, and informal conversations, workshop participants explored both the idiosyncrasies and common themes of the postdoctoral experience.

The workshop had two major goals:

- To illuminate the processes, characteristics, and outcomes of the postdoctoral appointment.
- To identify concepts, opportunities, and priorities for NSF uniquely at the postdoctoral level that will strengthen science, mathematics, and

¹ “Pan-organizational Summit on the U.S. S&E Workforce,” Government-University-Industry Research Roundtable, National Academies, Washington, D.C., December 2002.

engineering in the United States and the human resources required for maintaining leadership.

Because the workshop was sponsored in part by the Division of Chemistry, its starting point was the postdoctorate in chemistry, and particularly those positions supported by NSF. However, the discussion ranged well beyond chemistry, and the conclusions and suggestions contained in this report have relevance for all postdocs and for all institutions that sponsor or host postdocs.

Issues of terminology arose several times at the workshop. A number of workshop participants expressed their displeasure with the terms “postdoctorate” and “postdoc.” The words seem to imply the termination of a period of training, not the initial steps of a young scientist toward research independence. Various alternatives were discussed, such as research fellow or associate, but the workshop participants made no recommendation to replace the terms, and this report continues to use “postdoctorate,” “postdoctoral,” and “postdoc.” Nevertheless, workshop participants felt that continued attention should be directed to the deficiencies of these terms and that widely accepted alternatives should continue to be sought.

NSF has begun to explore new models for the postdoctorate. Under discussion are national “Discovery Corps Fellowships” that could enhance the nation’s research infrastructure and help meet strategic national research needs, “Senior Discovery Corps Fellowships” that could provide an opportunity for midcareer scientists to explore new ways of contributing to the scientific enterprise, and “International Discovery Corps Fellowships” that could strengthen scientific ties between the United States and other countries through exchanges of research personnel. The issues and possible new initiatives described in this report can inform these discussions and help shape innovative programs, not only within the Chemistry Division but also throughout NSF and in other scientific organizations.

The workshop did not seek to achieve consensus on programmatic recommendations, nor was it able to speak to all the underlying questions. Rather, its intent was to identify those aspects of the postdoctorate that are worthy of attention as new programs are considered or existing ones reviewed. Indeed, the workshop represents the beginning of a process, not the end. We are convinced that the ideas contained in this report can inspire a broader discussion of the postdoctorate so that strengths can be enhanced and weaknesses eliminated. Such a discussion could help reinvigorate the postdoctoral experience so that it is meaningful and significant to the postdoc, the supervisor, the host institution, the sponsors, and the nation. We hope that this report will help engage the scientific community in a wide-ranging, in-depth, and searching examination of this vital time in the life of young scientists.

Foreword

NSF's strategic vision speaks of investing in "people, ideas, and tools." Through its support of postdocs, the Foundation takes critical steps toward achieving the first two goals and develops the base of expertise needed to achieve the third. In that respect, the postdoctoral experience is at the center of the Foundation's mission and should be a focus of the Foundation's attention. This workshop report can help bring to the postdoctorate the attention it needs and deserves.

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The Postdoctoral Experience: Shared Goals, Diverse Experiences

NO TWO POSTDOCTORAL APPOINTMENTS ARE EXACTLY the same, yet almost all postdocs hope to achieve certain objectives during their postdoctoral years. The most important of these is to become established as someone capable of doing independent or team-based research. Most postdoctoral appointments are organized around the conduct of research, though the time spent actually doing research can vary widely. Through these experiences, postdocs develop their creativity and sharpen their ability to design experiments, use equipment, analyze data, build on the published scientific literature, make presentations, write and review papers, and perform all the other myriad activities associated with the conduct of research.

Postdocs can learn many other valuable skills as part of their involvement in research. They can learn to interact and work together with other researchers, from senior faculty to undergraduates. They can learn to initiate research programs and to choose tractable problems from a wide range of possible research directions. They can learn how to create and administer a research budget and execute the many managerial tasks that must be handled by the leader of a research team.

Postdocs also can learn many skills that are not directly related to research but that can figure prominently in their future careers. They can hone their abilities to teach graduate students and undergraduates. They can develop skills in communicating about science to non-scientists. They can learn about the formation of institutional or governmental policies and apply their scientific expertise to the development of those policies. They can learn about the institutional structure of universities or industry and gain experience with the governance of those institutions.

The advisors of postdocs and the institutions within which postdocs work also have goals they wish to achieve through the postdoctorate. Postdocs are responsible for a substantial fraction of the research conducted in many laboratories. One analysis found that 43 percent of the first authors of the research articles in two recent issues of *Science* were postdocs.² In addition, postdocs can bring

² Gretchen Vogel, *Science* 285 (1999):1531.

familiarity and expertise with a technique to a lab eager to use that technique. They can lead teams of graduate students or undergraduates who are performing part of a complex research project. In some institutions, they spend part of their time teaching or mentoring students or providing services to the institution or the wider community.

Because of the value of the postdoctorate—both to the individual postdoc and to the institutions where postdocs work—one or more postdoctoral appointments have become increasingly common in research careers. Most positions in higher education and many industrial jobs require that candidates have completed one or more postdoctoral appointments. Even when new Ph.D.s are offered jobs immediately upon receiving a degree, their future employers often make provisions for them to have a postdoctoral appointment before beginning the job.

The value of the postdoctorate also has led to a substantial growth in their numbers in some fields. Though the number of postdocs in chemistry has grown only modestly over the past two decades, the total number of postdocs has boomed. In academic institutions, the number of postdocs rose from about 18,000 in 1981 to 41,000 in 2000, driven largely by increases in the life sciences.^{3,4} In chemistry, about 3,800 postdocs were in doctorate-granting institutions in 2001.⁵ Including postdoctoral appointments in industry and government, the total postdoctoral population in science and engineering in the United States probably exceeds 50,000.⁶

Even as the number of postdocs has increased, the average time individual researchers spend as postdocs has lengthened. Again the trends are most dramatic in the life sciences, where the amount of time spent in postdoctoral appointments can be five years or more.⁷ But the time spent as a postdoc in chemistry and other fields also could lengthen if faculty positions become scarce or if the economy suffers a substantial downturn.

About half of postdocs overall are temporary residents in the United States.⁸ In chemistry, the proportion of temporary residents is even higher—two-thirds of the chemistry postdocs in doctorate-granting institutions in 2000 were tem-

³ Committee on Science, Engineering, and Public Policy, National Academy of Sciences, National Academy of Engineering, Institute of Medicine, *Enhancing the Postdoctoral Experience for Scientists and Engineers* (Washington, DC: National Academy Press, 2000).

⁴ National Science Foundation, Division of Science Resources Statistics, *Graduate Students and Postdoctorates in Science and Engineering: Fall 2000* (Arlington, VA: National Science Foundation, 2002).

⁵ S. Wilkinson, "Academic R&D Spending Trends," *Chemical & Engineering News* 81, No. 29(2003):25-29; http://pubs.acs.org/cen/pdf/8129web_only.pdf.

⁶ Committee on Science, Engineering, and Public Policy, op. cit.

⁷ Office of Scientific and Engineering Personnel, National Research Council, *Trends in the Early Careers of Life Scientists* (Washington, DC: National Academy Press, 1998).

⁸ National Science Foundation, Division of Science Resources Statistics, op. cit.

porary visa holders.⁹ Very few postdocs are underrepresented minorities—only about 1,500 in all of science and engineering in a recent survey.¹⁰ With so few minority postdocs, the number of minority faculty remains substantially lower than the proportions of those groups in the overall population.

NSF currently supports about 600 postdocs in chemistry, representing an annual expenditure of about \$16 million.¹¹ The total number of postdocs supported by NSF is an order of magnitude larger—about 5,500, with annual expenditures of approximately \$160 million.¹² Most NSF-supported postdocs receive their salaries through the grants of their advisors, though a small portion have fellowships that cover their salaries.

About 60 percent of all chemistry postdocs take jobs in industry following their postdoctorate.¹³ Roughly a quarter go into academia, with the remaining 15 percent getting jobs in government and other organizations.

At the workshop, several participants likened the postdoctorate to other career paths. One analogous model is the traditional separation of craftsmen into apprentices (graduate students), journeymen (postdocs and non-tenure-track faculty members), and masters (tenured and tenure-track faculty and industrial or governmental employees). Another is the medical school model of students, residents, and interns. Each of these models has both intriguing parallels and differences with the postdoctoral experience.

Such analogies are complicated by the tremendous variety of the postdoctoral experience. Some postdocs are virtual peers with their advisors, working as equal partners on research projects and with students. In other cases, and especially in labs that include large numbers of people, postdocs act as “lieutenants” to oversee teams of students and researchers. Other postdocs have much less autonomy and responsibility; some act simply as skilled executors of an advisor’s ideas and have very little independence to initiate new activities.

The postdoctoral experience varies along many other dimensions. Pay levels differ substantially from academia to industry to government, from discipline to discipline, and even within a single discipline. For example, postdoctoral appointments in physical chemistry tend to pay more than appointments in organic chemistry. Some postdocs do little except research while others have many additional responsibilities. Some postdocs are treated as institutional

⁹ Ibid.

¹⁰ National Science Foundation, Division of Science Resources Statistics, *Characteristics of Doctoral Scientists and Engineers in the United States: 2001* (Arlington, VA: National Science Foundation, 2003).

¹¹ Data from Paul Spyropoulos, Division of Chemistry, National Science Foundation.

¹² R. Colwell, “Perspectives from NSF on the Postdoctoral Experience,” *Science NextWave*. <http://nextwave.sciencemag.org/cgi/content/full/2002/08/27/8>.

¹³ Joel Shulman, “New Opportunities, Models, and Missions,” paper presented at the workshop.

employees, with benefits and employment protections, while others are more like contract workers.

The source of a postdoc's funding can shape that person's experiences. If funding is from an individual research grant, the postdoc may be expected to devote more time to research. If a postdoc has independent funding, that postdoc may have more freedom to shape a postdoctoral program. If funding comes through a department or through the university, teaching responsibilities may be greater.

As one of the workshop participants pointed out—quoting Steven Sample, president of the University of Southern California and chair of the Association of American Universities' Committee on Postdoctoral Education—“Postdoctoral education today is almost exactly where Ph.D. education was in the 1890s—very *ad hoc*.”

Perspectives on the Postdoctoral Experience

ACCORDING TO ONE WORKSHOP PARTICIPANT, “being a postdoc is the best job in the world—for many of us.” Certainly many current and past postdocs report high levels of satisfaction with their postdoctoral appointments. A postdoctoral appointment gives many young scientists an opportunity to concentrate on research to an extent that may not be possible later in a career.

Yet many postdocs—including several of the postdocs who attended the workshop—report that they had or are having very unsatisfactory experiences. One breakout group at the workshop divided these problems into four categories: pay, status, standards, and roles.

Average pay levels for postdocs are very low for people with their amount of training and their job responsibilities. The average pay for postdocs in academic settings was reported to be about \$30,000 per year—with pay levels in chemistry tending to be even lower than the average. Furthermore, many postdocs do not receive health insurance, retirement contributions, child-care assistance, or other benefits. And the resulting financial pressures often fall during a period of life when many postdocs are starting or supporting families. Attendees noted that postdoctoral appointments in industry or at government laboratories typically pay better, but in general postdocs make much less than their peers who have entered other professions.

The low levels of pay and lack of benefits can discourage many people from undertaking a postdoctoral appointment. Several established academic researchers at the workshop who had been postdocs reported that they had nearly chosen other career paths when facing the financial disincentives of a postdoctoral appointment. Some postdocs have other financial resources on which they can draw during their postdoctoral years. People without such resources may choose professional routes that are less financially onerous.

In that regard, the financial demands placed on a postdoc can be an especially strong disincentive for minorities underrepresented in the sciences and engineering. Several minority scientists at the workshop expressed the belief that more minorities would choose to become postdocs if the financial sacrifices were

not so great. Especially for first-generation college students, the short-term strains of a postdoctoral appointment can easily outweigh a long-term desire to remain in academia.

Beyond the financial demands of the postdoctorate, many postdocs feel that they do not get the respect or visibility that they need and deserve. Because their positions are transitional and unstandardized, many postdocs feel invisible to their institutions—indeed, many universities know very little about the number or characteristics of the postdocs who work on their campuses. Essentially, the postdoctorate as an established position was seen to have grown tremendously without a commensurate increase in the visibility and respect accorded postdocs. This lack of visibility can be especially acute for temporary residents in postdoctoral appointments, many of whom need help adjusting to a new culture, mastering a new language, and dealing with immigration issues.

Many institutions have few standards for the employment or treatment of postdocs. Postdocs reported that they rarely benefit from annual performance reviews, grievance procedures, or authorship guidelines. Few institutions have policies that ease the demands on postdocs with family responsibilities. The right of postdocs to receive adequate guidance, mentoring, and skills development is rarely made explicit.

Finally, most postdocs feel that their roles are highly uncertain. Though the primary objective of the postdoctorate is to foster independence and creativity in young researchers, many postdocs said they found it difficult to achieve this objective. They may not receive sufficient guidance from an advisor, may not be able to collaborate with others, may not be sufficiently recognized for their contributions to a project, or may not receive responsibilities commensurate with their abilities. A number of workshop participants pointed to the tension that characterizes many postdoctoral appointments: advisers want postdocs to produce as much research as possible, while postdocs have goals in addition to research.

The failure of many postdoctoral appointments to foster critical skills has major negative consequences. Employers of individuals who have completed postdoctoral appointments often say that many of the people emerging from those appointments do not have the attributes needed to be a successful faculty member or government or industrial researcher. While someone who has completed a postdoctoral position may be technically proficient and well versed in a particular area of science, that person can lack the creativity, independence, adaptability, teamwork skills, and communication skills needed to be a scientific leader. The postdoctoral experience needs to foster these abilities, workshop participants said, even if the price to be paid is less time spent on research.

Workshop participants pointed to other lost opportunities created by deficiencies in the postdoctoral experience. In particular, postdocs could play a much

greater role in strengthening the nation's research infrastructure than they do today. For example, one workshop participant pointed out that half of the nation's undergraduates are enrolled in community colleges, and three-quarters of elementary and secondary school teachers receive their only science education at community colleges. Involving postdocs in research programs and other activities at these and other institutions could benefit such institutions in many ways and build skills that many postdocs do not acquire today.

Deficiencies in the postdoctoral experience have been one of the factors driving the establishment of postdoctoral associations at individual institutions and on broader scales. For example, the National Postdoctoral Association,¹⁴ which received a founding grant in December 2002 from the Alfred P. Sloan Foundation, has as its goals to establish a self-sustaining organization that can provide a voice for postdoctoral scientists, build consensus about best-practices policies for postdocs, develop educational initiatives, and work collaboratively with government bodies, funding agencies, and professional organizations to advocate for improvements in postdoctoral policies.

¹⁴ <http://www.nationalpostdoc.org>; see also <http://nextwave.sciencemag.org/pdn/index.shtml> for information about the Postdoc Network.

Proposals for Changing the Postdoctoral Experience

THE POSTDOCTORATE BRINGS BENEFITS TO individual scientists, the scientific community, and the nation as a whole, and these benefits should be protected in policy initiatives affecting the postdoctorate. At the same time, the postdoctoral experience can be made much richer and more useful through modifications of existing programs, the development of new models, and better information about the status and prospects of postdocs.

A. Strengthening the “Traditional” Postdoctorate

The “traditional” postdoctorate conducted at a research-intensive university serves many people well, but these appointments could be strengthened and enhanced by taking several key steps.

- According to workshop participants, the postdoctoral experience essentially should begin in graduate school and extend through a person’s first job. Every graduate student should receive career counseling that would describe the range of career options available, the advantages and disadvantages of the postdoctorate, and the need to develop skills beyond research. Graduate students should gain an understanding of whether they should enter into a postdoctoral appointment and what they need to achieve through the experience. This career counseling should continue throughout the postdoctorate so that postdocs take advantage of the full range of learning opportunities available during their postdoctoral years.
- Workshop participants pointed to serious problems that can stem from the recruitment of postdocs. The placement of postdocs often occurs through personal contacts among established researchers. This reliance on personal recommendations can cause researchers to overlook equally qualified or more qualified candidates, including minorities underrepresented in science.

A central database that lists individuals who are looking for postdoctoral appointments could help open up the self-contained networks that

generate many such appointments today. Partnerships between research-intensive universities and minority-serving institutions also could help channel minority Ph.D.s into postdoctoral appointments, as could targeting of graduate students in settings with substantial minority populations. Collaborations with organizations serving under-represented minorities, women, and scientists with disabilities also can serve these ends.

- In their role as mentors, individual faculty members are as critically important in guiding the career development of the postdocs they oversee as they are in offering guidance to their graduate students. However, faculty members are usually most familiar with the world of academia and know less about other career options. They therefore should not be the only source of career information for graduate students and postdocs. Departmental meetings, institutional postdoctoral associations, and local and regional workshops and meetings of graduate students and postdocs can provide opportunities to pool experiences and share information. Supplemental funds allowing graduate students and postdocs to travel to conferences can support essential elements of their education. Such conferences can be focused on science while also including sessions on teaching, institutional governance, running a research program, professional ethics, and the many other issues postdocs will encounter during their careers. Professional organizations should be strongly urged to include these themes in their programming.
- At the beginning of a postdoctoral appointment, the expectations of both the postdoc and the advisor should be spelled out in some sort of contract. Such a document, whether formal or informal, could address such issues as sources of financial support and benefits, policies on authorship and intellectual property, and responsibilities and opportunities for both research and other activities. To facilitate this step, templates could be devised, perhaps by professional associations or funding agencies, and made available to institutions, which could tailor them to meet specific institutional or departmental conditions. Contracts could be reviewed and modified by mutual agreement during regularly scheduled evaluations and progress reports. These reviews and evaluations also could provide funding agencies and other institutions with information about the outcomes of a given postdoc's experiences.
- Institutions also need to be integrally involved in the professional development of postdocs, including career counseling, development of management or teaching skills, attention to ethical and intellectual property considerations, and other issues discussed elsewhere in this report. One way to heighten such involvement would be for funding

agencies, including NSF, to provide grants to institutions or departments specifically for postdoctoral advising. Such grants also could support graduate student mentoring and advising, perhaps through institutional centers for teaching.

- A cognizant institutional officer should be charged with oversight of the postdocs on campus. As one workshop participant pointed out, most institutions pay more attention to the condition of research animals than to postdocs. This authority could be divided among individuals, but one should have final responsibility for postdoctoral affairs beyond the research itself. A growing number of institutions have created such positions and offices.¹⁵

At the same time, postdocs should be involved in the governance of their institutions, especially by serving on institutional committees. This would help develop leadership in the scientific community and provide a way to bring the concerns of postdocs to the rest of the institution.

- Postdocs should be encouraged to participate in postdoctoral associations, both within institutions and across institutions. These associations can build a sense of community and provide a mechanism for advocacy and education. They can be particularly valuable for underrepresented minorities, who otherwise can feel isolated in a given lab or institution.
- Investigators who apply for grant renewals at NSF are now required to describe “any contribution to the development of human resources in science and engineering.” NSF-supported researchers also have to provide information about the “broader impacts” of proposed research on social, educational, and minority issues. NSF needs to emphasize and vigorously enforce the use of this “second criterion” in its requests for proposals and in reviews by requiring that requests for postdoctoral support document previous mentoring and successes of postdocs in the applicant’s laboratory. Such requirements would provide incentives for researchers to act as strong mentors and advisors to postdocs. Grant applications also could have a section on institutional programs designed to enhance the educational components of the postdoctoral experience.
- Pay, benefit, and status levels for postdocs need to rise. Workshop participants felt that NSF should forcefully support a policy of fair

¹⁵ See <http://nextwave.sciencemag.org/cgi/content/full/2000/11/06/5> for a summary.

compensation for postdocs. NSF also should work to ensure the provision of health insurance and other benefits for all postdocs.¹⁶ And policies need to be established that ease the tension between the postdoctorate and family responsibilities; examples include the provision of for couples to live in the same location. As one workshop participant put it, “Postdocs are people, too.”

Only by fully addressing the issues of compensation and benefits, workshop participants said, will it be possible to ensure the diversity of the postdoctoral population and of the scientific and technical workforce.

B. New Models

Recent years have seen the development of new models for the postdoctorate, such as postdoctoral positions in industrial or government labs or hybrid appointments done in multiple institutions. This diversification of the postdoctorate needs to be extended and strengthened, and new models should be supported as valuable and valued ways to serve the needs of individuals, institutions, and the nation as a whole. However, as one participant noted, any program patterned on the postdoctorate needs to know what it is preparing people for, what doors it is opening professionally for participants, and the range of possible contributions participants could make to society, knowledge, and other areas.

- Today, many people have postdoctoral appointments at institutions other than research-intensive universities, not only in government or industrial labs, but also in primarily undergraduate institutions, independent research organizations, and so on. These non-traditional postdoctorates have broadened the base of experience of the postdocs who have done them while simultaneously strengthening the nation’s research and broader scientific infrastructure outside research-intensive universities. Postdoctoral appointments that combine experiences in different institutions—such as 12 months in industry followed by 12 months in a university—can serve a similar purpose. Such postdoctorates can leverage the funding of federal agencies and help achieve national goals that traditional postdoctorates cannot. For example, a particularly important form of partnership is between research-intensive universities and institutions serving predominantly minority populations, including historically black colleges and universities, tribal colleges, and institutions serving largely Hispanic populations.¹⁷
- Postdoctoral appointments that take place at least in part outside research-

¹⁶ See B. L. Benderly, “The California Plan,” *Science NextWave*: <http://nextwave.sciencemag.org/cgi/content/full/2003/07/30/3>

¹⁷ See, for example, <http://www.emory.edu/WHSC/MED/PHYSIOLOGY/FIRST>.

intensive universities could be equally valuable when done in many other institutions, such as museums, community colleges, courts, legislatures, think tanks, and so on. Such programs could build unique blends of skills directed at critical unmet needs. They also could bring scientific expertise to sectors of society where such knowledge can be particularly useful. Such programs need not be large to have an important impact, both on the institutions where a postdoctoral appointment takes place and on the academic institutions with which a postdoc interacts.

- Hybrid postdoctoral appointments often lead to hybrid careers. As workshop participants often pointed out, society benefits when postdocs take the experience they have gained and enter teaching, legislatures, the courts, journalism, business, and other sectors of society. At the same time, postdocs who have had experiences with multiple institutions have much to offer in academic jobs by broadening the vision of students and faculty members. For that reason, workshop participants insisted, nontraditional postdoctoral appointments should not disqualify a person from being considered for faculty positions at research-intensive universities.
- New models for the postdoctorate could be an explicit focus of the Discovery Corps Fellowships now being discussed within NSF. Every postdoctoral appointment should be centered on research. But the Discovery Corps Fellowships could emphasize appointments in which research is paired with one or more other activities designed to enhance the value of the postdoctorate.

These fellowships could be structured in various ways. Institutions, departments, individual investigators, mid-career scientists, or graduate students could apply for a Discovery Corps Fellowship. If the applicant were a graduate student, the fellowship could be portable and perhaps extend into the initial stages of a job following the postdoctorate. If the applicant were an institution, department, or investigator, the fellowship could require adherence to guidelines designed to meet the fellowship's stated objectives. In this way, the fellowship could help change the culture of the postdoctorate through its support of institutional change.

A fellowship program of this type could have many benefits. It could enhance career development, foster scientific leadership, and meet specific needs within institutions not usually served by postdocs. It could improve the management of the postdoctoral experience and provide new ideas for how to structure postdoctoral programs. Eventually, a clearinghouse of innovative programs could provide institutions with models of documented successes and allow institutions to benchmark their programs against others.

- Workshop participants often noted the need to loosen and not augment existing hierarchies of status and mobility within academia, particularly as these hierarchies affect the postdoctorate. Individuals who participate in new models for the postdoctorate should not be automatically excluded from consideration for certain professional positions. This is particularly a concern for underserved communities, including women, underrepresented minorities, and persons with disabilities, who should not be shunted into less-valued career paths.
- Many of the individuals who undertake nontraditional postdoctoral appointments are likely to choose nontraditional career paths. Nevertheless, all postdocs need to interact with other scientists on a regular basis, stay current in their fields, and maintain strong research programs. Partnerships between institutions should be as seamless as possible, so that existing distinctions are blurred rather than accentuated. NSF's support for new models for the postdoctorate would help legitimate and promote these programs, so that they receive the respect they will need to be successful.

C. The Need for More Information About the Postdoctoral Experience

New initiatives cannot be successful unless they meet a recognized need. And to establish whether a need is being met, the value of new and existing programs must be assessed.

Measuring the value of a postdoctoral appointment is not easy. Research output is one indicator, but that should not be the only indicator even for a traditional postdoctorate. The problem of measuring non-research outcomes is even more acute for nontraditional postdoctorates that explicitly combine research with other activities.

Much useful information will be generated by a set of surveys of postdocs to be conducted by Sigma Xi beginning in 2004.¹⁸ Survey questions will focus on research activities, career choices and goals, compensation and benefits, interactions with advisors, and perceptions of institutional policies and practices. These surveys will provide institutions, postdoctoral associations, professional societies, and postdocs themselves with considerable information about the numbers and current status and concerns of postdocs. Furthermore, the surveys will be conducted on an ongoing basis, which will provide information about postdocs over time.

¹⁸ <http://postdoc.sigmaxi.org>.

In addition to the Sigma Xi survey, workshop participants identified other assessment needs.

- Assessment mechanisms should be built into new postdoctoral programs from the beginning. These assessments should employ both quantitative and qualitative means, such as those that would be generated in an annual review of a postdoc's activities and accomplishments. Also useful would be long-term tracking of what happens to postdocs at later stages in their careers, including when they get their first job, where they work, reflections on their postdoctoral experiences, their salaries, and so on. This information could be collected and publicized by institutions as a way of promoting the postdoctorate. Information from different institutions also could be collected in a central location, allowing postdocs to compare experiences and institutions.
- In general, the understanding of the characteristics and outcomes of the postdoctorate needs to become much stronger and more comprehensive. Surveys of scientists conducted several years after the completion of their postdoctoral appointments could provide information about the ways in which the postdoctorate proved more and less useful. Longitudinal survey data from individuals who are planning, experiencing, and have completed postdoctoral positions could help answer many questions about the postdoctoral experience. Much more needs to be known about foreign scientists doing postdoctorates in the United States: how many return home, how many stay in this country, and what are their contributions to this nation's scientific enterprise and to that of their home countries if they return following their postdoctoral appointments. Surveys of institutions and researchers could reveal why a postdoctorate appointment has become a *de facto* standard.

In the longer run, even broader assessments of the postdoctorate would be desirable. One workshop participant posed the following challenge: determine what number of postdocs is needed to maintain a society with minimal technological advance, and then determine what number of postdocs is needed to maintain the rate of technological advance of the past 30 years. These numbers could act as upper and lower bounds on the potential population of postdocs and justify policy actions that affect the postdoctorate.

Conclusion

BY CONSTITUTING THE INITIAL STEPS OF A NEW scientist into a professional career, the postdoctorate has become a critical institution within the scientific enterprise. Thus, to strengthen and diversify the scientific and technical workforce and leadership in the United States, the postdoctoral experience must be a sustained focus of attention. The workshop discussed in this report provides an opportunity to enlist the assistance of the NSF in promoting positive change in the goals, nature, and outcomes of the postdoctoral experience.

As one workshop participant said, our goal must be to “honor the past, empower the present, and imagine the future.” In doing so, the workshop participants hoped to create better opportunities for individuals and for the nation as a whole.

Further Reading

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Appendix 2: Workshop Agenda

Postdoctoral Appointments: Roles and Opportunities

An NSF Workshop

MAY 11-13, 2003

NATIONAL SCIENCE FOUNDATION

ARLINGTON, VIRGINIA

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Supported by the Division of Chemistry
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Directorate for Mathematical and Physical Sciences,
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NSF Workshop Postdoctoral Appointments: Roles and Opportunities

Workshop Goals:

The goals of the workshop are twofold:

- to illuminate the processes, characteristics and outcomes of the postdoctoral appointment;
- to identify concepts, opportunities, and priorities for the National Science Foundation uniquely at the postdoctoral level to strengthen science, mathematics, and engineering in the United States and the human resources required to maintain leadership. Activities could include but not be limited to new programs or modifications of existing programs, and could elucidate additional research possibilities to extend and fill in gaps in the understanding of the postdoctorate.

To reach these goals, the workshop will explore how the postdoctoral period—the time immediately following receipt of the doctorate—can be used most effectively in the education and training of scientists. It will examine whether and how components of postdoctoral opportunities could be conceptually extended or modified without diminishing their roles as ways to enhance scientific and technical skills and knowledge. The postdoctorate commonly is the last step before a new scientist enters into an independent professional career. Reexamination and possible broadening of the types of postdoctoral experiences represent a particularly important and timely opportunity because of the need to strengthen and diversify the scientific and technical workforce and leadership in the United States.

AGENDA

Sunday, May 11, 2003 (at Hilton Arlington and Towers, 950 North Stafford Street, Arlington, VA)

- 5:00 – 6:00 p.m. Meeting for breakout session leaders and rapporteurs with Steering Committee
Gallery II
- 6:00 – 7:00 p.m. Registration and reception (cash bar)
Gallery II, Foyer
- 7:00 – 7:15 p.m. Welcome and workshop overview
Gallery II
Willie Pearson, Jr.
Robert L. Lichter
- 7:15 – 7:30 p.m. Welcome and opening remarks
Arthur B. Ellis, Director, Division of Chemistry,
NSF
- 7:30 – 8:20 p.m. Session 1: The Role of the Postdoctorate in the Changing Landscape of Science

Moderator: Robert L. Lichter

The nature, conduct, venue, and practitioners of science change over time, at a rate that unarguably has accelerated in recent years. What have been the key roles of the postdoctorate during that period? What practices are common to postdoctoral positions across institutional, laboratory and even disciplinary settings? What benefits and added value have historically emerged as a result of postdoctoral work, and for whom, particularly in NSF-funded programs? Do these benefits still apply? How does the postdoctorate relate to the availability, nature and expectations of full-time positions?

Plenary Speaker: R. Stephen Berry, University of Chicago and the James Franck Institute
“Postdoctorals: Why and How?”

The postdoctoral associate role became an established niche in the educational pattern of scientists just at the beginning of the post-Sputnik boom in science. Newly available funds made it possible for young scientists to get broader and deeper experience than their doctoral studies allowed, to provide valuable new

kinds of assistance to senior researchers, and to create a “holding pattern” for young scientists seeking positions, during a time when those positions were coming into existence. The postdoctoral period subsequently became almost mandatory for becoming an independent scientist. But the traditional academic world had no automatic pre-existing positions to fit postdoctoral scientists, so the experience adopted a variety of styles, and created problematic situations for some. This talk will give an overview of some of the problems and dilemmas, some associated with academic and governmental institutions trying to deal with a non-traditional “rank,” some with problems of matching expectations of postdoctoral scientists and mentors, some simply with the heterogeneity of styles among the sciences. We may examine provocative ways we might use to deal with some of these problems.

8:20 – 9:30 p.m. **Breakout Session 1**

Group 1	Leader: Greer	Rapporteur: Smith Gallery II
Group 2	Leader: Mitchell	Rapporteur: Donovan Merkert Picasso Suite
Group 3	Leader: Wenzel	Rapporteur: Martinez Renoir Suite
Group 4	Leader: Hartline	Rapporteur: Sullivan DaVinci Suite

Monday, May 12, 2003 (at NSF, 4201 Wilson Blvd.)

- 7:30 – 8:15 a.m. Continental breakfast
Room 555 Foyer, Stafford II
- 8:15 – 9:15 a.m. Full group discussion (reports from Room 555,
previous breakout session groups) Stafford II
- 9:15 – 10:15 a.m. **Session 2: The Traditional Postdoctorate:
Building on Success**

Moderator: Arti C. Patel, National Cancer Institute

NSF currently supports ca. 5,500 postdoctoral researchers. Many more are supported by other sources, including other Federal agencies, industry, private foundations, and academic institutions. Funds for about 95 percent of the NSF-supported postdoctoral positions come from individual investigator grants, center grants, and facility grants. Thus, it is clear that strong interest in the traditional postdoctorate continues to exist. If so, what are its positive features, and for

whom? What information is required to generate a better understanding of the role and impact of the postdoctorate?

Plenary Speakers:

9:15 – 9:45 a.m.

Room 555, Stafford II

**Norma M. Allewell, University of Maryland,
College Park**

*“Student? Apprentice? Employee? Colleague? The
Existential Angst of the Postdoctoral Experience”*

The past decade has been a period of revolutionary change in American science. Great discoveries have been made, new areas of inquiry have emerged, and major changes in the way research is conducted have occurred. One critical aspect of the scientific enterprise that has changed relatively little during this period is the nature of the postdoctoral experience, which many postdoctoral scientists experience as a time of extreme uncertainty and ambiguity. Although many aspire to become faculty members, both their role within the university and their relationship to their mentors are often very poorly defined. Are they students whose major goal should be to broaden and deepen their understanding of science? Apprentices mastering the skills needed to be admitted to the guild? Employees who will be held accountable for their productivity? Or colleagues working together to solve a common problem? They also face major uncertainties about the future. Will they succeed in landing one of those coveted assistant professorships? Should they be contemplating alternative careers, by choice or necessity? These issues have been the subjects of numerous thoughtful studies. However, implementing their recommendations requires the support of the federal agencies. The National Science Foundation has catalyzed many of the very positive changes that American science has undergone in the past decade. This workshop provides an opportunity to enlist the assistance of the National Science Foundation in promoting positive change in the goals, nature and outcomes of the postdoctoral experience.

9:45 – 10:15 AM

Jenny Zilaro, Sigma Xi

“The Sigma Xi Postdoctoral Survey Project”

The Sigma Xi Postdoctoral Survey Project seeks to improve the training and research experiences of postdoctoral researchers by providing a better understanding of the factors that contribute to productive and positive postdoctoral experiences and by enabling institutions to benchmark their postdoctoral policies and practices against those of their peer institutions. Survey questions will focus on postdoctoral scientists’ research activities, their career choices and goals, their compensation and benefits, their interactions with their PIs, and their perceptions of the policies and practices at their institutions. Sigma Xi will create

and make available at no cost to participating institutions a set of resources designed to help postdoctoral offices and associations survey their postdoctoral scientists in an efficient and methodologically sound manner. The package will consist of a professionally worded and tested set of survey questions (that can be extended locally), software for conducting web surveys (hosted and administered by Sigma Xi), professionally designed methodological guidelines, a privacy policy and data protection guidelines that have been vetted by RTI International's IRB, publicity and marketing materials for encouraging survey participation, modest financial resources for local survey expenses, professionally designed data analyses, administrative support, and a set of customized reports. Sigma Xi will help to coordinate a number of these local surveys during the 2003-2004 academic year. Local results will be made available to participating institutions, and the results will be pooled to obtain information about the national population of postdoctoral scientists.

10:15 – 10:30 a.m. Break Room 555 Foyer, Stafford II

10:30 – 11:45 a.m. **Breakout Session 2**

Group 1	Leader: Teich	Rapporteur: Shultz Room 555, Stafford II
Group 2	Leader: McBay	Rapporteur: Raber Room 1005, Stafford I
Group 3	Leader: Ratner	Rapporteur: Walter Room 1020, Stafford I
Group 4	Leader: Knobler	Rapporteur: Neal Room 1060, Stafford I

11:45– 12:45 p.m. Full group discussion (reports from Room 555,
previous breakout session groups) Stafford II

12:45-1:45 p.m. Lunch Room 555 Foyer, Stafford II

1:45 – 2:45 p.m. **Session 3: Examples from the Community:**
A Panel Discussion

Moderator: Joseph A. Gardella, Jr., University at Buffalo, SUNY:

Panelists: Sibrina Collins, Claflin University Room 555,
Tracy Morkin, Columbia University Stafford II
James Vyvyan, Western Washington University
Catherine Woytowicz, Department of State

Postdoctoral Appointments: Roles and Opportunities

Not all postdoctoral positions follow the academic-setting research-only model. Some exist in industry or government labs, some incorporate other activities such as teaching, development of curricula, engagement in policy, or strengthening of communication skills. Panel members will describe their postdoctoral experiences and how they contributed to their professional development.

2:45 – 4:00 p.m.	Breakout Session 3	
Group 1	Leader: Estler	Rapporteur: De La Garza Room 555, Stafford II
Group 2	Leader: Parker	Rapporteur: Seymore Room 1005, Stafford I
Group 3	Leader: Coppola	Rapporteur: Robinson Room 1020, Stafford I
Group 4	Leader: Engstrom	Rapporteur: Lisy Room 1060, Stafford I
4:00 – 4:15 p.m.	Break	Room 555 Foyer, Stafford II
4:15 – 5:15 p.m.	Full group discussion (reports from previous breakout session groups)	Room 555, Stafford II
Evening	Dinner on your own	

Tuesday, May 13, 2003 (at NSF, 4201 Wilson Blvd.)

7:30 – 8:15 a.m.	Continental breakfast Room 555 Foyer, Stafford II	
8:15 – 9:15 a.m.	<u>Session 4: New Opportunities, Models and Missions: A Panel Discussion</u>	Room 555, Stafford II

Moderator: John H. Hall, Morehouse College

Panelists:
Julio DePaula, Haverford College
Morton Hoffman, Boston University
Carter Kimsey, National Science Foundation
Joel Shulman, Procter & Gamble and University of Cincinnati

Panelists will describe existing or potential alternative possibilities for strengthening professional capabilities at the postdoctoral level. Incentives and motivations for establishing these alternatives will be described. Existing or projected impacts will be discussed.

Postdoctoral Appointments: Roles and Opportunities

9:15 – 10:30 a.m.	Breakout Session 4	
Group 1	Leader: Crim	Rapporteur: Nieter Burgmayer Room 555, Stafford II
Group 2	Leader: Roberts	Rapporteur: Watkins Room 1005, Stafford I
Group 3	Leader: Baker	Rapporteur: Fackler Room 1020, Stafford I
Group 4	Leader: Fourkas	Rapporteur: Haak Room 1060, Stafford I
10:30 – 10:45 a.m.	Break	Room 555, Foyer, Stafford II
10:45 – 11:45 a.m.	Full group discussion (reports from previous breakout session groups)	Room 555, Stafford II
11:45 – 12:30 p.m.	Full group development of consensus recommendations	Room 555, Stafford II
12:30 – 12:45 p.m.	Final announcements and adjournment	Room 555, Stafford II