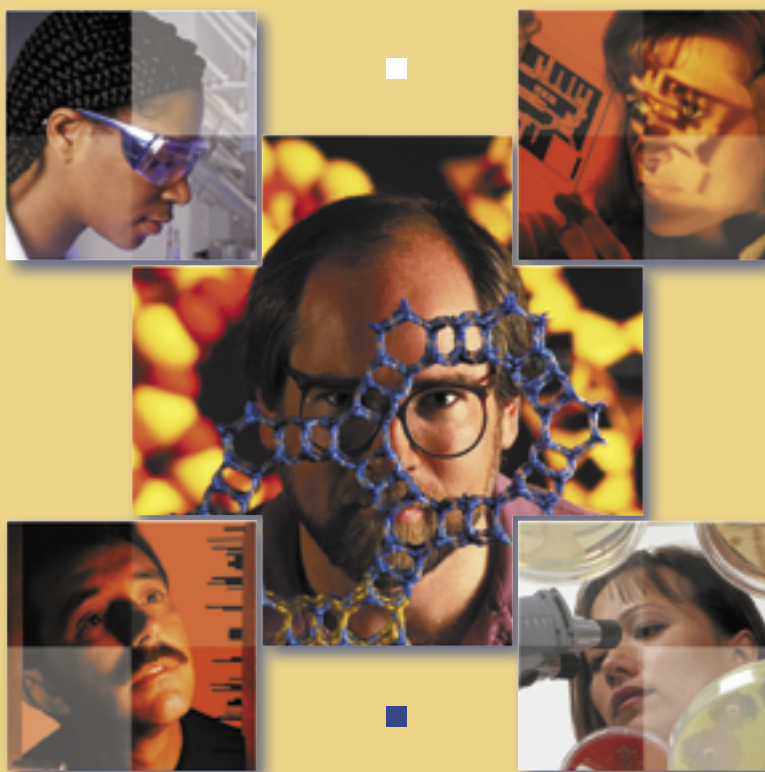


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# DOCTORS WITHOUT ORDERS

HIGHLIGHTS OF THE SIGMA XI POSTDOC SURVEY



■ ■ ■ ■ ■ ■ ■

This project was funded by a grant  
from the Alfred P. Sloan Foundation



# SIGMA XI

THE SCIENTIFIC RESEARCH SOCIETY

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# DOCTORS WITHOUT ORDERS

## HIGHLIGHTS OF THE SIGMA XI POSTDOC SURVEY

Geoff Davis

*This preview of a forthcoming formal survey report summarizes information gleaned from some 7,600 postdoctoral investigators and illuminates this much-neglected tier of the scientific workforce. The results suggest some straightforward measures to make postdoctoral experiences more successful.*



Meet two young scientists, Bob and Alice. You might have run into this fictional pair before, perhaps in reading about quantum physics or cryptography.<sup>1</sup> Here you'll find out a little more about the professional lives and frustrations of these two budding scholars—and many more like them who are hard at work conducting scientific research all across America.

Bob and Alice both recently received their doctoral degrees, and both are now undertaking “postdocs,” short-term apprenticeships that normally begin immediately after obtaining a Ph.D. These newly minted doctors are following a long tradition in science education, one that dates back to the late 19th century. The goal of this august institution is to provide a select group of Ph.D.-holders with additional training and the opportunity to focus on research without having to teach or to be burdened with administrative responsibilities. Postdoctoral years thus represent a kind of academic bachelorhood, a time when promising scholars can enjoy intellectual exploration in stimulating surroundings before ultimately settling down to a career of teaching and research. This freedom from ancillary responsibilities enables these scientists (also dubbed “postdocs”) to be tremendously productive: A 1999 study found that they make up 43 percent of first authors of research articles published in *Science*.<sup>2</sup>

Despite the obvious attraction of such positions, postdoctoral appointments were relatively rare before the 1950s. Postdocs enjoyed moderate growth in their numbers from the 1950s to '70s, followed by a rapid rise in the 1980s and '90s. But that expansion was not deliberate. Rather, it was driven by economic factors—in particular, the burgeoning number of new Ph.D. scientists at a time when faculty positions were increasing only modestly.

So Bob and Alice now find themselves in good company—more than 50,000 other people also hold postdoctoral appointments in the United States.<sup>3</sup> The majority are federally funded (69 percent).<sup>4</sup> Most are doing research in the life or health sciences, but 22 percent are in the physical sciences or engineering, and 4 percent are working in the social sciences or humanities.

When they first took up their positions, Bob and Alice were ignorant of the many concerns that educators and policymakers had voiced about the largely unexamined growth in the population of postdocs. It seems no one had ever suggested that they read *Enhancing the Postdoctoral Experience for Scientists and Engineers*,<sup>5</sup> a report published by the National Academies Press in 2000. Nor had they discovered a 1998 report on postdoctoral education carried out by the Association of American Universities.<sup>6</sup> These works, and a smattering of similar studies dating back to the early '80s, shed light on many of the problems that postdocs have encountered in the past and to a considerable extent still face now. Yet these reports are rarely required reading for graduate students or postdocs.

This oversight is perhaps not so surprising. After all, many educators are not aware of these studies—and those who are may not want to risk discouraging highly talented young scientists. What *is* surprising is how slow administrators at most of the institutions employing postdocs have been in addressing

### TOP RESEARCH AREAS

Molecular Biology	24%
Cell Biology	20%
Biochemistry, Biophysics and Structural Biology	18%
Neuroscience and Neurobiology	13%
Genetics, Genomics and Bioinformatics	13%
Immunology and Infectious Diseases	11%
Chemistry	8%
Developmental Biology	7%
Microbiology	6%
Pharmacology, Toxicology and Environmental Health	5%
Oncology	5%
Physics	4%
Physiology	4%
Psychology	3%
Ecology and Evolutionary Biology	3%
Materials Science	2%
Plant Sciences	2%
Cardiology	2%
Biomedical Engineering	2%
Hematology	2%
Earth Sciences	2%

*Because participants could select multiple categories, the values above sum to more than 100 percent.*

*In other parts of this report, the percentages shown may not sum to exactly 100 because results are rounded to the nearest whole number.*

*Geoff Davis was a postdoc and then an assistant professor in the math department at Dartmouth College (from 1994 to 1998), a researcher at Microsoft (1999 to 2000), and later a software developer. His interests in science education began in 1995, when he established the Web site [PhDs.org](http://PhDs.org). Davis is currently a Sigma Xi Visiting Scholar. E-mail: [gdavis@sigmaxi.org](mailto:gDavis@sigmaxi.org)*

## PARTICIPATING INSTITUTIONS

### UNIVERSITIES

Arizona State University  
 Boston University  
 California Institute of Technology  
 Duke University  
 Emory University  
 Georgetown University  
 Lehigh University  
 Massachusetts Institute of Technology  
 North Carolina State University  
 Rutgers, The State University of New Jersey  
 Stanford University  
 University of California, Berkeley  
 University of California, Davis  
 University of California, Los Angeles  
 University of California, San Diego  
 University of Colorado at Boulder  
 University of Georgia  
 University of Illinois at Urbana-Champaign  
 University of Michigan-Ann Arbor  
 University of North Carolina at Chapel Hill  
 University of Notre Dame  
 University of Pennsylvania  
 University of Pittsburgh  
 University of Wisconsin-Madison  
 Vanderbilt University  
 Wake Forest University  
 Washington University in St. Louis  
 Yale University

the issues raised in these documents. Indeed, much of the initiative for addressing the concerns of postdocs has come from these young scholars themselves, through various postdoc associations or, in the case of the University of Connecticut Health Center, from a bona fide labor union for postdocs.

A big problem hindering efforts to assess the situation of postdocs is that whereas anecdotes are plentiful, real data are scarce. Those that are available are of limited utility. For example, the National Science Foundation's annual data collection about postdocs is limited to a tally of their numbers. The NSF's Survey of Doctorate Recipients only covers the 53 percent of postdocs who earned their degrees in the United States. The more comprehensive surveys have largely been local efforts conducted by postdoc associations, which are impossible to compare across campuses because of large differences in design and focus. Postdocs are indeed a difficult population to study: Many institutions don't even know who their own postdocs are.

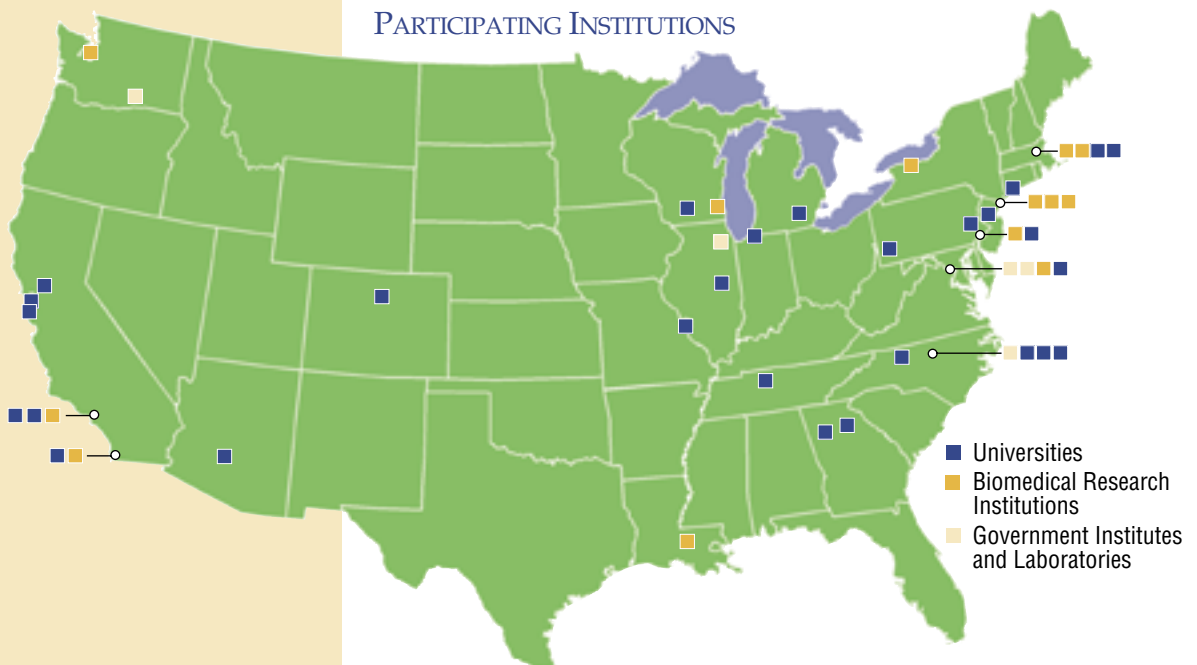
## THE SIGMA XI POSTDOC SURVEY

In 2003, the staff of Sigma Xi, The Scientific Research Society began a multi-campus survey of postdoctoral scholars, one intended to provide a detailed picture of the current state of affairs. We hoped that the results of the survey would enable administrators responsible for postdoc welfare to compare their policies with those of other institutions, thus providing guidance in an area of education that lacks any consistent standards.

To carry out this survey, we partnered with the National Postdoctoral Association, *Science's Next Wave*, an online publication of the American Association for the Advancement of Science, and the National Bureau of Economic Research (under the auspices of its Science and Engineering Workforce Project). The Alfred P. Sloan Foundation provided financial support.

Recruiting institutions for the survey proved challenging because responsibility for postdocs is widely diffused—at many institutions it appears to rest almost entirely at the level of the principal investigator. We sent invitations to participate in our survey to 1,432 provosts and vice provosts, deans, human resources personnel and leaders of postdoc offices and associations at 174 institutions. In the end we enlisted 46 institutions, including 18 of the top 20 academic employers and the largest government employer of postdocs, the National Institutes of Health (NIH).

## PARTICIPATING INSTITUTIONS



*A postdoc position is not a permanent job. I am just testing myself for creativity, independence, ability to understand other fields. I explore. Sometime soon, I will judge myself.*

SURVEY RESPONDENT



We used e-mail to contact the 22,000 postdocs at the participating institutions, roughly 40 percent of all postdocs now at work in the United States. Our message outlined the goals of the survey and described procedures whereby responses could be submitted securely over the World Wide Web, so participants would not have qualms about answering candidly during the half-hour or so required.

Although we had to cajole some of these people, contacting them several times before they responded, we ultimately heard back from more than 7,600 postdocs, or 34 percent of those initially contacted. With such large numbers, the formal statistical sampling errors are, in general, less than 1 percent.

## DEMOGRAPHIC COMPOSITION

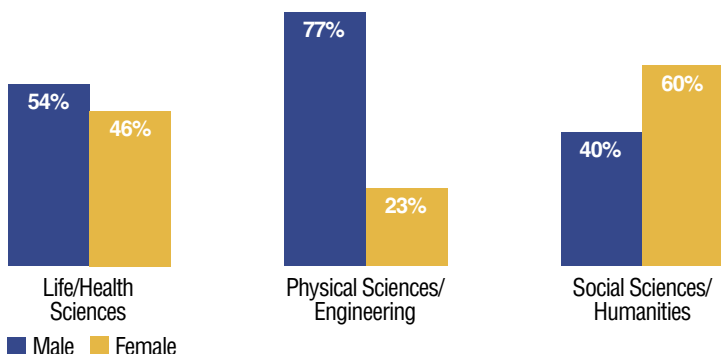
**W**hat did we find out about the makeup of the survey respondents? In a nutshell:

**Sex:** Given recent concerns about low numbers of women in the sciences, we were reassured to find that women constitute a slight majority (51 percent) of the postdocs who are U.S. citizens or permanent residents. The temporary-visa holders (“international postdocs”), however, are mostly men (65 percent). So in the aggregate women constitute 42 percent of all postdocs. Men outnumber women in the life and health sciences (54 percent to 46 percent) and even more so in the physical sciences and engineering (77 percent to 23 percent), but women are a distinct majority in the social sciences and humanities (60 percent to 40 percent).

**Race and Ethnicity:** About three-quarters of the citizens and permanent residents identified themselves as white, 17 percent as Asian, 4 percent as Hispanic/Latino and about the same number as black/African American.

**Citizenship:** People from other countries proved to be in the majority: 54 percent of our respondents hold temporary visas. (Some 40 percent are U.S. citizens and about 6 percent are permanent residents.) The nation of origin

### SEXES BY FIELD



## PARTICIPATING INSTITUTIONS

### GOVERNMENT INSTITUTES AND LABORATORIES

Argonne National Laboratory

National Institute of Environmental Health Sciences

National Institute of Standards and Technology

National Institutes of Health

Pacific Northwest National Laboratory

### BIOMEDICAL RESEARCH INSTITUTIONS

Albert Einstein College of Medicine of Yeshiva University

City of Hope National Medical Center/Beckman Research Institute

Dana-Farber Cancer Institute

Fred Hutchinson Cancer Research Center  
Harvard Medical School

Joan and Sanford I. Weill Medical College & Graduate School of Medical Sciences

Johns Hopkins University School of Medicine

Medical College of Wisconsin

Memorial Sloan-Kettering Cancer Center

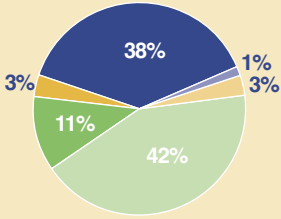
Pennington Biomedical Research Center

The Scripps Research Institute

Thomas Jefferson University

University of Rochester School of Medicine and Dentistry

### CITIZENSHIP AND EDUCATION



Doctorate obtained in US:

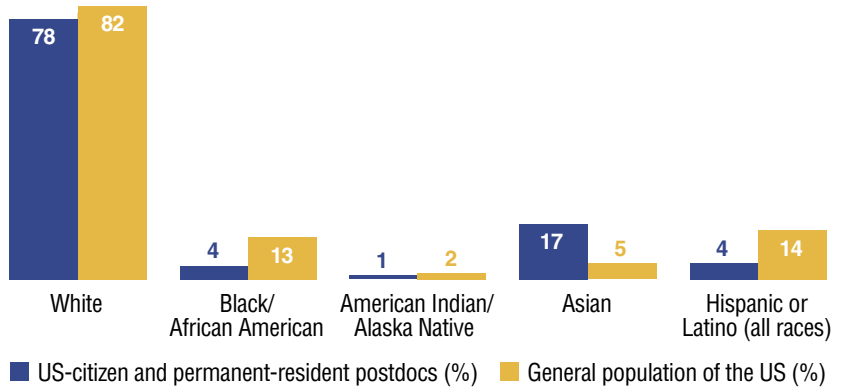
- US citizens
- Permanent residents
- Temporary-visa holders

Doctorate obtained elsewhere:

- US citizens
- Permanent residents
- Temporary-visa holders

### RACE AND ETHNICITY

(PARTICIPANTS COULD SELECT MORE THAN ONE CATEGORY)

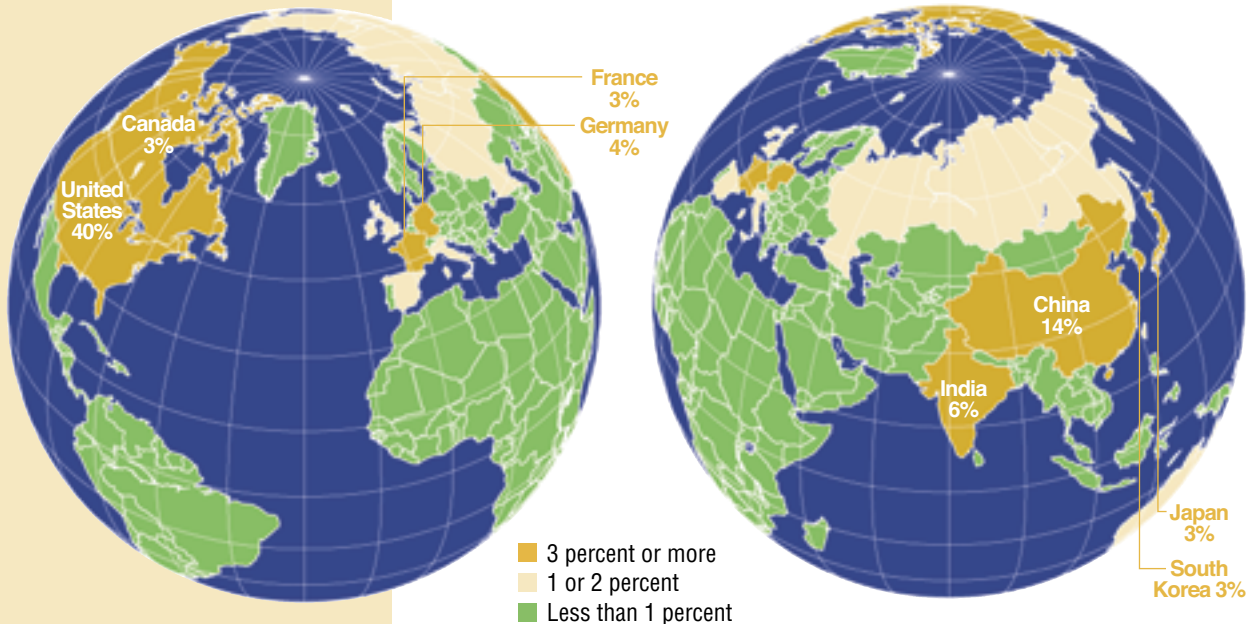


of these visa-holders is most commonly China, followed by India, Germany, South Korea and Japan. Other countries each account for fewer than 3 percent of our respondents. Although one might imagine that many of these international postdocs must have attended graduate school in the United States, our survey indicates that, in fact, most of them (79 percent) obtained their doctorates elsewhere, primarily in their countries of citizenship.

**Age and Family Structure:** Participants proved to have a considerable age spread. Although the majority (58 percent) are between 30 and 35, nearly 10 percent are 40 or older. Most (69 percent) are married or otherwise partnered, and about a third (34 percent) have children.

With this information, a picture of Bob and Alice begins to come into focus. Bob must be a pseudonym: He probably adopted it when he discovered that his Chinese name was too hard for American colleagues to pronounce. But it's a good bet that Alice, like so many other women in her postdoc cohort, is a U.S. citizen. We'll say that Bob and Alice are each 33 and that both are married (but not to each other). One of them has children. But before looking into their situations more closely, one has to ask: As survey participants, are Bob and Alice truly representative?

### COUNTRY OF CITIZENSHIP



## TESTING FOR BIAS

The rate of response we garnered, 34 percent, is on par with surveys of this type.<sup>7</sup> The important question is, are the people who answered representative of the entire postdoc population? For example, might we have tapped into a vein of disgruntled scholars eager to share their negative experiences with us? We tested for possible nonresponse biases in two ways.

First, we compared the demographics of respondents with those at one of the rare institutions having comprehensive records about its postdocs. We were reassured to find that the differences were no more than would be expected from sampling error.

Next we compared responses from the people who completed the survey right away (our hypothetical disgruntled postdocs eager to share) with those from people we had to remind several times (perhaps happy scientists too busy publishing). A common methodological assumption is that those who do not respond to surveys are more like late responders than early ones. Big differences between late and earlier responders provide a red flag for bias. We found no such evidence that our population is uncharacteristically disgruntled (or pleased). It does appear, however, that international postdocs are slightly underrepresented.

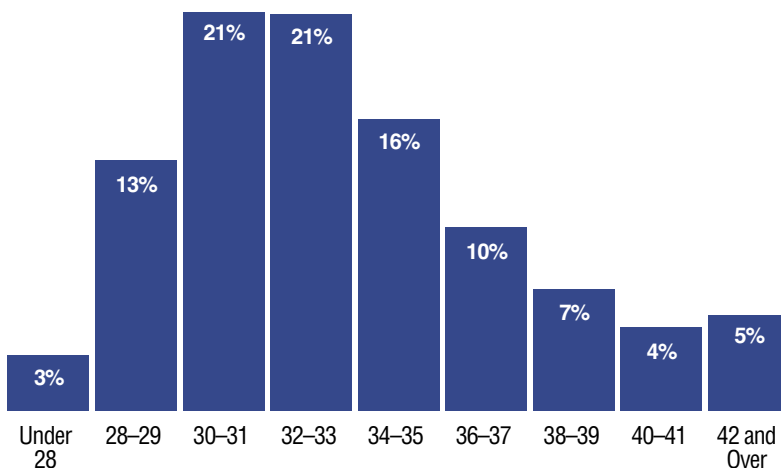
The postdocs we surveyed *are* atypical in one very important way: There was greater administrative oversight over postdocs at participating institutions than is typical. Three quarters of these institutions had either a postdoc office, association or both, and all others had at least one administrator with a strong interest in postdoc welfare—features that allowed us to enlist these institutions in the first place. As a result, our survey respondents are probably better off than the postdoc population as a whole.

## SATISFACTION

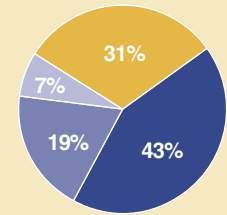
A number of past studies have expressed concerns about dissatisfaction among postdocs, so we were heartened that 70 percent of postdocs report being satisfied overall with their current experience (22 percent are dissatisfied, and 8 percent are neutral). These statistics are comparable with those seen in a random sampling of all workers in the United States.<sup>8</sup> However, things could be much better, given that only 11 percent of Ph.D. scientists and engineers overall report being dissatisfied with their jobs.<sup>9</sup>

Dissatisfaction among postdocs does not stem from any single dominant source. Some complain of low wages or a lack of employment benefits. Some are unhappy with their advisors, and in some cases open conflicts have arisen. Some are stuck in a postdoctoral holding pattern for five years or more. Some struggle with visa issues. Individually, each of these problems affects a small fraction of the population, but their cumulative effect is troubling: Half of all

### AGE DISTRIBUTION



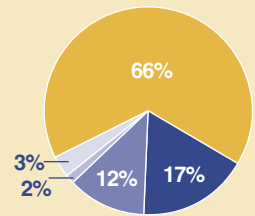
### FAMILY STRUCTURE



Not married/partnered

Married/partnered (69% total):

- Spouse/partner employed
- Spouse/partner not employed
- Spousal employment unspecified



No children

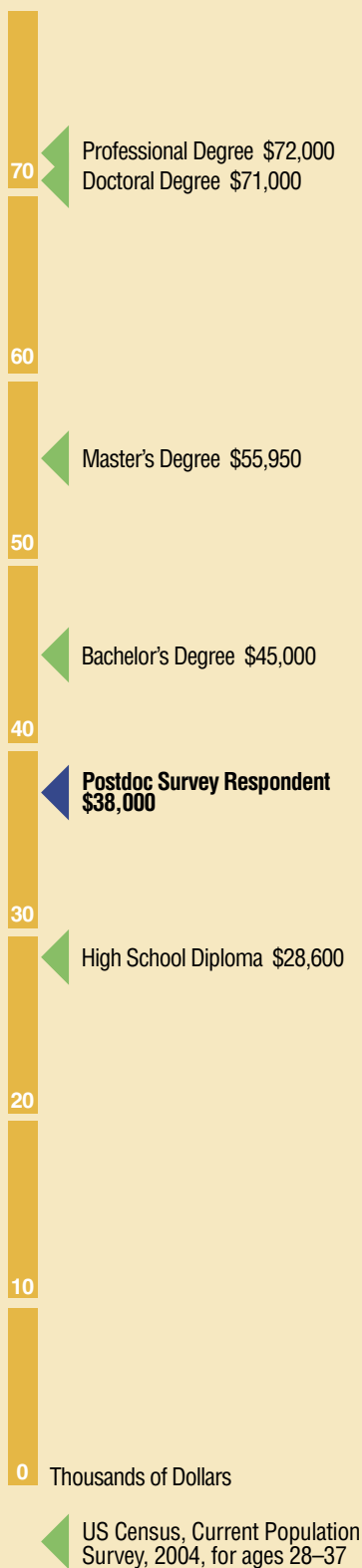
Children (34% total):

- 2 working parents
- 1 nonworking parent
- Single parent
- Parental employment unspecified

*Postdocs have families.  
This is being ignored  
most of the time.*

SURVEY RESPONDENT

## MEDIAN SALARIES



postdocs have experienced one or more of these difficulties. This general finding is reminiscent of what Tolstoy said about families—our version: All happy postdocs are alike; each unhappy postdoc is unhappy in his or her own way.

## EXPECTATIONS

If there is any overarching cause for the troubling undercurrent of malaise, it may be the mismatch between expectations and likely outcomes, which often proves to be the root cause of job dissatisfaction in other spheres. What exactly are postdocs' expectations? Like our hypothetical Alice and Bob, who seek to follow in the footsteps of their former graduate advisors and current faculty mentors, the participants in our survey express strongest interest in working at a research university. A substantial fraction (38 percent) are relatively set in their plans and indicate that they are very interested in working at a research university but only somewhat or not at all interested in working for any other type of organization.

But Bob and Alice would be well advised to consider the reality of their situations. An NSF study found that 35 percent of the science and engineering postdocs from the 1960s through the 1980s were in tenure-track or tenured positions in academia in 1995.<sup>10</sup> (NSF data also suggest that many of these people ended up at liberal arts colleges or comprehensive colleges, not research universities.)<sup>11</sup> Another 15 percent of these former postdocs were in other types of jobs at educational institutions. A different 35 percent went on to careers in industry, and the remaining 15 percent worked for nonprofit organizations or in government.

Given that the growth in the number of science and engineering postdocs over the past decade (2.8 percent per year)<sup>12</sup> has outstripped the rate of increase in the number of full-time science and engineering faculty positions (0.8 percent per year),<sup>13</sup> the fraction of the current postdoc population that will find tenure-track positions will likely be even smaller than in the past. So despite their high hopes, most of the postdocs we surveyed will probably not become faculty members at a research university. Indeed, they will likely end up outside of academia altogether.

Alice and Bob should thus realize that undertaking postdoctoral training with the goal of becoming a professor is a gamble. It might pay off in the end, and it might not. In the meantime, their remuneration is the intellectual pleasure that comes with their rewarding work in research—and modest salaries of not quite \$40,000 a year.

## SALARIES

As postdoc salaries go, Bob and Alice are doing about average. The NSF found that the median salary for postdocs was only \$28,000 in 1995<sup>14</sup> (\$34,700 in 2004 dollars). Since then, funding organizations, both public and private, have made a considerable effort to increase postdoc stipends, and many universities have followed suit. As a result, compensation has increased considerably. The median salary for respondents to our survey is \$38,000, a 10-percent increase since the mid-1990s in inflation-adjusted dollars. This is welcome news. But it's not clear yet that postdocs should be rejoicing.

Consider, for example, how postdocs are doing compared with people of similar age who are not pursuing careers in scientific research. Postdocs earn more than do others in this age bracket (which, for the purposes of comparison with U.S. Census data, we take to be 28 to 37 years) who have just high school diplomas (they earn a median of \$28,600).<sup>15</sup> But Bob and Alice make less than their contemporaries who have only bachelor's degrees (median \$45,000 a year) and considerably less than those with master's (\$55,950) or professional degrees (\$72,000)—and less than Ph.D.-holders in general (\$71,000). If one factors in the 51 hours they report spending at the job each week, postdocs are drawing a rather modest wage of \$14.90 per hour, not much more than the \$14 per hour that janitors earn at Harvard.<sup>16</sup>



*I have actually enjoyed my postdoc. It has exceeded my expectations. But I am a father and need a high-paying position. In hindsight, I wish I had opted for an MBA or law degree and not continued in research.*

SURVEY RESPONDENT



Despite their difficulties keeping up with the Joneses, Bob, Alice and most other postdocs are lucky compared with the 25 percent of our survey respondents who reported that they earn less than \$35,000 (an annual salary that raised concerns with the National Research Council five years ago)<sup>17</sup> and the small but not negligible portion (more than 3 percent) of the postdocs who make less than \$30,000 a year. The survey results highlight another worry: Temporary-visa holders earn about \$2,000 less per year on average than their U.S.-citizen or permanent-resident counterparts, even after controlling for institution, field, years of experience and funding mechanism.

Compensation is a particular concern to the 3 percent of survey respondents who, technically, are only employed part time. Strangely, they report putting in an average of 45 hours per week, more than most full-time workers. In recognition that the designation of part-time status for postdocs carries with it the potential for abuse (if used as an excuse not to offer benefits or to avoid paying the minimum stipend allowed by university rules), some institutions have placed restrictions on this practice. The University of Alabama at Birmingham, for example, prohibits part-time postdoctoral appointments except in special circumstances, such as the birth of a child.<sup>18</sup>

Can postdocs live off what they are paid? Certainly. Can they live well? Probably not. Housing costs are a particular burden for many postdocs, because their host institutions tend to be concentrated in pricey areas. More than 46 percent of our respondents work in one of the 15 most expensive cities in the United States. It helps that most of the married postdocs (who, in all, constitute almost 70 percent of our sample) have spouses who are gainfully employed. On the flip side, at least 28 percent of the married postdocs do not have spouses bringing home a paycheck. The statistic is worse for international postdocs with spouses, 43 percent of whom do not work outside the home, in some cases because of visa restrictions. Of the many single-earner households, nearly half (49 percent) spend more than a third of their income on rent.

## EMPLOYMENT BENEFITS

Fortunately, our hypothetical postdocs, Bob and Alice, are not all that worried about money. They figure they are smart enough to get by. But both are concerned about having health benefits. After all, anyone can get sick. And they have heard too many horror stories from older friends who had to purchase health insurance on their own or risk going without. One reason is that many postdocs who obtain independent funding—often prestigious fellowships—do not automatically get health insurance. Thankfully, some employers now provide equal

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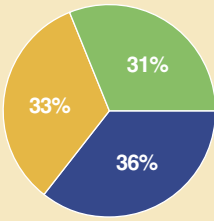
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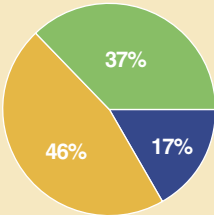
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## PRIMARY MODE OF TRAINING

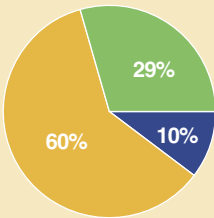
### RESEARCH ETHICS



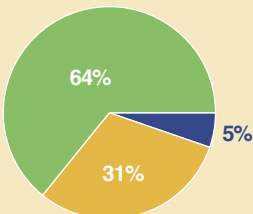
### PROPOSAL WRITING



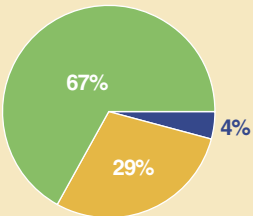
### WRITING SKILLS



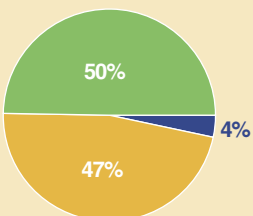
### TEACHING SKILLS



### NEGOTIATING SKILLS

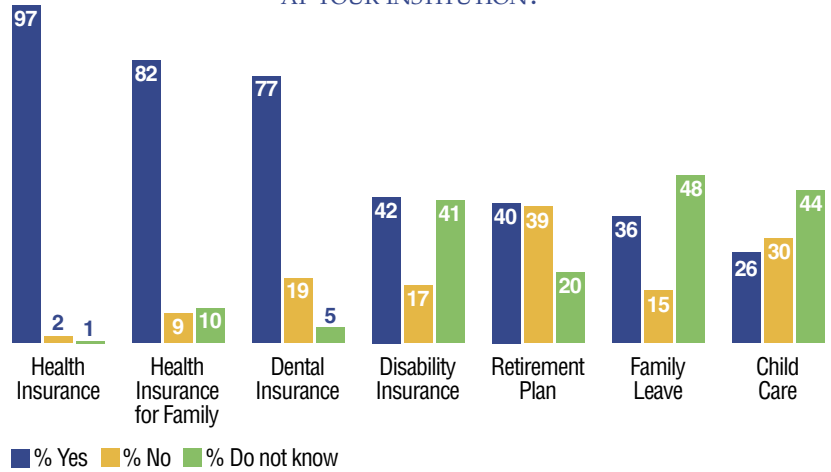


### GROUP OR LAB MANAGEMENT



- Workshop or formal coursework
- Informal, on-the-job training
- No training

## QUESTION: ARE THE FOLLOWING BENEFITS AVAILABLE TO YOU AT YOUR INSTITUTION?



benefits to all postdocs regardless of their source of funding, and the NIH has recently increased the institutional allowance for health benefits associated with its National Research Service Awards.<sup>19</sup> Nearly all the people we surveyed (97 percent) report that health insurance is offered to them. (Regrettably, we do not know whether they had to bear all, part or none of the cost.)

The availability of other benefits is considerably more varied. Our respondents' highest priorities for benefits they wished their employers would provide or improve are, in order, retirement benefits, dental insurance and child care. Understandably, child care ranks first for the 34 percent of postdocs who are raising kids—a fraction that will probably rise, given the steady increase over time in the number of years spent in graduate study.

Easy access to child care and other family-friendly policies are of particular importance to many of the mothers in our survey, who appear to shoulder most of the child-rearing responsibilities in their families. Women with children report working almost six fewer hours per week in the lab than their childless peers, whereas for men the reduction associated with parenting is only three hours per week. This difference may explain part of the 10-percent disparity in publication rates between men and women, something observed both in our survey and in previous studies.<sup>20,21</sup>

## TRAINING AND EDUCATION

So what if Bob publishes a little more frequently than Alice? What matters is quality, not quantity, right? And if the quality of their papers is any reflection of the quality of their postdoctoral experiences, the scales are bound to tip in favor of Alice, who (for the purposes of illustration) we'll imagine is receiving far better training. Indeed, Bob hardly recognizes his postdoc to be professional training at all, matching what we heard from nearly half (43 percent) of our respondents.

Most of the education that postdocs get is informal and experiential, coming primarily from their advisors. On the whole, the people we queried give good marks to their advisors, so this aspect of the system appears to be working well for most. However, a surprisingly large fraction (24 percent) do not consider their advisors to be mentors. So the concerns voiced in the past about the uneven quality of postdoctoral training appear to be well founded.

In recent years, a number of institutions have begun to supplement the usual informal training with coursework and seminars. Still, such activities constitute only a very small part of the postdoctoral experience. Our respondents reported spending, on average, only about an hour in formal training during the week before they completed the survey. And it is clear they are hungry for more.

## CONTROL OF PROJECT

## PLANNING NEW RESEARCH PROJECTS

A majority (62 percent) indicate a desire to improve their skill at crafting proposals, and substantial minorities (40 percent or more) express interest in obtaining training in lab and project management, in writing, in teaching and in negotiating. Some 44 percent report that their advisors encourage them to obtain such education, 48 percent feel no pressure either way, and a small fraction (8 percent) are discouraged from pursuing such training.

The notion that any postdoc might be compelled to forgo training is troubling. One frequently cited problem is that some postdocs do not have control of their work and essentially become just another pair of skilled hands in the lab. A lack of independence is a concern for some of the people we surveyed, 20 percent of whom say they are dissatisfied with the degree of influence they have in decisions affecting their research. Would allowing these investigators greater independence solve their problems? Perhaps. But as we explain below, some of the best remedies will probably require these young scholars to shift gears and move in the opposite direction.

## EXPLORING IMPROVEMENTS

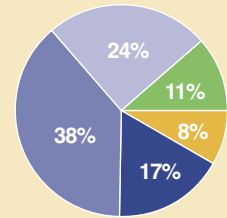
A number of institutions and funding agencies have invested considerable resources in improving the postdoc experience. They have attempted to do so in a variety of ways. Our survey explored some of these strategies, and the results suggest that a few straightforward and inexpensive measures can indeed make a big difference.

One broad area that demands attention might be best classified as administrative oversight and structure. Let's say that Alice's postdoctoral appointment scores highly in this regard. Bob's does not. For starters, Alice received a formal letter of appointment. It specified her compensation and employment benefits, along with university guidelines for vacation and sick leave. Her letter also outlined some of the less concrete terms of her appointment, including her scholarly responsibilities and those of her advisor. It pointed out a page on the university Web site where she could access considerable information about postdoctoral appointments in general and about the outcomes of postdocs from her host department in particular. Bob got a short missive that said little more than "congratulations."

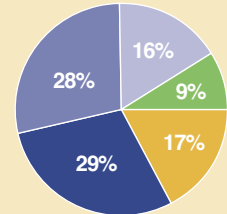
Once Alice arrived at her new academic home, she was given an employee handbook along with contact information for an ombudsperson. The administrator responsible for her training provided her with a copy of the university's policies on authorship, misconduct and the ownership of intellectual property. After being told, "You probably won't need this," she was handed a one-page summary of procedures for resolving grievances. She also received a card that allowed her access to the gym. It was explained to Alice that she would be included in all departmental directories and mailing lists. And she discovered that it would be possible for her to transfer to a different lab, should she wish to make use of that option. Alice found it somewhat daunting that she and her advisor would be required to draw up a formal plan for what they hoped would be accomplished during her two-year stay (and how this work would advance her long-term career goals), but online resources<sup>22</sup> were a big help, and after completing that exercise she was thankful to have been asked. Every six months, she was expected to meet with her advisor for a formal review of her progress. After learning that these procedures were adopted only lately at the behest of the local postdoc association, Alice promptly joined it.

Bob's experience was more typical. After arriving at his host institution, he found his postdoc advisor, who explained little more than where Bob's desk was located and where he was to pick up his monthly paycheck. He and his advisor then launched into matters specific to their research agenda.

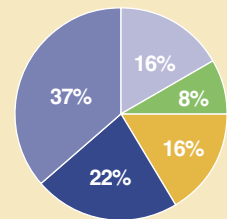
Bob's and Alice's appointments also differed markedly in the degree of formal training they each received. Alice's local postdoc office staged a series of well-attended seminars on everything from proposal writing to teaching to project management, skills that would serve her well whether she ended up in



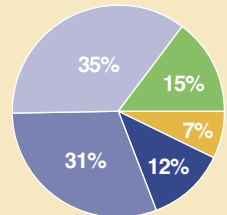
## CHOOSING COLLABORATORS



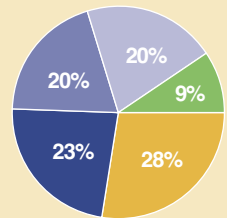
## TERMINATING A FAILING PROJECT



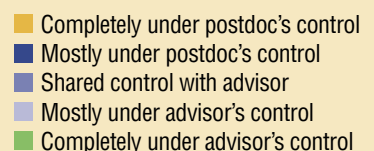
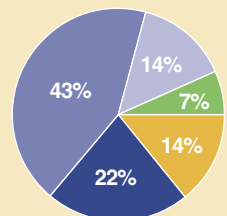
## WRITING PAPERS



## WRITING GRANT PROPOSALS



## DETERMINING AUTHORSHIP



*The life of a postdoc seems very unclear and unfocused. With expectations in research, and with technical, intellectual and career development having not been established at the outset, I feel that I have very much drifted.*

SURVEY RESPONDENT

*I would like some more feedback about expectations and performance—am I up to snuff?*

SURVEY RESPONDENT

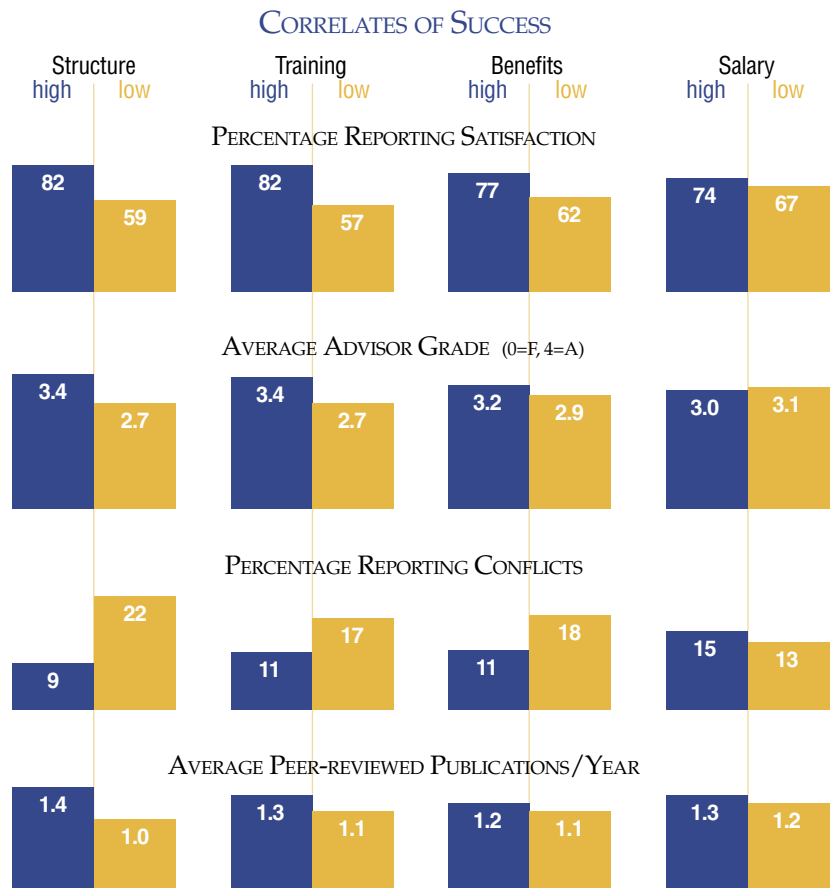
Groups labeled high and low include participants who ranked, respectively, in the upper and lower quartiles of the survey population in each of the four categories shown. Three composite metrics, each accounting for multiple attributes reported on the survey, were used to gauge the level of administrative structure, professional training and employment benefits that the postdoc experienced. Results shown for salary, however, are based simply on the dollar amount reported.

academia, government or industry. In this respect, Alice's host institution was following the examples of the Burroughs Wellcome Fund and the Howard Hughes Medical Institute, which have developed an impressive course in laboratory management,<sup>23</sup> and of Dartmouth College, which has experimented with sending scientists-in-training to its business school.<sup>24</sup> Bob gained mastery of some new analytical techniques, but he learned little that would be particularly valuable (or marketable) should he not eventually land a job in a closely allied field of research.

## CORRELATES OF SUCCESS

These differences in the ways the fictional Alice and Bob were treated represent extremes in the spectrum of conditions our survey participants reported to us—conditions that didn't, in general, reflect their sex, age, citizenship or other personal characteristics. Are the people whose postdoctoral stints match that of Alice better off than those whose experiences more resemble Bob's? To answer that question, we partitioned our respondents according to the extent of administrative oversight associated with their appointments. We determined that rather abstract quantity by assessing 27 different attributes—whether the host institution maintained an office responsible specifically for postdocs, whether performance was formally reviewed and so forth. This procedure provided us with a convenient yardstick for what we assumed to be a beneficial degree of structure (something that varies considerably, even within individual departments). We performed a similar exercise to gauge the formal training available. And we also scored our participants according to the number of employment benefits available to them and according to their salaries.

We then measured the extent to which these general features of the postdoctoral experience—structured oversight, formal training, employment benefits and



*Though it's been tough, in two years I have accomplished an immense amount of work. My advisor went to bat for me to get me access to the resources I needed. I am a very independent person, and no one tried to rein me in.*

SURVEY RESPONDENT



salary—correlate with various measures of success. In particular, we looked at the reported levels of satisfaction, at the quality of the postdocs' relations with their faculty advisors (as measured by such things as the "grade" they gave to their advisors), at the number of conflicts with their advisors and at the quantity of publications and grant proposals the postdocs generated each year.

The results are striking: Postdocs reporting the greatest amount of structured oversight and formal training are much more likely to say they are satisfied, to give their advisors high ratings, to experience relatively few conflicts with their advisors and to be more productive in terms of numbers of publications compared with those with the least oversight and training. Both relations are statistically significant (for all outcome variables,  $p < 0.0001$  for structure and  $p < 0.02$  for training) after controlling for sex, citizenship, funding mechanism, field and institution. A rich set of employment benefits and high salaries are both weakly associated with higher satisfaction but not at all with any of the other positive outcomes.

Of course, correlation does not prove causation, but these results are certainly suggestive—and quite surprising. Although the emphasis has recently been on improving postdoc salaries and making health insurance available to them, the influence of structured oversight and training on the quality of the postdoctoral experience appears to be much greater. It turns out that a single-standard-deviation difference in our measure of structured oversight or of formal training (roughly equivalent to adding a written plan that covers both postdoc and advisor responsibilities and instituting regular, formal reviews) corresponds to the same difference in satisfaction seen in people with salary differentials of \$20,000.

In exploring possible reasons for the observed correlations, we focus on structured oversight for two reasons: First, this set of attributes has the strongest and most consistent association with positive outcomes. Second, our metric for training, the other predictor of success, really measures two different things: the availability of formal training and the extent to which a postdoc avails him- or herself of it. Because of this mixture, one could reasonably argue that the association between training and positive outcomes is simply a reflection of the fact that postdocs who have sought out formal training are especially savvy or industrious. It is much harder to make the case that our measure of structured oversight, which merely tallies the presence or absence of various administrative procedures, suffers from the same problem.

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*As we realize the system is broken, the more intelligent and rational among us are preparing to leave it.*

SURVEY RESPONDENT

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Does structured oversight cause success? In answering that question, one should consider all plausible explanations, including:

**Hypothesis 1:** Structured oversight directly causes greater satisfaction, higher productivity and so forth. This is the most obvious interpretation of the survey data.

**Hypothesis 2:** Structured positions attract people who are by their nature highly productive. We tested this hypothesis by looking at whether our data better fit a model in which the association between structure and productivity extends throughout a person's entire postdoctoral career (which in many cases spans multiple appointments), as would be expected from this hypothesis, or for only the duration of the current postdoctoral position, as would happen, say, if the first hypothesis were true. Our analysis provides evidence against Hypothesis 2.

**Hypothesis 3:** Structured oversight, satisfaction and productivity are all associated with a common (and unobserved) underlying cause. Perhaps the presence of administrative structure is an indicator that the postdoc's university or research group is well run or has ample funding. Maybe the real source of the success is not the structure itself but rather the managerial skills and resources commanded by the scientist running the postdoc's lab. Even if this explanation proves true, the statistical association uncovered here would nevertheless be useful: Postdocs (or graduate students looking to be postdocs) could still use structure as an aid to finding positions that are most likely to benefit them. This interpretation provides less concrete guidance for increasing the quality of the postdoc experience in general, although it does suggest that management training for postdoc advisors might pay off handsomely.

The survey results alone do not definitively rule out any of these three hypotheses, but it would be straightforward to design an experiment that could test them rigorously. A funding agency, such as NSF or NIH, could require such things as research plans and formal feedback of a randomly selected subset of fellowship recipients. Outcomes could then be compared with those for a control group, just as in a clinical trial of a new therapeutic drug.

Although such an exercise would remove any uncertainty, the proposition that some simple changes will broadly improve postdoctoral experiences makes too much sense to ignore while awaiting irrefutable evidence. (Recent reports of the NSF and National Academies recommend similar measures.)<sup>25,26</sup> And indeed, a careful look at the correlations between administrative structure and markers of success (high satisfaction, positive postdoc-advisor relations, reduced incidences of conflict, and increased research output) helps illuminate why such structure in all probability acts to increase satisfaction and productivity.

The yardstick for structure used here has more than two dozen different components. Only one is associated with all four measures of success in a statistically significant way: whether the postdoc and his or her advisor put together a plan at the beginning of the appointment. Five more attributes are associated in a statistically significant fashion with all measures but productivity: (1) whether the research plan covered what the advisor would do, (2) whether the postdoc received a letter of appointment or a contract that specified the advisor's responsibilities, (3) whether the advisor provides the postdoc with formal performance evaluations, (4) whether the postdoc knows of a written policy addressing misconduct and (5) whether the postdoc is able to transfer to a different research group if he or she desires.

Together these six components tell a consistent story. The postdoctoral experience appears to be at its best when the rules of the game are well defined and spelled out in advance. That is, the responsibilities of both the postdoc and the advisor should be clear; there should be checkpoints in the form of performance evaluations so that the postdoc knows how he or she is doing; boundaries of acceptable behavior need to be documented; and an escape route should be available should problems arise.

Of these suggestions, the imperative to formulate a plan at the outset is likely to prove the most effective. Research in both psychology and economics has shown

that often satisfaction is more a function of how one's situation compares with one's expectations than of absolute circumstances.<sup>27</sup> The act of constructing a serious plan of research and career development is a valuable expectation-setting exercise. In our survey, 20 percent of postdocs who drew up no initial plan indicated that their advisor is not meeting their initial expectations, whereas less than 5 percent of those with written plans addressing their own as well as their advisors' obligations report such complaints. Regular evaluations would, presumably, help as well in keeping expectations at a realistic level, as would formal training that educates postdocs about the limited opportunities available in academic research and gives them skills that would be marketable in a variety of careers.

## THE TWO CULTURES

Had Bob and Alice compared notes after a year or two as postdocs, they might have chuckled at the irony. At the outset of their appointments, both of them were probably eager to take advantage of the independence that a postdoc promises. And both probably perceived this freedom to pursue almost any topic, any time of day and on one's own terms as an attractive part of the culture of academic research. Yet in the end, Alice, whose work was structured using the same planning and accountability one finds in the corporate world, gained more during this period of independence. So there will likely be significant cultural barriers to overcome—even among postdocs—before such changes take effect on a wide scale.

The fastest and most effective way to bring about positive changes would be for funding organizations to require a minimum amount of administrative oversight for postdocs. The NIH requirements for training in ethics<sup>28</sup> or the use of animals in research<sup>29</sup> provide a useful model and precedent. But institutions need not wait to act. Their experimentation and innovation will surely shape any requirements that funding agencies may eventually adopt. In the meantime, grant-makers should support institutions in the creation of postdoc offices, the establishment and dissemination of skills-training programs and various other initiatives. Such changes would help address the concerns of those postdocs who are truly struggling—and they would benefit the overall research enterprise too. If these measures were to bring about even a 1-percent increase in average productivity, they would create the research equivalent of some 500 new postdoctoral positions, which would otherwise cost taxpayers tens of millions of dollars each year.

## MONEY WELL SPENT

These survey results, and the policy prescriptions attached to them, do not squarely address what is clearly a fundamental question: Should so many people be receiving so many years of advanced training?

One certainly wonders whether some of these young scientists are being well served, the gap between their expectations and opportunities being often too large to bridge. But assuming that the answer is no might be too harsh—perhaps postdoctoral training is valuable even for those people who ultimately work outside of research in careers they had not previously envisioned. Longitudinal studies of former postdocs would help resolve that key question.

Another reason to seek answers is that the education of these scientists represents a considerable expense, paid largely by the major government funding agencies—each person requiring \$100,000 or more in the form of postdoc stipends, graduate assistantships, research fellowships, tuition and more. So policymakers should certainly scrutinize the current state of affairs. At the very least, those who offer postdoctoral appointments and benefit from the vast amount of research these investigators carry out should do everything possible to help these bright people utilize their considerable intellectual skills in a variety of settings, not just in academia. Such actions would help countless postdocs in establishing rewarding careers while maximizing the value society derives from its considerable investment.

*I may complain about some aspects of the postdoc experience, but I am staying in the game, and I would not have chosen differently if I had to do it over again.*

SURVEY RESPONDENT

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