Evaluation of the Faculty Early Career Development (CAREER) Program

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4201 Wilson Blvd.
Arlington, VA 22230

Prepared by
Jennifer Camey
W. Carter Smith
Amanda Parsad
Karen Johnston
Mary Ann Millsap

With the Assistance of:
Nancy Brigham
Samantha Carney
Beth Gamse
Sonju Harris
Nancy McGarry
Cris Price
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The CAREER program and Impetus for the Evaluation

The National Science Foundation’s Faculty Early Career Development Program (CAREER) is a foundation-wide initiative to provide investigators at the start of their careers with the impetus and resources to integrate research and education. CAREER is the NSF’s primary support mechanism for junior faculty members. Although a central CAREER Coordinating Committee oversees the program, CAREER proposals are submitted to and funded through individual research programs across all of NSF’s Directorates as well as the Office of Polar Programs (OPP). CAREER provides awardees a minimum amount of $400,000 over a period of five years to support the “early development of academic careers dedicated to stimulating the discovery process in which the excitement of research is enhanced by inspired teaching and enthusiastic learning.” Between 1995 and 2005, the CAREER program received a total of 20,403 proposals from 12,989 individual PIs. Thirty percent of PIs who applied during this period received a CAREER award, with ultimately over 234 NSF programs making CAREER awards to 3,881 principal investigators (PIs) at 347 different institutions.

As the program entered its 10th year, NSF contracted with Abt Associates Inc. to conduct an external evaluation of CAREER. This is the final evaluation report. Two earlier evaluations of the CAREER program—one by Abt Associates in 1999 and one by an external Committee of Visitors in 2001—both recommended that NSF continue to assess the impact of CAREER on awardees and their institutions. At the time of the first evaluation, only four years had elapsed since the earliest cohort of awardees had received their CAREER awards. The current study permitted an assessment of longer-term impacts of CAREER on awardees’ professional advancement, research productivity, and engagement in integration that was not possible in the first evaluation. In particular, NSF’s CAREER Coordinating Committee (CCC) was concerned about any potential adverse effects of CAREER on awardees—for example, if the award was perceived as emphasizing educational innovation at the expense of research capability, were awardees disadvantaged in terms of research productivity or receiving tenure? Finally, the evaluation was motivated by strong interest in the extent to which CAREER was fostering the integration of research and education—both at the level of individual awardees and within their departments and institutions.

Evaluation Questions & Study Design

This evaluation was designed to answer the following research questions:

1. How do stakeholders at NSF perceive the CAREER program and its relationship to the mission of NSF?

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1 The minimum award amount in the Biology directorate is $500,000.
3 Beginning in 2002 individual PIs were limited to a total of three attempts to win CAREER. Prior to this, there was no limit on the number of attempts permitted.
2. What is the impact of CAREER on the research activities and career advancement of awardees?

3. What is the impact of CAREER on the integration of research and education by awardees?

4. How do faculty members in departments that host CAREER awardee(s) view the CAREER program and its relationship to their research and educational missions?

To address these questions, the study used a mixed methods design, incorporating multiple data sources. Survey and interview data were used to describe how various stakeholders (awardees, other faculty members, department chairpersons, NSF program staff) perceived the CAREER program (questions 1 and 4). Descriptive analyses of these data described how the goals of the CAREER program were perceived within NSF by program officers from each of the directorates. Next, the study examined how these goals are disseminated outside NSF to potential awardees and their departments, and the extent to which perceptions of stakeholders in the field aligned with NSF’s conceptualization of the program. One important focus was the extent to which CAREER is promoting the integration of research and education, one of the core goals of the program.

To assess the impact of CAREER on awardees (questions 2 and 3), survey, bibliometric, and extant NSF data were collected from CAREER awardees and a comparison group of individuals who applied for CAREER and were declined, but who received other NSF funding between 1995 and 2004. The goal of the impact component of the evaluation was to determine whether awardees would have exhibited the same set of outcomes even if they had not received a CAREER award. To compare outcomes for CAREER awardees and non-awardees we used propensity score analysis (PSA) to control for selection bias at two stages of the study. First, NSF-maintained data on characteristics of applicants for NSF funding were used to select the sample of awardees and non-awardees; second, survey data from the two groups of respondents were incorporated into impact models. PSA reduces the risks associated with selection bias by using a set of observed characteristics other than award receipt to predict, for each individual, a propensity, or likelihood, that the individual would be found in the treated (i.e., awardee) group. Using these assigned propensities, strata were formed such that individuals within each stratum were equally likely to receive the award based on the set of pre-existing observed characteristics (e.g., gender, minority status, number of CAREER proposals submitted, prior receipt of NSF funding, etc.). Subsequent impact models comparing awardees and non-awardees on specified outcomes incorporated the results of the PSA. These methods and their limitations are described in detail in Chapter 1 and Appendix A of the full report. As with any quasi-experimental study, caution is necessary in interpreting the impact estimates.

Although the propensity score analysis can reduce the confounding effect of pre-existing differences on the comparison of awardees and non-awardees, this technique cannot eliminate the chance that some unmeasured pre-existing difference between the two groups accounts for differences in their outcomes. In addition, this study was designed to examine the CAREER program across the Foundation, with representation from each of the directorates that have funded awardees. It is important to note that the study was not designed to provide findings for individual directorates within NSF, nor to allow directorate-to-directorate comparisons. The design also did not permit an examination of interaction effects between observed outcomes for CAREER awardees and characteristics of either PIs (e.g.,

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4 Selection bias leads to invalid conclusions if pre-existing differences between awardees and non-awardees, rather than the CAREER award itself, are responsible for differences in outcomes between the two groups.
discipline, gender, minority status, prior training) or their institutions (e.g., geographic location, research intensity, minority serving institutions).

Data sources and sample selection

Data sources and samples are described in detail in Chapter 1. The data sources used to address each of the research questions included:

- Principal Investigator (PI) Survey of a sample of 1,400 CAREER awardees and 1,800 non-awardees;
- Bibliometric Analysis of a subsample of 300 CAREER awardees’ and 300 non-awardees’ publication and citation histories;
- Department Chair Survey of a sample of the chairpersons of 700 university departments hosting an active CAREER awardee;
- Site visits to 22 departments hosting one or more active CAREER awardees;
- Interviews with 16 members of the CAREER Coordinating Committee (CCC), plus 22 NSF program officers representing a random sample of programs that had made a CAREER award within the past two years; and
- Extant NSF-maintained data on individuals who have applied for NSF funding.

Sample of awardees and non-awardees

A sample of 1,400 awardees was drawn from the universe of all individuals who were awarded a CAREER grant from the inception of the program in 1995 to the Fall of 2004. A comparison sample of 1,800 non-awardees was drawn from the universe of individuals who applied for and did not receive CAREER funding (as of Fall 2004), but who had received other NSF funding as a Principal Investigator (PI) either before applying to the CAREER program, or within 5 years after their first submission to the CAREER program. Awardees and non-awardees were sampled relative to the proportion of total CAREER awards granted by the NSF directorate to which they applied for funding. The final sample consisted of 1,357 awardees and 1,737 non-awardees after ineligibles were dropped. Response rates for the two groups were 84 percent (n = 1,138 awardees) and 80 percent (n = 1,394 non-awardees).

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5 We refer to the survey of CAREER awardees and non-awardees as the Principal Investigator survey (members of each group had received NSF funding as PI as a condition for inclusion in the study sample).

6 The CAREER program made its first awards in 1995. We selected October 1, 2004 as a cutoff for inclusion in the study in order to allow Awardees sufficient time to begin implementing grant activities prior to completing the PI survey, fielded in the 2006-07 academic year.

7 Other NSF funding was defined as an NSF single-PI grant, excluding postdoctoral awards, travel grants, workshop or conference support. Power calculations reveal that this sample yields a minimum detectable effect size of 0.12 in outcomes between CAREER awardees and non-awardees (see Appendix B).

8 For example, if the number of CAREER Awardees from the MPS directorate represented 25 percent of all CAREER awards between 1994 and 2004, then we drew our sample such that 25 percent of the selected Awardees had applied to the MPS directorate.

9 Because our response rates were 80 percent and higher for both the awardee and non-awardee groups, we do not report a non-response bias analysis.
To conduct a bibliometric analysis of publication and citation histories, we drew a subsample of 300 awardees and 300 non-awardees from the existing sample of PIs. For each of these PIs, articles indexed in the Science Citation Index (SCI), the Social Science Citation Index (SSCI) were searched to determine each PI’s:

- Total number of publications after the last CAREER application; and
- Mean number of citations per paper after the last CAREER application.

**Department chairpersons**

To examine the perception of the CAREER award in, and its influence on, host departments, we sampled 700 department chairs in departments representing each of the eight NSF directorates across 217 institutions. Departments with at least one active CAREER awardee were targeted for selection. The number of departments sampled to represent a given NSF directorate was proportional to the number of departments to which a given directorate had directed CAREER funding. After eliminating ineligible departments, 674 department chairpersons were invited to participate in the survey. Of these, 564 responded, for a response rate of 84 percent.

**Site visits**

A purposive sample of 22 departments with at least one active and one past CAREER awardee in 11 universities was selected for site visits. Interviews were conducted with both active and past CAREER awardees; other junior faculty (including non-awardees and non-applicants); senior (i.e., tenured) faculty; department chairs; and university administrators.

**Interviews with NSF program officers**

To examine views of the CAREER program within NSF, we selected a sample of 25 programs within each of seven directorates. Only programs that made at least one CAREER award in 2004 or 2005 were chosen for the sample. One program officer from each program selected was interviewed. We also interviewed members of the CAREER Coordinating Committee.

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10 The subsample was drawn to preserve the same proportional representation of NSF directorates as existed in the survey sample of PIs. The impact models required data from the PI survey (i.e., to calculate a propensity score); thus any PI in the bibliometric subsample without survey data was excluded from impact analyses. Of the 600 PIs in the bibliometric subsample, 147 failed to complete the survey, requiring that they be excluded from analyses; publication data for 11 other PIs could not be located in the citation indices. The final bibliometric analysis sample included 223 awardees and 219 non-awardees.

11 Bibliometric data were collected for each PI between 1990 and 2006. Thus, for each PI, the total number of publications between the year after last CAREER application and 2006 was used as the outcome, while the total number of publications from 1990 through the year of the last CAREER application was included as a covariate to control for pre-existing differences between awardees’ and non-awardees’ publication records.

12 Twenty-six departments were ineligible: for three departments, the chair had participated in a pilot test of the survey; an additional 23 departments had merged into another department and so did not have their own chairperson who could respond to the survey.

13 The Office of Polar Programs was not selected for this part of the study, due to the small number of CAREER awards granted.
Key Findings

Below we highlight key findings of the study related to the study’s four research questions. Relevant tables and chapters of the full report are referenced in parentheses for readers wanting more information.

How do stakeholders at NSF perceive the CAREER program and its relationship to the mission of NSF? (Chapter 2)

Individual program officers at NSF play a key role in articulating the goals of the CAREER program. They advise potential applicants on a range of matters including whether or not to apply for CAREER, where to direct a particular proposal, and the criteria on which CAREER proposals are evaluated—including the requirement that applicants propose an integrated research and education plan. During the review phase, program officers educate panelists about the criteria on which CAREER proposals should be judged. Interviews with 22 NSF program officers in each of the directorates point to several key findings.

Goals of the CAREER Program
Program officers across the Foundation identified three overarching goals for the CAREER program:

- **Goal #1: SUPPORTING PROMISING RESEARCHERS:** CAREER should launch the careers of talented new scientists and engineers by providing five years of stable, long-term support.

- **Goal #2: REWARDING THE BEST RESEARCHERS:** CAREER awards should recognize exceptional leaders in the field. CAREER funding is highly prestigious and serves to identify and reward the best and brightest “rising stars” in a discipline.

- **Goal #3: PROMOTING THE INTEGRATION OF RESEARCH AND EDUCATION:** CAREER should promote the integration of research and education by encouraging a generation of scholar-scientists to view research and education as complementary, mutually reinforcing activities.

The adoption and prioritization of these purposes varies across directorates, and sometimes even across programs within a single directorate, but program officers in each directorate acknowledged all three goals. Goals #1 and #2 are somewhat at odds with each other. While program officers in some programs make CAREER awards only to the premier candidates, other program officers want all faculty members in the early stages of their careers to apply to CAREER, and they seek to make as many awards as possible. In contrast, program officers across the Foundation consistently agreed that CAREER applications are different from other “regular” research grant applications because they must propose education activities and a plan for the integration of research and education (Goal #3).

Defining integration

From its inception, the CAREER program has required potential awardees to describe how they will integrate research and education. However, what that integration means has changed over time, as reflected in the language of the solicitations over the life of the program. Two distinct meanings of the integration of research and education emerge from a review of CAREER program solicitations between 1994 and 2005.

1. The description of “integration” emphasized in earlier solicitations suggests that awardees should pursue a professional career that combines both high quality research and high quality education:
that is, the awardee’s career should be an integrated one in which both research and education are valued and pursued with vigor. Awardees are expected to be both the most promising researchers and the most promising educators, but excellence in these two spheres can be pursued separately.

2. In contrast, the description of integration prominent in more recent solicitations is that awardees’ research and educational activities should themselves be mutually reinforcing; research should inform the learning process, and the learning process should inform the research agenda. Awardees should be not only the most promising researchers and the most promising educators, but should implement activities that facilitate synergies between research and education.

While there was consensus among program officers that CAREER’s strong emphasis on the integration of research and education is greater than traditional research grants, program officers were not in agreement as to what “integration of research and education” actually means, and both of the definitions derived from the solicitations emerged in interviews. Interviews with NSF program officers in each of the directorates suggest several findings about how program officers interpret CAREER’s emphasis on the integration of research and education:

- Program officers widely agree that the integration of research and education is a distinguishing feature of the CAREER award that receives a strong emphasis in the review process. While all research proposals at NSF must address NSF’s “broader impacts” criterion, program officers state that CAREER’s emphasis on the integration of research and education is stronger than in regular grant competitions. To win a CAREER award, a strong research proposal is necessary but not sufficient, which distinguishes CAREER from regular research grants.

- Program officers support CAREER’s encouragement of junior faculty to integrate research and education from the start of their careers, as a means of enhancing awardees’ abilities as teacher-scholars and to foster integration among the junior faculty members who will one day be leaders in their institutions and fields. Virtually all program officers describe CAREER as a mechanism through which NSF encourages faculty members to focus on more than just research, and some program officers also view CAREER as a way to bring about institutional change in academic universities by increasing academic faculty members’ emphasis on the integration of research and education.

- Although the CAREER solicitation explicitly calls for applicants to address three distinct components in their CAREER proposal—the proposed research project, the proposed educational activities, and how the research and educational activities are integrated with one another—program officers almost always spoke of awardees’ plans for integrating research and education and their educational plans as interchangeable. This finding mirrors that of the 2006 Committee of Visitors, which reported that “the panel was unclear on the meaning of the integration of research and education components.”

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14 NSF began reviewing grants under two criteria (intellectual merit and broader impacts) during the 2000s. “Broader impacts” is defined as activities that: advance discovery and understanding while promoting teaching, training and learning, broaden the participation of underrepresented groups (e.g., gender, ethnicity, disability, geographic, etc.), enhance the infrastructure for research and education, such as facilities, instrumentation, networks and partnerships, disseminate results broadly to enhance scientific and technological understanding, and/or benefit society in other ways.
**Supporting Diversity**

In addition to weighing the three goals outlined above, many CAREER program officers also consider other applicant characteristics in the selection process, and expressed an implicit desire to increase the diversity of CAREER awardees across a variety of dimensions, including institutional size, type, and geography; whether the applicant's institution is from an EPSCoR state; whether the applicant is from an underrepresented group (such as women, minorities); and how “hot” the research topic is. Analyses of NSF proposal and award data on this population of awardees reveals that:

- Three-fourths of the population of CAREER awardees funded between 1995 and 2005 were male, and, of those reporting race/ethnicity, 92 percent were white or Asian.\(^{15}\)
- Eleven percent of all CAREER awardees came from EPSCoR states; two percent were from minority serving institutions.
- Twenty-nine percent of awardees had already held an NSF grant prior to winning CAREER.
- Just under half (48 percent) of awardees applied from universities that devoted 40 percent or more of their academic expenditures (research and education combined) to research.

An examination of the characteristics of PIs for CAREER proposals received versus those awarded indicates that some of these characteristics appear to be correlated with higher success rates. Proposals from women, prior NSF grantees, and faculty members at more research-intensive institutions had an advantage relative to their representation in the applicant pool (Exhibits 2.8 and 2.9).

**What is the impact of CAREER on the research activities and career advancement of awardees? (Chapters 3, 4 and 5)**

The most common reasons cited by active\(^{16}\) CAREER awardees for applying to CAREER were CAREER's importance in tenure review (78 percent) and CAREER's prestige (66 percent), reflecting a perceived benefit to professional career advancement.\(^{17}\) Although awardees did not regard winning a CAREER award as a requirement for tenure, nearly half (49 percent) of awardees reported that junior faculty members within their departments were expected to apply for CAREER (Exhibit 3.3).

After receiving their CAREER award, all CAREER awardees report positive benefits from their CAREER award for their own professional development. The benefits most frequently cited by past awardees were support for their own research (98 percent) and enhancement of tenure review (96 percent). Awardees also valued CAREER’s expansion of their research program by enabling them to pursue new research topics (50 percent). When it came to pursuing additional funding, CAREER awardees reported both that CAREER freed them from having to apply for other research funding (51 percent) and enabled them to leverage other funds to support their research (58 percent) (Exhibit 4.4).

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\(^{15}\) Because five percent of awardees do not report their race or ethnicity to NSF, the reported percentage of awardees who are white or Asian may under- or over-estimate the true percentage.

\(^{16}\) In this report, active awardees are those whose award period was still active at the time they completed the survey (between October 2006 and March 2007).

\(^{17}\) The results tally to more than 100 percent because respondents could check more than one response.
Quasi-experimental impact analyses incorporating propensity score analysis were used to examine the impact of CAREER on awardees relative to the comparison group of non-awardees. Data for these analyses came from awardee and non-awardee survey responses. Exhibit E.2 on page 13 summarizes these impacts.

With respect to professional advancement, three findings emerged:

- Awardees were significantly more likely to have earned tenure by the time of survey completion than were non-awardees who had had equal opportunity to earn tenure (Exhibit 5.1);
- Awardees were no more or less likely than non-awardees to have earned the rank of Full Professor by the time of survey completion (Exhibit 5.2);
- Awardees who changed institutions after receiving CAREER were significantly more likely to move to more research-intensive institutions\(^\text{18}\) than were non-awardees who changed institutions after receiving a comparison NSF grant (i.e., the grant that made them eligible for the study) (Exhibit 5.4).

With respect to this latter finding, it is important to note that equal proportions of awardees (29 percent) and non-awardees (29 percent) changed institutions post-award; however, awardees’ appear either to be more inclined or to have a greater opportunity to move to institutions that place a greater emphasis on research than their pre-award institution.

To examine the impact of CAREER on research productivity, we conducted analyses on two different samples: the full sample included all awardee and non-awardee survey respondents; the bibliometric subsample included 223 awardees and 219 non-awardee survey respondents for whom extant publication and citation data were available in two citation indices. In the full sample,

- There were no statistically significant differences between the amount of time that awardees and non-awardees devoted to research or to instructional activities (Exhibit 5.6);
- Between 2004 and 2006, awardees (both active and past) reported that they produced, on average, 19 publications of various types (including articles in peer-reviewed journal, chapters in edited volumes, technical manuals, research monographs, textbooks, edited volumes or other books and conference publications)\(^\text{19}\). Non-awardees were equally productive during this period, producing 18 such publications on average; there was no statistical difference between these totals (Exhibit 5.5b).

\(^{18}\) The measure of research intensity used was the percent research expenditure of an institution, defined as the ratio of expenditures on research to expenditures on research and instruction combined; data on expenditures for each institution of higher education were derived from the Integrated Postsecondary Education Data System (IPEDS).

\(^{19}\) To reduce respondent burden and prevent possible recall bias, principal investigators were asked to report publications only within the two most recent years at the time of survey completion. Asking about a longer time period would have likely required PIs to look up publication data—an undue burden—or to base their responses on memory, likely introducing recall biases into the data. Analyses comparing awardees and non-awardees controlled for the total number of years elapsed between 2007 and the date that PIs received their Ph.D.
Thus, the CAREER award does not increase or decrease awardees’ research productivity from what it would have been in the absence of the award.

This finding was supported by examining extant rather than self-reported data for a subsample of PIs in the study. For PIs in the bibliometric subsample, we examined PIs’ number of papers and citations in indexed, peer-reviewed publications after the date of their last CAREER application (i.e., for awardees, after their successful CAREER proposal; for non-awardees, after their final unsuccessful CAREER proposal). To determine the unique impact of CAREER, these analyses controlled for the number of publications (or mean citations per paper) prior to last CAREER application (a pre-existing characteristic that could differ between awardees and non-awardees) and for the number of years between 2007 and the date of the PI’s receipt of the doctorate (to control for the fact that some PIs may have had a longer period of years in which to accrue publications and citations). Analysis of the sub-sample indicated that:

- Awardees and non-awardees in the subsample produced, on average, equivalent numbers of publications after their last application to CAREER (Exhibit 5.5a);
- There was no statistically significant difference between the mean number of citations per paper for awardees and non-awardees in the subsample (Exhibit 5.5a).

**What is the impact of CAREER on the integration of research and education by awardees? (Chapter 7)**

Sixty percent of active CAREER awardees cited alignment between CAREER’s emphasis on integrating research and education and their own goals as one of the reasons they applied for CAREER funding (Exhibit 3.3), and 43 percent of awardees noted that CAREER provided them with an opportunity to pursue an educational activity that subsequently benefited their research (Exhibit 4.4).

Because CAREER applicants are encouraged to propose original and innovative education plans that integrate with their research plan, it was not possible to create a single, common rubric to measure the degree to which awardees integrate research and education. Indeed, the CAREER solicitation explicitly acknowledges that integration may take on different forms in different disciplines. Neither members of the CAREER Coordinating Committee, NSF program officers nor awardees interviewed agreed on a common definition for integration. Instead, respondents described various activities as examples of integration; these examples tended to be descriptions of educational activities. To assess integration, the evaluation team reviewed CAREER solicitations and consulted with NSF to develop a list of activities that could be regarded as integrative. Exhibit E.1 groups these activities into three categories: engaging with graduate students; engaging with undergraduate students; and engaging in outreach beyond the university.\(^{20}\) This list was not intended to be comprehensive; PIs could be engaged in activities not listed in Exhibit E.1 that could also be considered integrative. Since both awardees and non-awardees were asked to report which of these activities they had conducted in the previous year (i.e., 2005-06), the activities were not labeled explicitly as “integrative” or otherwise related to CAREER.

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\(^{20}\) Although NSF staff did not necessarily regard publishing with graduate students as an integrative activity, some CAREER awardees did. Thus we include it in Exhibit E.1 to show the range of professional activities about which respondents were asked.
Activities that active and past awardees reported conducting in 2005-06 (multiple responses possible)

<table>
<thead>
<tr>
<th>Type of activity</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engaging with graduate students</td>
<td></td>
</tr>
<tr>
<td>Publish or submit a paper with a graduate student as author</td>
<td>94%</td>
</tr>
<tr>
<td>Establish an industrial internship program for graduate students</td>
<td>8</td>
</tr>
<tr>
<td>Engaging with undergraduate students</td>
<td></td>
</tr>
<tr>
<td>Supervise an undergraduate student research project or thesis</td>
<td>78</td>
</tr>
<tr>
<td>Discuss current research in an undergraduate course</td>
<td>74</td>
</tr>
<tr>
<td>Publish or submit a paper with an undergraduate student as author</td>
<td>41</td>
</tr>
<tr>
<td>Require undergraduates in a course to design and carry out an original research project (beyond a literature review)</td>
<td>28</td>
</tr>
<tr>
<td>Conduct research on how undergraduates learn STEM concepts</td>
<td>7</td>
</tr>
<tr>
<td>Establish an industrial internship program for undergraduate students</td>
<td>4</td>
</tr>
</tbody>
</table>

| Engaging in outreach beyond the university                |         |
| Talk with elementary, middle, or high school students about own field or research | 46      |
| Collaborate with elementary, middle, or high school teachers or staff on developing STEM curricula or teacher preparation | 19      |
| Engage local community college faculty or students in conversations or projects related to my field or research | 16      |
| Develop a museum exhibit or event to foster public interest in STEM | 9       |

Exhibit reads: Ninety-four percent of CAREER awardees (active or past) reported publishing or submitting for publication a research paper with a graduate student between 2005-2006.

Notes:
a Activities were not necessarily those directly funded by CAREER because respondents included both active and past awardees.
b Percentages add to more than 100 percent because respondents could check multiple responses.
Sources: PI Survey

Without a clear definition of integration, a single, direct test of the impact of CAREER on the integration of research and education was not possible. Instead, we examined the impact of CAREER on six outcomes deemed to be representative of the integration concept. Exhibit E.2 on page 13 shows the results of these impact analyses.

- CAREER had no statistically significant impact on awardees’ engagement of undergraduates in research: there were no statistically significant differences between the percentages of awardees and non-awardees who published a paper with an undergraduate; discussed their current research in an undergraduate course; required undergraduates to conduct an original research project; or supported an undergraduate on an NSF award (Exhibit 5.7).\(^{21}\)

\(^{21}\) Only PIs with a currently active CAREER award or Comparison NSF grant were asked whether or not they were using funds to support undergraduates.
• CAREER had no statistically significant impact on awardees’ development of museum exhibits or other events to spur public interest in STEM topics (Exhibit 5.8).

• CAREER had a statistically significant impact on awardees’ engagement with K-12 teachers and students: 54 percent of awardees, compared to 47 percent of non-awardees talked with elementary, middle, or high school students about their field or their research; collaborated with elementary, middle, or high school teachers or staff on developing STEM curricula or teacher preparation; and/or conducted research on how elementary, middle, or high school students learn science, mathematics or engineering (Exhibit 5.8).

Thus, we conclude that CAREER does not appear to enhance awardees’ inclination to involve undergraduates in research or conduct outreach activities for the general public beyond what they would have done in the absence of the award, but does appear to increase awardees’ engagement with K-12 students or teachers. However, it is unclear to what extent NSF considers awardees’ outreach to K-12 schools an “integration” of research with education; aside from those PIs actually researching how K-12 students learn STEM concepts, awardees may have pursued K-12 educational outreach as a separate activity in addition to—but not necessarily synergistic with—their research. If the goal of CAREER is to encourage the most promising researchers to serve as educational ambassadors beyond the university, then this finding may be viewed as evidence for a positive impact of CAREER on the integration of research and education. If, however, the goal of CAREER is to encourage awardees to pursue research and educational activities that are themselves mutually reinforcing—that is, such that research informs education and education informs research—these data do not provide evidence for integration one way or the other.

The lack of a clear definition at NSF for the integration of research and education limited the study’s ability to assess adequately the impact of CAREER on this goal. If integration refers to outreach to K-12 students and teachers, then the study provides some evidence that awardees are more likely than non-awardees to engage with the K-12 community. However, if integration refers to a PI’s ability to create a synergism between educational and research activities, such that the investment in education returns dividends to research, and vice versa, then the study provides little evidence one way or the other about the impact of CAREER on promoting this latter goal. This does not mean that this form of integration is not occurring, only that this study was not designed to measure it. Determining whether CAREER awardees are more likely than non-awardees to meet this second interpretation of integration would likely require a detailed review by content experts of research and educational activities undertaken by PIs in particular disciplines.

How do faculty members in departments that host CAREER awardee(s) view the CAREER program and its relationship to their research and educational missions? (Chapter 6)

Responses from the department chair survey and interviews with faculty members during site visits provide some insight into ways in which faculty members in departments that host CAREER awardees view the CAREER program, as well as ways in which CAREER awardees are perceived to influence other faculty members and/or departmental policies and procedures. Unlike the impact data reported above, there are no comparison data for findings of departmental effects. As a consequence, it is impossible to know the counterfactual—i.e., whether other grants would have provided CAREER awardees and subsequently their departments and institutions with the same types or level of benefits described here in the absence of CAREER awards. It should also be noted that the perceptions reported here represent those of faculty members and department chairs within departments that were currently
hosting a CAREER awardee at the time of data collection. So these findings are not representative of all academic departments or even all academic departments from which faculty members apply for CAREER funding – only those that have been successful in recent years.

According to department chairs, applying for a CAREER award is essential for junior faculty in many departments and winning a CAREER award is perceived as a significant factor in tenure decisions. Department chairs shared awardees’ perception of the importance of CAREER: while less than two percent strongly agreed that the CAREER award is viewed within their department as a requirement for tenure, 93 percent agreed that winning a CAREER award serves as an important stepping stone to advancement within the department. This stems in part from the fact that CAREER is viewed as a substantial, prestigious research award, with 75 percent of department chairs reporting that the CAREER award is the most prestigious award in their discipline. Site visit interviews also revealed that in the tenure and promotion process, the CAREER award is viewed as an external endorsement of the quality of a PI’s research, but not a factor in judging the candidate’s capacity as an educator.

Departments typically do not provide CAREER awardees with support beyond that provided to all faculty members, or treat them differently from other faculty members (Chapter 3). Department chairs do, however, perceive some influence of CAREER awardees on other faculty members and on the department in general. According to department chairs, the presence of CAREER awardees in a department has a far stronger effect on the research side of the university culture than on the education and integration side. As a result of CAREER’s perceived prestige, the effect most widely perceived at the department level was CAREER’s strong influence in increasing departmental prestige (81 percent). Many department chairs also report that CAREER helps increase the supply of funding for graduate students (57 percent), and improves the overall quality and quantity of faculty-led research (49 percent). CAREER’s strongest effect on education was perceived to be in driving the development of new courses (45 percent), and 30 percent of chairs reported that the presence of CAREER awardee(s) in their department has increased the value placed by departmental faculty on the integration of research and education (Exhibit 6.1).

The CAREER award is not perceived as a catalyst for change in institutional practices and policies, although when the CAREER award matches the organizational goals of the department or fills an organizational need, the award can subtly change the culture of departments, particularly those with a high proportion of awardees. CAREER awards were characterized as especially useful in departments whose faculty specialize in disciplines most heavily funded by NSF, were upgrading their emphasis on research, or were revamping or reorganizing their departments through their junior faculty.
## Exhibit E.2

### Impact of CAREER on awardees

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Mean¹</th>
<th>Awardees</th>
<th>Non-awardees</th>
<th>Estimated Impact</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Professional advancement</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percent earned tenure by survey completion date³</td>
<td>81</td>
<td>70</td>
<td>11</td>
<td>&lt; 0.001</td>
<td></td>
</tr>
<tr>
<td>Percent earned Full Professor by survey completion date³</td>
<td>27</td>
<td>26</td>
<td>1</td>
<td>0.79</td>
<td></td>
</tr>
<tr>
<td>Difference in percent research expenditure: post-award institution – pre-award institution³</td>
<td>6.1</td>
<td>-2.2</td>
<td>8.2</td>
<td>0.005</td>
<td></td>
</tr>
<tr>
<td><strong>Research productivity (full sample)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td># of publications, 2004-2006⁴</td>
<td>18.9</td>
<td>18.0</td>
<td>1</td>
<td>0.52</td>
<td></td>
</tr>
<tr>
<td># of presentations, 2004-2006⁴</td>
<td>13.4</td>
<td>12.6</td>
<td>0.8</td>
<td>0.35</td>
<td></td>
</tr>
<tr>
<td>Percent time spent on research⁴</td>
<td>35</td>
<td>36</td>
<td>-1</td>
<td>0.25</td>
<td></td>
</tr>
<tr>
<td>Percent time spent on instruction⁴</td>
<td>42</td>
<td>42</td>
<td>-1¹</td>
<td>0.25</td>
<td></td>
</tr>
<tr>
<td><strong>Research productivity (bibliometric subsample)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td># of publications after Last CAREER application¹</td>
<td>23</td>
<td>21</td>
<td>2</td>
<td>0.45</td>
<td></td>
</tr>
<tr>
<td># of citations per paper after Last CAREER application¹</td>
<td>8.9</td>
<td>7.9</td>
<td>1.0</td>
<td>0.41</td>
<td></td>
</tr>
<tr>
<td><strong>Integration: Engaging undergraduates in research</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percent who published a paper with undergraduate as author²</td>
<td>41</td>
<td>37</td>
<td>4</td>
<td>0.13</td>
<td></td>
</tr>
<tr>
<td>Percent who discussed current research in undergraduate course²</td>
<td>75</td>
<td>73</td>
<td>2</td>
<td>0.37</td>
<td></td>
</tr>
<tr>
<td>Percent who required undergraduates to conduct original research project²</td>
<td>30</td>
<td>27</td>
<td>3</td>
<td>0.24</td>
<td></td>
</tr>
<tr>
<td>Percent who supported undergraduate on NSF award²</td>
<td>41</td>
<td>41</td>
<td>0</td>
<td>0.85</td>
<td></td>
</tr>
<tr>
<td><strong>Integration: Outreach beyond the university</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percent who engaged in one or more activities with K-12 students or educators³</td>
<td>54</td>
<td>47</td>
<td>7</td>
<td>0.02</td>
<td></td>
</tr>
<tr>
<td>Percent who developed a museum exhibit or other event to foster public interest in STEM²</td>
<td>10</td>
<td>8</td>
<td>2</td>
<td>0.29</td>
<td></td>
</tr>
</tbody>
</table>

See exhibit notes on next page
Exhibit reads: Eighty-one percent of awardees and 70 percent of non-awardees reported that they had achieved tenure (as of the date of survey completion), an impact of 11 percentage points. This difference is statistically significant (p< .001).

Notes:

a All values shown are regression-adjusted for propensity strata and other covariates as noted for each outcome.
b 1101 awardees and 1348 non-awardees who had ever held an academic position responded to this item. Tenure status was indicated at the time of survey completion which varied by respondent between October 25, 2006 and March 30 2007. Analyses controlled for the number of years between 2007 and the date PI accepted first tenure-track position.
c 1112 awardees and 1357 non-awardees who had ever held an academic position responded to this item. Academic rank was indicated at the time of survey completion which varied by respondent between October 25, 2006 and March 30 2007. Analyses controlled for the number of years between 2007 and the date PI accepted first tenure-track position. This analysis was based on PIs' self-reported rank. For purposes of analysis a PI was coded as having achieved the rank of Full Professor if rank was coded as any of the following titles: Full Professor; Full Professor, Distinguished; Full Research Professor; Endowed Chair.
d This analysis is based on the employment histories of N = 262 awardees and N = 323 non-awardees who changed institutions post-award and whose pre- and post-award institutions' research expenditures could be determined. For awardees the award was CAREER; for non-awardees the award was the comparison NSF grant that determined eligibility for the study. This analysis controlled for the number of years elapsed between 2007 and the date of receipt of Ph.D.
e N = 1081 awardee and 1330 non-awardee respondents to this survey items were included in this analysis. Total number of publications included: Published or in press articles in peer-reviewed journals; chapters in edited volumes; edited volumes (as Editor or Co-Editor); technical manuals or research monographs; textbooks; books other than textbooks based on PI's own research; conference publications. Analysis controlled for the number of years elapsed between 2007 and the date of receipt of Ph.D.
f N = 1074 awardees and 1322 non-awardees. Total number of presentations given included: Invited presentations (keynote speaker, etc.) at national meetings of professional organizations; peer-reviewed presentations at national meetings of professional organizations; invited presentations at seminars, symposia, or other forums outside PI's institution. Analysis controlled for the number of years elapsed between 2007 and the date of receipt of Ph.D.
g N = 1101 awardees, 1346 non-awardees. Survey respondents reported the percent time spent on each of the following: instruction with undergraduates; instruction with graduate students; research/scholarship; professional growth; administration; service; and other.
h N = 1101 awardees, 1346 non-awardees. Survey respondents reported the percent time spent on each of the following: instruction with undergraduates; instruction with graduate students; research/scholarship; professional growth; administration; service; and other. Time on instruction included that spent on instruction with undergraduate and graduate students.
i Due to rounding error, the estimated impact is -1 despite the fact that the rounded mean percents for awardees and non-awardees are equal.
j N = 223 awardees and 219 non-awardees who were in the bibliometric subsample and responded to the survey. Publication records indexed in the Science Citation Index and the Social Science Citation Index were searched for each PI between 1990 and 2006. Analysis controlled for the total number of publications produced before and including the year of the last CAREER application and the number of years elapsed between 2007 and the date of receipt of Ph.D.
k N = 223 awardees and 219 non-awardees who were in the bibliometric subsample and responded to the survey. Citation records indexed in the Science Citation Index and the Social Science Citation Index were searched for each PI between 1990 and 2006. Analysis controlled for the mean number of citations per paper before and including the year of the last CAREER application, and the number of years elapsed between 2007 and the date of receipt of Ph.D.
l N = 1015 awardees and 1249 non-awardees.
m N = 463 awardees and 549 non-awardees. Only PIs with a currently active CAREER award or Comparison grant were asked whether or not they were using funds to support undergraduates.
n N = 1096 awardees and 1343 non-awardees. Engagement with K-12 students or educators included: PI talked with elementary, middle, or high school students about their field or their research; collaborated with elementary, middle or high school teachers or staff on developing science, technology, engineering, or mathematics curricula or teacher preparation; or conducted research on how elementary, middle or high school students learn science, mathematics, or engineering.
o N = 1096 awardees and 1343 non-awardees.

Sources: PI Survey; Integrated Post-Secondary Educational Data System (IPEDS); Science Citation Index; Social Science Citation Index.
Chapter 1: Introduction, Research Questions, and Evaluation Methodology

This is the final report from the evaluation study of the National Science Foundation’s Faculty Early Career Development (CAREER) Program. In this chapter, we introduce the CAREER program, outline the purposes and research questions of this evaluation study, describe the methodologies used to answer the research questions, and outline the remainder of the report.

About the CAREER Program

With dual emphases on promoting discovery and learning, the National Science Foundation (NSF) has increasingly attended to the integration of research and education, in order to strengthen the Nation’s science, technology, engineering, and mathematics (STEM) workforce. The National Science Foundation Act of 1950, as amended, authorizes and directs NSF to initiate and support:

- Basic scientific research and research fundamental to the engineering process;
- Programs to strengthen scientific and engineering research potential; and
- Science and engineering education programs at all levels and in all fields of science and engineering.

The Faculty Early Career Development (CAREER) Program is an agency-wide initiative that builds on these goals, competitively awarding grants to junior faculty members and other teacher-scholars who are practicing the integration of research and education. The CAREER program aims to provide beginning faculty with the impetus and resources to become leading teacher-scholars, leading producers of research, and ambassadors of their fields. They then contribute to the education of the next generation of STEM scholars and to advancing public understanding of science.

Since 1995, NSF has used the CAREER program to support over 3,881 teacher-scholars. Currently, CAREER provides a minimum of $400,000¹ over five years to support awardees’ research and education activities. CAREER proposals are submitted to individual research programs agency wide across the following Directorates and Offices:

- Biological Sciences (BIO),
- Computer and Information Science and Engineering (CISE),
- Engineering (ENG),
- Geosciences (GEO),
- Mathematics and Physical Sciences (MPS),
- Social, Behavioral and Economic Sciences (SBE),

¹ The current minimum award size in the BIO Directorate is $500,000,
• Education and Human Resources (EHR), and
• the Office of Polar Programs (OPP).

Successful CAREER applicants must propose creative, innovative, and effective research and education activities, as well as describe how the research and educational activities are integrated with one another. Funded awardees are expected to establish a “firm foundation for a lifetime of contributions to the integration of research and education.” CAREER aims to support the “early development of academic careers dedicated to stimulating the discovery process in which the excitement of research in enhanced by inspired teaching and enthusiastic learning.”

Contrasted with many programs at the NSF which only last for several years, CAREER’s duration is evidence of perceived relevancy to the research and education community. In 2005, the program’s 10th year, NSF initiated an evaluation of the CAREER program, to assess the success of the CAREER program in achieving its goals, and to provide information to help determine appropriate future directions for CAREER.

Study Purposes and Research Questions

Initially this study was designed to examine the impact of NSF’s CAREER award program on three different groups: on awardees; on institutions that have hosted awardees; and on NSF itself.

Questions about the impact of a treatment (i.e., the CAREER award) on a treated group require an appropriate comparison group to investigate what would have happened to the treated group in the absence of the treatment. Because it was not feasible to construct appropriate comparison groups to determine the impact of CAREER on host institutions or on NSF itself, the original research questions and accompanying study design were modified. Nevertheless, this report provides both impact estimates for CAREER awardees and rich descriptive data from faculty and department chairs at host institutions and from program officers at NSF to answer four primary research questions about NSF’s CAREER program:

1. How do stakeholders at NSF perceive the CAREER program and its relationship to the mission of NSF?
2. What is the impact of CAREER on the research activities and career advancement of awardees?
3. What is the impact of CAREER on the integration of research and education by faculty members?

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3 Initially, we intended to assess the impact of CAREER on departments and institutions by comparing departments hosting CAREER awardee to a comparison group of departments. However, significant difficulties arose in constructing a comparison group of departments due to the prevalence of CAREER Awardees (especially in some disciplines) and the challenge of equating the “quality” and research intensity of departments. As a result, our analysis uses descriptive data to characterize the perception of the CAREER program on host departments and institutions.
4 It was not feasible to conduct an impact evaluation of the effects of the CAREER program on NSF, because there is no appropriate comparison. Instead, we use descriptive data to characterize the perception of CAREER by NSF program officers and CAREER coordinating committee members about the program.
4. How do faculty members in departments that host CAREER awardee(s) view the CAREER program and its relationship to their research and educational missions?

To address the first and fourth research questions, we used survey and interview data to describe how various stakeholders (awardees, non-awardees, faculty in departments with past and active CAREER awardees, department chairpersons, institutional administrators, and NSF program staff) perceive the CAREER program.

To address the second and third research questions, we conducted a quasi-experimental impact evaluation to compare CAREER awardees to a comparison group of individuals who applied for CAREER but were declined (non-awardees). To be eligible for inclusion in the comparison group, all non-awardees must have received some other form of NSF-funding between 1995 and 2004. An online survey was administered to both awardees and non-awardees between September, 2006 and March, 2007.

As described in more detail in Chapter 2, CAREER has agency-wide features and goals, but much of its implementation is directorate-specific. This diversity of implementation across the agency makes it more difficult to evaluate and has implications for interpretation of study findings. This study was designed and powered to examine the impact of CAREER as a whole, across all years and disciplines. We are unfortunately unable to examine interaction effects between observed outcomes for CAREER awardees and characteristics of either PIs (e.g., discipline, gender, minority status, prior training) or their institutions (e.g., geographic location, research intensity, minority serving institutions).

Exhibit 1.1 summarizes the data sources used to address each of the evaluation’s research questions. These data sources include:

- Principal Investigator\(^6\) (PI) Survey of a sample of 1,400 CAREER awardees and 1,800 non-awardees;
- Bibliometric Analysis of a subsample of 300 CAREER awardees’ and 300 non-awardees’ publication and citation histories;
- Department Chair Survey of a sample of the chairpersons of 700 university departments currently hosting a CAREER awardee;
- Site visits to 22 university departments hosting one or more CAREER awardees; and
- Interviews with 16 members of the CAREER Coordinating Committee (CCC), plus 22 NSF program officers representing a random sample of programs which had made a CAREER award within the past two years.

\(^5\) Excluding NSF postdoctoral awards, travel grants, workshop or conference support.

\(^6\) We refer to the survey of CAREER awardees and non-awardees as the Principal Investigator survey (members of each group had received NSF funding as PI as a condition for inclusion in the study sample).
Exhibit 1.1

Data sources and research questions

<table>
<thead>
<tr>
<th>Research Question</th>
<th>PI Survey</th>
<th>Bibliometric Analysis</th>
<th>Department Chair Survey</th>
<th>Site Visits</th>
<th>Interviews with NSF Program Officers</th>
<th>Interviews with CCC members</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is the impact of CAREER on the research activities and career advancement of awardees?</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>What is the impact of CAREER on the integration of research and education by faculty members?</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>How do faculty members in departments that host CAREER awardee(s) view the CAREER program and its relationship to their educational and research missions?</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>How do stakeholders at NSF perceive the CAREER program and its relationship with the mission of NSF?</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The rest of this chapter provides a brief overview of these data sources and the evaluation methodology.

Determining the Impact of CAREER on Awardees

The evaluation was designed to examine the impact of the CAREER award on key aspects of recipients’ development as teacher-scholars, including:

- Awardees’ professional advancement;
- Awardees’ research program; and
- Awardees’ integration of research and education, as measured by:
  - engaging undergraduates in research activities; or
  - conducting outreach activities to non-collegiate students, teachers, or the public.

Particular outcomes tested are described in more detail in Chapter 5; here, we provide a brief description of the methods, data sources and sampling approach used in the impact analyses.

Design

The goal of the impact component of the evaluation was to determine whether awardees would have exhibited the same set of outcomes even if they had not received a CAREER award. Although a random assignment study would have allowed a more rigorous test of the causal impact of the CAREER award on its recipients, this design was not feasible (nor, perhaps, desirable) since awardees had already been selected based on the merits of their CAREER proposals. Instead, a quasi-experimental design was used to compare outcomes for CAREER awardees and non-awardees. The primary threat to the validity of a quasi-experiment comes from selection bias, namely, the
possibility that pre-existing differences between awardees and non-awardees, rather than the CAREER award itself, are responsible for differences in outcomes between the two groups. To reduce the risks associated with selection bias, the study incorporated propensity score analysis (PSA) to construct groups of awardees and non-awardees who were statistically similar across a number of pre-existing characteristics (e.g., gender, minority status, number of CAREER proposals submitted, prior receipt of NSF funding, etc.). Subsequent impact models incorporated the results of the PSA. These methods are described in more detail below and in Appendix A.

Two sources of data were used to address questions about the impact of the CAREER award on the awardees themselves: a Principal Investigator survey administered to a sample of awardees and non-awardees, and a bibliometric analysis of the publication and citation records of a subsample of awardees and non-awardees.

**Principal Investigator survey and sample**

**Survey Instrument**
An online survey was administered to CAREER awardees and non-awardees. The survey was designed to provide data on respondents' professional advancement and leadership, research and educational activities, and the extent to which respondents integrated research and education. Both awardees and non-awardees were asked about their educational, employment and grant histories; research publications and presentations; educational activities targeting graduate and undergraduate students. CAREER awardees were also asked how they used funding, about the benefits of the CAREER award and any barriers to implementing their proposed research and educational objectives.

**Sampling Awardees and Non-awardees**
Rather than collecting data from the entire population of CAREER awardees and an appropriate comparison group of non-awardees, we drew a sample of 1,400 awardees and 1,800 non-awardees to represent the underlying populations. The awardee sample was drawn from the universe of all individuals who were awarded a CAREER grant from the inception of the program in 1994 to the Fall of 2004.\(^7\) The comparison sample of non-awardees was drawn from the universe of individuals who applied for and did not receive CAREER funding (as of Fall 2004), but who had received other NSF funding as a Principal Investigator (PI) either before applying to the CAREER program, or within 5 years after their first submission to the CAREER program.\(^8\) Thus, to be eligible for inclusion in the sample, each PI had received either the CAREER award (awardees) or an eligible comparison grant (non-awardees).

Three other factors affected the sampling process. First, we conducted a power analysis to determine the sample size needed to detect a minimum standardized effect size of 0.12 in outcomes between CAREER awardees and non-awardees (See Appendix B). Second, because NSF directorates vary with respect to the number of CAREER awards granted, awardees and non-awardees were sampled relative to the proportion of total CAREER awards granted by the NSF directorate to which they

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\(^7\) The CAREER program made its first awards in 1995. We selected October 1, 2004 as a cutoff for inclusion in the study in order to allow Awardees sufficient time to begin implementing grant activities prior to completing the PI survey, fielded in the 2006-07 academic year.

\(^8\) Other NSF funding was defined as an NSF single-PI grant, excluding postdoctoral awards, travel grants, workshop or conference support.
Finally, a method of controlling for selection bias was used to select the sample. Selection bias and methods used to reduce it are discussed below.

Because individuals were not randomly assigned to receive or not receive a CAREER award, we needed to consider the possibility that awardees were systematically different from non-awardees, and that these existing differences, not the CAREER award itself, accounted for differences in professional, research, and educational outcomes. If there was such selection bias, then any differences in these outcomes may be due to differences in the types of individuals who win CAREER awards—and not necessarily to effects of the CAREER award itself. For example, consider two hypothetical individuals: one who received a CAREER award and one who applied but did not, and the CAREER awardee earned her doctorate from a prestigious graduate institution whereas the non-awardee did not. The CAREER awardee publishes seven peer-reviewed articles in seven years; the non-awardee publishes four such articles in seven years. Is the awardee’s greater number of publications attributable to the unique effect of winning a CAREER award, or was there something about the graduate training she received (relative to the non-awardee’s graduate training) that resulted in her higher research productivity? That is, if she had not received the CAREER award, would this individual still have been as prolific a researcher?

To mitigate the threat of selection bias, we used Propensity Score Analysis (PSA) to select a sample of awardees and an appropriate comparison group of non-awardees. If this comparison group is similar to the awardee group on all aspects except for receipt of the award, then outcomes for this comparison group represent what would have happened to the CAREER awardees in the absence of receiving the award. By comparing outcomes of awardees and an appropriately-selected comparison group, we can be more confident that any observed differences in the two groups are due to the unique effect of the CAREER award. Propensity score analysis uses a set of observed characteristics other than award receipt to predict, for each individual, a propensity, or likelihood, that the individual would be found in the treated (i.e., awardee) group. Once each individual is assigned a probability of award receipt, it is possible to form groups, or strata, of individuals (both those who ultimately received a CAREER award and those who did not) such that individuals within each stratum were equally likely to receive the award based on the set of observed characteristics. This stratification procedure results in a comparison group that minimizes the threat of selection bias when comparing outcomes for the two groups.

We used two rounds of PSA for the study: first, we employed PSA to select the sample of awardees and non-awardees who were subsequently invited to participate in the study. Then, we used PSA a second time, incorporating additional data provided by respondents on the PI survey, to ensure that the respondent awardee and non-awardee groups—on whom our impact analyses are based—had an equal propensity to win a CAREER award based on the most comprehensive set of data available. Data came from two sources: (1) an NSF-maintained database on characteristics of individuals who apply for NSF funding and (2) the survey administered to PIs as part of the study. The PSA includes/takes into account those variables on which there might have been systematic differences between awardees and non-awardees, or for which there is likely correlation with the success or failure of a CAREER proposal. For example, an individual with a proven track record of securing NSF funding in the past might be more likely to receive a CAREER award; thus, an indicator of prior

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9 For example, if the number of CAREER Awardees from the MPS directorate represented 25 percent of all CAREER awards between 1994 and 2004, then we drew our sample such that 25 percent of the Awardees had applied to the MPS directorate.
receipt of an NSF award was included in the PSA. In addition, we included other variables that might have influenced award decisions, for example, prioritizing awards to PIs belonging to groups traditionally underrepresented in STEM fields or working at institutions (e.g., from EPSCoR states) traditionally underrepresented among NSF’s grant portfolio. Technical details of the propensity score analysis are found in Appendix A.

**Resulting sample and response rates**

Exhibit 1.2 displays the sampling process. The universe of study-eligible PIs included 3,503 CAREER awardees and 3,252 non-awardees. A small number of awardees (N=8) and non-awardees (N=24) were not eligible for the study and were excluded from the sampling frame.\(^10\) From the resulting sampling frame (N=3,495 awardees; N=3,228 non-awardees), a stratified systematic sample of 1,400 awardees and 1,800 non-awardees was drawn to represent the eight NSF directorate and PSA strata (non-awardees were deliberately over-sampled because we anticipated that their response rate to the survey would be lower than that for CAREER awardees). For 74 individuals, no current contact information could be found. The remaining PIs received an email invitation to complete the web-based survey. After eliminating individuals who could not be located or were determined to be ineligible for the study\(^11\) the final sample consisted of 1,357 awardees and 1,737 non-awardees. Response rates for the two groups were 84 percent (n = 1,138 awardees) and 80 percent (n = 1,394 non-awardees)\(^12\).

Exhibit 1.3 illustrates that data and analyses based on the PI survey are representative of the population of awardees and non-awardees. First, the sample of awardees drawn for this study did not differ systematically from the population of awardees in the sampling frame (compare columns A and B). Second, the awardees who responded to the PI survey do not differ systematically from those invited to participate in the study (compare Columns B and C). Similarly, the non-awardees in the sample do not differ from those in the underlying sampling frame (columns D and E), and non-awardee respondents do not differ systematically from those invited to participate in the study (columns E and F).

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\(^{10}\) Either these excluded individuals had participated in a pilot test of the PI survey, or inspection of data showed that they were not eligible to have applied for CAREER or to participate in the study. Although it is likely that these data were erroneous, it was not possible to verify or correct the information provided.

\(^{11}\) Four individuals were deceased; an additional 32 had either never applied for or received a CAREER award, or were project officers currently on rotation at NSF. Six individuals in our initial sample were members of the Committee of Visitors charged with conducting their own evaluation of the CAREER program in 2006. These individuals were replaced in the sample.

\(^{12}\) Because our response rates were 80 percent and higher for both the awardee and non-awardee groups, we do not report a non-response bias analysis.
Exhibit 1.2

PI Survey sampling flowchart

Study-eligible PIs in NSF database, 1994-2004

Awardees: N = 3,503
Non-awardees: N = 3,252

Sampling Frame after exclusion criteria

Awardees: N = 3,495
Non-awardees: N = 3,228

Propensity Score Analysis:
Sampling Stratification

Sample

Awardees: N = 1,400
Non-awardees: N = 1,000

Sample after excluding ineligibles (not replaced)

Awardees: N = 1,357
Non-awardees: N = 1,737

Respondents

Awardees: N = 1,138
Non-awardees: N = 1,394

Response rates:
84% 80%

Propensity Score Analysis:
Balancing the analytic sample

Analytic Sample

Awardees: N = 1,138
Non-awardees: N = 1,393
### Exhibit 1.3

Characteristics of CAREER Awardees and Non-awardees in Sampling Frame, Sample, Respondent Groups

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>CAREER Awardees</th>
<th></th>
<th></th>
<th>Non-awardees</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sampling Frame</td>
<td>Sample</td>
<td>Respondents</td>
<td>Sampling Frame</td>
<td>Sample</td>
<td>Respondents</td>
</tr>
<tr>
<td></td>
<td>N = 3,495</td>
<td>N = 1,400</td>
<td>N = 1,138</td>
<td>N = 3,227</td>
<td>N = 1,800</td>
<td>N = 1,394</td>
</tr>
<tr>
<td>Percent male</td>
<td>76</td>
<td>77</td>
<td>76</td>
<td>76</td>
<td>76</td>
<td>77</td>
</tr>
<tr>
<td>Percent White</td>
<td>69</td>
<td>69</td>
<td>69</td>
<td>65</td>
<td>64</td>
<td>66</td>
</tr>
<tr>
<td>Percent Asian</td>
<td>20</td>
<td>19</td>
<td>20</td>
<td>24</td>
<td>24</td>
<td>23</td>
</tr>
<tr>
<td>Percent race unknown/not reported</td>
<td>6</td>
<td>7</td>
<td>7</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Percent underrepresented minoritya</td>
<td>8</td>
<td>7</td>
<td>7</td>
<td>9</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>Percent PI on prior NSF grantb</td>
<td>29</td>
<td>30</td>
<td>29</td>
<td>26</td>
<td>26</td>
<td>26</td>
</tr>
<tr>
<td>Percent from EPSCOR statec</td>
<td>11</td>
<td>12</td>
<td>12</td>
<td>14</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Percent from a minority-serving institutiond</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Percent from Doctoral/Research University-Extensivee</td>
<td>82</td>
<td>81</td>
<td>80</td>
<td>73</td>
<td>74</td>
<td>72</td>
</tr>
<tr>
<td>Percent from institutions with research expenditures half or more of total institutional expenditurese</td>
<td>80</td>
<td>81</td>
<td>81</td>
<td>84</td>
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<td>84</td>
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<tr>
<td>Percent from directoratef</td>
<td></td>
<td></td>
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<tr>
<td>BIO</td>
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<td>GEO</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>7</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>MPS</td>
<td>25</td>
<td>25</td>
<td>25</td>
<td>21</td>
<td>21</td>
<td>20</td>
</tr>
<tr>
<td>SBE</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>OPP, OD</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean number of years between last post-secondary degree and award receipt (std dev)</td>
<td>5.2 (3.0)</td>
<td>5.3 (3.1)</td>
<td>5.2 (2.7)</td>
<td>6.0 (3.4)</td>
<td>5.9 (3.3)</td>
<td>6.0 (3.3)</td>
</tr>
<tr>
<td>Mean number of grant proposals PI submitted to NSF, 1994-2004 (st dev)</td>
<td>6.4 (5.0)</td>
<td>6.6 (5.2)</td>
<td>6.6 (5.2)</td>
<td>8.2 (5.4)</td>
<td>8.3 (5.4)</td>
<td>8.3 (5.3)</td>
</tr>
<tr>
<td>Mean proposal rating score (st dev)</td>
<td>4.3 (.50)</td>
<td>4.3 (.50)</td>
<td>4.3 (.50)</td>
<td>4.2 (.50)</td>
<td>4.1 (.50)</td>
<td>4.2 (.50)</td>
</tr>
</tbody>
</table>
Exhibit 1.3 continued

Characteristics of CAREER Awardees and Non-awardees in Sampling Frame, Sample, Respondent Groups

Exhibit reads: In the sampling frame, 76 percent of CAREER awardees were male; 77 percent of those awardees sampled were male; 76 percent of awardee respondents were male.

Notes:

a Minority/ethnic groups traditionally underrepresented in STEM fields include those identifying as Black, Hispanic, American Indian, Alaskan native, Hawaiian native, Pacific Islander, or Multiracial. Note that figures for under-represented minorities exclude five percent of PIs who choose not to report their race/ethnicity.

b Whether or not individual had ever received an NSF grant prior to receiving CAREER award or eligible comparison grant.

c EPSCoR = Experimental program to stimulate competitive research. Indicates whether or not state from which PI submitted proposal for CAREER or eligible Comparison award was an EPSCOR state.

d Minority serving institutions include Historically Black Colleges and Universities (HBCUs), Hispanic-Serving Institutions (HSIs), and Tribal Colleges. Indicates whether or not institution from which PI submitted proposal for CAREER award or eligible Comparison grant was minority-serving.

e Classification of universities from which PI applied for CAREER or eligible Comparison grant taken from the Carnegie Ratings

f Percent research expenditure is the ratio of expenditures on research to the total of research and instructional expenditures combined. These data obtained from the Integrated Post-secondary Educational Data System (IPEDS)

 g BIO = Directorate for Biological Sciences; CSE = Directorate for Computer and Information Sciences & Engineering; EHR = Directorate for Education and Human Resources; ENG = Directorate for Engineering; GEO = Directorate for Geosciences; MPS = Directorate for Mathematical and Physical Sciences; SBE = Directorate for Social, Behavioral and Economic Sciences; OPP/OD = Office of Polar Programs and Office of the Director.

h For awardees, award receipt is the date when the CAREER award was received; for non-awardees, award receipt is the date that the NSF grant which determined study eligibility was received.

i For awardees, proposal rating refers to the rating of the winning CAREER proposal. For non-awardees, proposal rating refers to the that of the NSF grant which determined study eligibility.

Sources: NSF PI data files; PI survey.
Bibliometric data and sample

To examine whether or not CAREER awardees produced research that differed systematically in amount and influence from that produced by non-awardee PIs, we collected data on a subsample of 300 awardee and 300 non-awardee PIs included in our study sample. By searching articles and patents indexed in the Science Citation Index (SCI), the Social Science Citation Index (SSCI), the United States Patent and Trademark Office (USPTO), and the European Patent Office (EPO), Abt Associates' subcontractor, iplIQ, collected:

- The PI’s total number of publications and patents between 1990 and 2006;
- The total number of times each publication/patent was cited by another publication/patent indexed in these databases;
- The authorship/inventor position (first author, second author, etc.) of the PI on each publication/patent;
- The total number of authors/inventors on each publication/patent.

The methods used to compile and check these data for accuracy are detailed in Appendix C. The use of these data in analysis is described in Chapter 5.

To examine the impact of the CAREER award on research productivity and quality, we examined the publication records of a subsample of 300 awardees and 300 non-awardees. This subsample was drawn from the existing sample of awardees and non-awardees. The subsample was drawn to preserve the same proportional representation of NSF directorates as existed in the survey sample of PIs. A separate power analysis to determine the necessary size of this subsample is shown in Appendix B.

Perceptions of CAREER among Stakeholders

In addition to estimating the impact of CAREER on awardees, additional data were collected to assess how the CAREER award is implemented and perceived by recipients, host institutions, and NSF program officers. These data sources are described below.

Department chair survey and sample

To examine the influence of the CAREER award on host departments, we surveyed 700 department chairs in 217 institutions. A stratified simple random sample of unique university departments representing each of the eight NSF directorates included in the study was selected. That is, the sample was constructed so that the number of departments sampled to represent a given NSF directorate was proportional to the number of departments to which a given directorate had directed CAREER funding.

First, departments with at least one active CAREER awardee were targeted for selection. Of 3,495 CAREER awardees in the PI sampling frame, we retained 1,211 PIs who received their award after

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13 In order to insure that PIs included in the bibliometric analysis had had sufficient opportunity to publish, we limited eligibility for this subsample to the 589 awardees and 730 non-awardees who had last applied for CAREER in 1995, 1996, 1997, 1998, or 1999.
September, 2001; because the Department Chair survey was fielded in September, 2006, this date insured that participating department chairs were hosting (or had very recently hosted) an awardee whose CAREER grant was ongoing. Of those awardees receiving their award after September 2001, 1,178 awardees had an ongoing grant as of July 2006. Thirteen of these PIs were not from a university setting; removing them left a total of 1,165 active CAREER awardees distributed across 881 university departments.

Because some departments had multiple awardees with funding from different NSF directorate (e.g., one awardee’s funding came from CSE; another awardee’s funding was from ENG); duplicates were eliminated and each department was classified into a single NSF directorate based on the following rules:

- The department was classified as the directorate that had awarded that department the greater number of CAREER awards.
- If the department had an equal number of CAREER awards from two (or more) directorates, the department was randomly classified as one of these directorates.

After eliminating duplicates and reclassifying these departments into a single NSF directorate, there were 826 unique departments.

From these, a stratified simple random sample of 700 departments was drawn. After eliminating ineligible departments, we invited 674 department chairpersons to participate in the survey. Of these, 564 responded for a response rate of 84 percent.

Department chairs were asked about their familiarity with the CAREER award program and faculty awardees in their department; how their department supports the career advancement of junior faculty; policies and practices for faculty advancement, including tenure and promotion; their perception of the CAREER award and its influence on awardees and the department as a whole.

**Site visits to host departments**

To deepen our understanding of the contexts in which CAREER awardees implement their awards, we visited a sample of departments with at least one active CAREER awardee. We selected 22 departments in 11 universities. A purposive sample of university departments was selected for site visits. Universities were chosen first by determining which institutions had both active and past CAREER awardees (n = 201). Institutions that were classified as either “undergraduate” or “graduate focused”; from within each of these two strata, institutions where the concentration of former or active CAREER awardees was at least three percent (relative to the number of full-time equivalent faculty, either tenured or in tenure-track positions, in STEM fields) were selected (n = 99). Next, institutions were screened for the number of departments with past and active awardees; only institutions with at least two such departments were retained (n = 73). From these 73 universities, 11 were chosen such that:

- at least two institutions were in EPSCoR states;
- at least one institution was a minority-serving institution;

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14 Twenty-six departments were ineligible: for three departments, the chair had participated in a pilot test of the survey; an additional 23 departments had merged into another department and so did not have their own chairperson who could respond to the survey.
• no more than two institutions were located in the same state;

The 11 selected institutions were then examined for geographic diversity; one Midwestern university was replaced with a university from a Western state. From within each of these institutions, two departments were selected such that:

• each NSF directorate was represented in the sample by at least one department; and
• departments with the largest number of awardees (past or present) were selected from institutions with more than two eligible departments.\textsuperscript{15}

The final group of departments were contacted and asked to host a two-day site visit; all agreed to participate.

Interviews were conducted with both active and past (if any) CAREER awardees; other junior faculty (including non-awardees and non-applicants); senior (i.e., tenured) faculty; department chairs; and university administrators. Active and past awardees were asked about the role of the CAREER award in advancing their research, educational, and professional objectives; the perceived impact of the award on tenure and promotion within the department; the types of activities they implemented as a result of the CAREER award and factors that hindered or facilitated implementation of these activities; how they integrated research and education; the value of the CAREER award relative to other sources of support; and any departmental or other support they received from colleagues. Senior faculty, the department chair, and senior administrators were asked about their familiarity and perception of the CAREER award program and its goals; the department’s relative emphasis on research and education and the integration of these pursuits; whether or not CAREER faculty differed from other faculty as researchers or educators; and whether the presence of one or more CAREER awardees had influenced departmental policies or culture, especially as related to tenure and promotion decisions.

\textbf{Interviews with NSF program officers}

To examine views of the CAREER program within NSF, we selected a sample of programs within each of seven directorates.\textsuperscript{16} To identify program officers for interviews about the CAREER program, a sample of 25 NSF programs were selected. From each of seven directorates, one program was selected from each division. Only programs that made at least one CAREER award in 2004 or 2005 were chosen for the sample. Programs were selected from within divisions as follows:

• Within the division, the program that gave five or more CAREER awards was selected; if more than one program within the division gave five or more CAREER awards, one was randomly selected.
• If division had no programs that gave 5 or more awards the program that gave one to four awards was selected; if more than one program in the division gave one to four awards, a program was randomly selected.

\textsuperscript{15} If two departments had a similar number of awardees, departments with multiple sources of research funding were selected over those with a single source of external funding.

\textsuperscript{16} The Office of Polar Programs was not selected for this part of the study, due to the small number of CAREER awards granted.
Program officers were asked to describe how CAREER proposals were reviewed and selected within their program; how the CAREER award fit into their program’s overall grant portfolio; how they viewed the CAREER program as a vehicle for supporting junior faculty; how they viewed the CAREER requirement that awardees integrate research and education; and whether the CAREER program had had any effect on other grant award processes within their program.

Organization of This Report

This final report on the evaluation of the CAREER program is organized as follows;

- Chapter 1: Introduction, Research Questions and Evaluation Methodology
- Chapter 2: The CAREER program at NSF
- Chapter 3: CAREER Awardees and Award Implementation
- Chapter 4: CAREER Awardees as Teacher-Scholars
- Chapter 5: Impact of CAREER on Awardees
- Chapter 6: The CAREER Award within the Department Context
- Chapter 7: Promoting the Integration of Research and Education
- Chapter 8: Summary and Recommendations for the CAREER Program
- Appendix A: Impact Study Methodology
- Appendix B: Sample Sizes, Power, and Minimum Detectable Effect Sizes
- Appendix C: Bibliometric data collection methodologies
- Appendix D: Variations in the CAREER solicitation over time
Chapter 2: The CAREER Program at NSF

While the CAREER program has one centralized solicitation, the selection of CAREER recipients occurs within specific NSF research programs, as CAREER applicants submit their proposals to the individual NSF research programs most closely aligned with their work. This decentralized funding has resulted in varied interpretations of CAREER’s purpose and function, as program officers within individual directorates seek to utilize the CAREER framework to meet the needs of rising researchers in their own disciplines. Interpretation of this evaluation’s findings must be informed by an understanding of the variation under which CAREER has historically been and is currently implemented.

In this chapter, we describe the goals of the CAREER program as conceptualized across the Foundation and the mechanisms through which CAREER is implemented within each Directorate. We examine variations in program implementation over time, and the extent to which program officers at NSF explicitly (and implicitly) encourage faculty members in their disciplines to apply for CAREER funding. In this chapter, we present data on the universe of CAREER awardees who won their award between 1995 and 2005 \( (n = 3,881) \) as well as findings from interviews with selected NSF program officers. ¹

Overview of Chapter Findings

The highlights of the findings in this chapter include the following:

- CAREER is NSF’s primary support mechanism for junior faculty members. CAREER proposals are submitted to individual research programs across all of NSF’s Directorates as well as the Office of Polar Programs (OPP). Three directorates, MPS, CISE, and ENG, have received more CAREER proposals and have funded more awards than the other directorates.

- Between 1995 and 2005, 234 research programs collectively made 3,881 CAREER awards. Some programs fund dozens of CAREER awards annually; others one or two annually. While the number of CAREER awards granted each year has remained roughly steady, the number of proposals has increased over time, resulting in slightly declining award rates over the ten-year span.

- The current award minimum is $400,000 ($500,000 in the Biology Directorate) for five years. The median award size has increased over time from $200,000 in 1995 to $410,303 in 2005. Relative to regular NSF research grants, the CAREER minimum award size varies by directorate—in some disciplines, it is average, in others, it far exceeds the average single PI award.

- Proposals from women, prior NSF grantees, and faculty members at more research-intensive institutions have an advantage relative to their representation in the applicant pool (e.g., although 21 percent of CAREER proposals are from women, 24 percent of proposals awarded are made to women).

¹ When presenting data on the census of CAREER awardees (or applicants), rather than a sample, there is no need for statistical testing, calculation of standard errors or confidence intervals as these are statistical procedures that apply to sample data. It is common to present the standard error of an estimate or a 95% confidence interval around an estimate, but when figures are reported on a census, the figure is not an estimate but is, in fact, the true population value.
• Eligible faculty members can submit up to three applications for CAREER. Fifty-nine percent of CAREER awardees won on their first attempt. The success rates for individuals who applied multiple times do not differ much from the success rates of those who applied only once, suggesting that multiple applications do not necessarily increase the likelihood of winning a CAREER award.

• Program officers across the Foundation identify three primary goals for the CAREER program: (1) supporting promising new researchers, (2) rewarding the best researchers, and (3) promoting the integration of research and education. The adoption and prioritization of these goals varies across directorates, and sometimes even across programs within a single directorate.

• Program officers across the Foundation consistently agree that CAREER applications are different from other “regular” research grant applications because they must propose education activities and a plan for the integration of research and education.

• While there is consensus that CAREER’s strong emphasis on the integration of research and education is greater than in traditional research grants, program officers are not in agreement as to what “integration of research and education” actually means. The latter finding may reflect the fact that the Foundation’s conceptualization of “integration” has shifted over time.

• Program officers vary in the extent to which they encourage CAREER applications from all eligible junior faculty; applications only from eligible junior faculty who have a planned program of research (not just an individual research project) and a creative commitment to their educational component; or discourage junior faculty from applying to CAREER unless they are proposing an integrated program of research and education that is substantially more complex and innovative than a normal research grant proposal.

Origins and Intentions of the CAREER Program

Initiated in 1994, the National Science Foundation’s CAREER program replaced all other NSF funded programs that targeted junior faculty, such as the NSF Young Investigator program (which had grown out of the Presidential Young Investigator program and the Presidential Faculty Fellows program) and several Research Initiation Awards programs.

A centrally organized CAREER Coordinating Committee (CCC), with representatives from each Directorate, the Office of Polar Programs, and the Office of International Science and Engineering, sets the overall objectives of CAREER, drafts the program solicitation and guidelines for reviewers, and makes recommendations about the management of CAREER as an NSF-wide program. Certain aspects of the CAREER award, including amount, duration, and eligibility, are standardized for all awards, regardless of discipline:

• The minimum CAREER award size, established in the program’s second year, has increased from $200,000 in FY1995 to $400,000 (with the exception of awards made within the Biology directorate, for which the minimum is $500,000).

• The award duration, initially established at three to five years, is currently set at five years for all awards. As most NSF research grants span three years, CAREER represents a significantly longer investment in single investigators than other research awards.
• **Eligibility criteria** for prospective applicants have been modified over time to be more inclusive of individuals in non-faculty positions and of individuals who begin their academic faculty career after having spent some time working in a non-tenure-track position. For the FY 2006 through 2008 competitions, applicants must hold a doctoral degree in a field of science or engineering supported by NSF, be untenured, and have not previously received an NSF PECASE or CAREER award. In addition, applicants must be employed in a tenure-track position (or equivalent) as an assistant professor (or equivalent) at either an institution that awards degrees in a field supported by NSF or an organization that is a non-profit, non-degree-granting organization such as a museum, observatory, or research lab.

In most respects, the goals of the CAREER program—to promote the development of a cadre of outstanding new faculty committed to advancing both research and education in science, technology, engineering, and mathematics (STEM) fields—have remained relatively constant since the first awards were made in 1995. Over the years, however, NSF has refined the program to emphasize the importance of integrated research and educational agendas. Appendix D outlines changes in award size, duration, and eligibility requirements since the program’s inception. The remainder of this chapter discusses variations among NSF’s Directorates in CAREER implementation.

**NSF’s Portfolio of CAREER Awards**

CAREER proposals are submitted to individual research programs across all of NSF’s Directorates as well as the Office of Polar Programs (OPP). For the most part, CAREER applications are reviewed through regular research programs by the same panel of reviewers. In a few cases, programs or divisions put together a separate panel to review the CAREER proposals. As with all research grant applications, review panels provide recommendations and ratings on all applicants. Program officers then review the applications and panel recommendations, and make funding decisions.

Between 1995 and 2005, 234 research programs have made CAREER awards, with between 84 and 134 programs accepting CAREER proposals in any given year. The programs accepting CAREER applications have changed over time. The median number of CAREER awards granted by any given research program is two; the range extends from one to 33. There are some programs from which dozens of CAREER awards are made each year, and many programs which only award one or two CAREER awards annually. The median award size has increased over time from $200,000 to $410,303 (Exhibit 2.1).

Between 1995 and 2005, NSF awarded 3,881 CAREER awards. The number of CAREER awards granted annually, like the number of programs making CAREER awards, has remained roughly steady (median = 378 awards per year). However, the number of CAREER proposals NSF has received has increased over time from a low of 1,499 in FY1998 to a high of 2,368 in FY2005 (Exhibit 2.2).

Three directorates, MPS, CISE, and ENG, dominate the CAREER program. These three receive more applications and award more funds than the other directorates: 25, 27, and 29 percent of all CAREER awards, respectively, for MPS, CISE, and ENG (Exhibit 2.3). Ten percent of CAREER awards were granted by the BIO directorate, which is equal to the percentage of CAREER awards that the remaining three directorates combined have awarded (Exhibit 2.4).
Exhibit 2.1

CAREER-granting NSF research programs and median CAREER award size, FY1995-2005

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of programs awarding CAREER</th>
<th>Median CAREER award size</th>
</tr>
</thead>
<tbody>
<tr>
<td>1995</td>
<td>115</td>
<td>$200,000</td>
</tr>
<tr>
<td>1996</td>
<td>121</td>
<td>$261,093</td>
</tr>
<tr>
<td>1997</td>
<td>84</td>
<td>$269,650</td>
</tr>
<tr>
<td>1998</td>
<td>93</td>
<td>$300,000</td>
</tr>
<tr>
<td>1999</td>
<td>112</td>
<td>$305,339</td>
</tr>
<tr>
<td>2000</td>
<td>125</td>
<td>$297,110</td>
</tr>
<tr>
<td>2001</td>
<td>126</td>
<td>$380,496</td>
</tr>
<tr>
<td>2002</td>
<td>126</td>
<td>$375,001</td>
</tr>
<tr>
<td>2003</td>
<td>129</td>
<td>$418,000</td>
</tr>
<tr>
<td>2004</td>
<td>134</td>
<td>$447,778</td>
</tr>
<tr>
<td>2005</td>
<td>133</td>
<td>$410,303</td>
</tr>
<tr>
<td>All years</td>
<td>234a</td>
<td>$375,000</td>
</tr>
</tbody>
</table>

a The number of programs across all years is not equal to the sum of all years as programs begin and end variously during this time.

Table reads: In 1995, 115 programs granted CAREER awards. Across all awards granted in 1995, the median award size was $200,000.

Source: NSF Proposal data files.

Exhibit 2.2

Number of CAREER proposals received vs. awarded, FY1995-2005

Exhibit reads: In 1995 NSF received a total of 1,618 CAREER proposals; of these, 341 were awarded.

Sources: NSF Proposal data files.
Exhibit 2.3
Number of CAREER proposals received vs. awarded, by directorate, FY1995-2005

Exhibit reads: Between 1995 and 2005, the Engineering directorate (ENG) received a total of 7,142 CAREER proposals. Of these, 1,125 were awarded.

Exhibit 2.4
Percent of CAREER awards by NSF directorate, FY1995-2005

Exhibit reads: The MPS directorate has awarded 25 percent of all CAREER awards made by NSF between 1995 and 2005.
Notes: OPP and OD: < 1 percent; EHR: 2 percent; SBE: 3 percent; GEO: 4 percent; BIO: 10 percent; MPS: 25 percent; CISE: 27 percent; ENG: 29 percent. Sum exceeds 100 percent due to rounding error.
Sources: NSF Proposal Datafiles.

CAREER award success rates (number of awards divided by the number of applicants) have varied substantially across Directorates and over time, in part due to rising numbers of applications and changes in research program budgets. Success rates within directorates have ranged from 4 percent to 100 percent. Cumulatively across the whole Foundation, the annual success rates for CAREER awards have
ranged from 12 to 23 percent (Exhibit 2.5), and success rates have slightly declined since FY1999 (Exhibit 2.6). In FY2005, GEO had the highest success rate, followed by CISE and MPS.

### Exhibit 2.5
**CAREER Applications and Award Rates, By Directorate, FY1995-2005**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>ENG</td>
<td>7,142</td>
<td>1,125</td>
<td>16%</td>
<td>10%</td>
<td>20%</td>
</tr>
<tr>
<td>MPS</td>
<td>4,508</td>
<td>966</td>
<td>21</td>
<td>11</td>
<td>28</td>
</tr>
<tr>
<td>CISE</td>
<td>4,228</td>
<td>1,029</td>
<td>24</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>BIO</td>
<td>2,307</td>
<td>390</td>
<td>17</td>
<td>7</td>
<td>22</td>
</tr>
<tr>
<td>SBE</td>
<td>977</td>
<td>114</td>
<td>12</td>
<td>4</td>
<td>20</td>
</tr>
<tr>
<td>GEO</td>
<td>802</td>
<td>185</td>
<td>21</td>
<td>9</td>
<td>55</td>
</tr>
<tr>
<td>EHR</td>
<td>343</td>
<td>66</td>
<td>19</td>
<td>5</td>
<td>100</td>
</tr>
<tr>
<td>OPP/OD</td>
<td>96</td>
<td>26</td>
<td>26</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td><strong>ALL</strong></td>
<td><strong>20,463</strong></td>
<td><strong>3881</strong></td>
<td><strong>19</strong></td>
<td><strong>12</strong></td>
<td><strong>23</strong></td>
</tr>
</tbody>
</table>

Exhibit reads: The Engineering (ENG) directorate has received, over the life of the CAREER program, a total of 7,142 CAREER proposals and has granted 1,125 CAREER awards, for a cumulative success rate of 16 percent. The yearly success rate in the ENG directorate has ranged from a low of 10 percent to a high of 20 percent.

*NSF Proposal Data Files*

### Exhibit 2.6
**CAREER Award Rate by Fiscal Year and Directorate**

[Chart of CAREER Award Rate by Fiscal Year and Directorate]

Chart reads: In 1996, programs in the GEO directorate collectively awarded 53 percent of CAREER applications they received. Note: In 1996, EHR received two proposals, both of which were awarded. This 100 percent award rate is not depicted in the graph. OPP and OD are not shown on this chart because of high year-to-year variation in award rates.

*Sources: NSF Proposal data files.*
Purposes of CAREER as Implemented across the Foundation

Collectively, program officers across the Foundation identify three primary goals for the CAREER program: (1) supporting promising new researchers, (2) rewarding the best researchers, and (3) promoting the integration of research and education, as follows:

1. SUPPORTING PROMISING RESEARCHERS

CAREER should launch the careers of talented new scientists and engineers with stable, long-term support. Providing five years of significant research funding takes pressure off of new faculty members. Not having to worry about research funding until after their tenure review is completed allows faculty members to focus on getting their research started and helps them establish their program faster. This goal promotes the funding of a larger number of awardees.

2. REWARDING THE BEST RESEARCHERS

CAREER should be used to recognize exceptional leaders in the field. CAREER funding is highly prestigious and serves to identify and reward the best and brightest “rising stars” in a discipline. In keeping with this intention, NSF selects nominees for the Presidential Early Career Awards for Scientists and Engineers (PECASE) from among the most meritorious new CAREER awardees. This goal promotes the funding of a smaller number of awardees than goal #1.

3. PROMOTING THE INTEGRATION OF RESEARCH AND EDUCATION

CAREER should promote the integration of research and education by encouraging a generation of scholar-scientists to view research and education as a single set of activities which should be integrated together, with the hope that awardees will support the ideas of integrating research and education and valuing education throughout their careers. As awardees become tenured faculty members within the academic community, ultimately residing in positions of power within departments and overseeing the tenure review process, they may be in a position to influence how education is valued within the academic system and to effect a cultural change.

The adoption and prioritization of these purposes varies across directorates, and sometimes even across programs within a single directorate, but program officers in each directorate acknowledged all three goals. Exhibit 2.7 provides examples of comments from program officers illustrating the ways in which these goals are conceptualized.
Exhibit 2.7

Program officer comments about the purposes of CAREER

Supporting Promising Researchers

➢ "CAREER is a powerful mechanism for young investigators to really start their careers."
➢ "CAREER is a leg up for people coming in the door: the promise of five years of funding without having to get a renewal, to get them started in their research."
➢ "In some applicants' 2nd or 3rd year, they show such great promise that you want to accelerate the process through their own work. CAREER provides a stronger base of support than a regular grant."

Rewarding the Best Researchers

➢ "These aren't seed grants — they are awards for the best in the community."
➢ "We view CAREER as an elite award rather than a run of the mill [regular research] award."
➢ "CAREER is a prestigious award... as such, it should have a higher competition level. We set the bar high — these are the future leaders in research and scholarly education activities."

Promoting the Integration of Research and Education

➢ "CAREER was the first NSF program to push the integration of research and education."
➢ "We replaced the PY1 with CAREER because we wanted a program that emphasized the integration of education and research."
➢ "All NSF proposals have a broader impact component for education and training, but we expect it to be more intense and a bigger part of the proposal for CAREER."


Dueling program purposes

Two of CAREER’s goals, Supporting Promising Researchers and Rewarding the Best Researchers, are sometimes at odds with each other. While program officers in some programs make CAREER awards only to the premier candidates, other program officers want all faculty members in the early stages of their careers to apply and make as many awards as possible. One program officer acknowledged this dichotomy:

There is a tension between two somewhat conflicting goals. You can pick the cream of the crop, and expect them to be leaders in their field. But typically fields do not have thousands of leaders, Another possible view is [that CAREER] is a capacity-building program. You pick people who have capacity. They may not be the best, but they have potential to be very, very good. Give them a start, so that you build the capacity of the field to do quality research. Leaders and followers build the research of a field. (NSF Program Officer)

The extent to which program officers within a given research program elevate the first or second of these goals is influenced by a number of factors, including:

• The average dollar amount of a single PI research award in a given program (in some programs, CAREER awards far exceed other single PI grants; in other programs, CAREER awards would be considered small);

• A program’s overall operating budget (for programs with smaller budgets, a single CAREER award may represent a large proportion of the program’s total funding);
• The nature of research in a program’s discipline (in some fields, the best research is conducted by the newest, most up to date researchers; in others, only more established researchers have the skills to be the best); and

• The degree to which new researchers in a field are eligible for CAREER (in some fields, researchers are housed in research laboratories, not universities).

As a result of variations in these factors and the inherent conflict between these two goals, individual NSF research programs tend to align with one or the other.

Promoting the integration of research and education

In contrast, CAREER’s third goal of promoting the integration of research and education complements the other two goals. Program officers across the Foundation consistently agree that CAREER applications are different from other “regular” research grant applications because they must propose education activities and a plan for the integration of research and education.

However, CAREER’s conceptualization of integration has evolved over time. It has moved away from requiring applicants to specify a career plan and towards asking applicants to describe how they plan to integrate research and education activities. The CAREER program preceded NSF’s current two-pronged review criteria for all grants of intellectual merit and broader impact. Some program officers credit CAREER with helping transition the entire agency and field towards thinking about research’s broader impact and integration with education. Now that all grants are reviewed for broader impact (which is often defined by program officers and members of the research community as an educational or outreach component, although it encompasses other impacts as well), program officers distinguish CAREER as having a higher emphasis on education than other grants’ broader impact components:

We have to pay lip service to the broader impact for regular proposals, but for CAREER, the education plan is 50 percent of the proposal. A CAREER proposal with excellent research and a weak education component wouldn’t fly – whereas a regular proposal with excellent research and a weak broader impact section might fly (might get funded). (NSF Program Officer)

While there is consensus that CAREER’s emphasis on education is greater than in traditional research grants, program officers do not agree about what integration of research and education actually means. Furthermore, the weight individual programs place on the education component relative to the research proposed varies; even within programs, program officers vary in terms of how much they emphasize the educational plan. These variations carry out into the field, where (as discussed in Chapter 7) faculty members are unclear what exactly is meant by “integration” or what makes an educational plan “innovative.”

Increasing diversity

In addition to weighing the three goals outlined above, many CAREER program officers also consider other applicant characteristics in the selection process, and expressed an implicit desire to increase the diversity of CAREER awardees across a variety of dimensions, including institutional size, type, and geography; whether the applicant’s institution is from EPSCoR; whether the applicant is from an underrepresented group (such as women, minorities); and how “hot” the research topic is.

An examination of the characteristics of PIs for CAREER proposals received versus those awarded indicates that some of these characteristics appear to be correlated with higher success rates. Exhibit 2.8
reveals that proposals from women and from prior NSF grantees have an advantage relative to their representation in the pool of applicants. For example, although 21 percent of CAREER proposals received in 1994 to 2004 were from PIs who were prior NSF grantees, 29 percent of such proposals were awarded. Conversely, proposals from individuals from EPSCoR states or Minority serving institutions are slightly less likely to be funded than might be expected given their representation in the applications pool. For example, 16 percent of proposals received came from PIs in EPSCoR states, but only 11 percent of such proposals were awarded. Members of ethnic minority groups traditionally underrepresented in STEM (URMs) appear to win CAREER awards in proportion to their representation in the applicant pool; eight percent of proposals are received from URMs and eight percent of CAREER awardees are URMs. It is important to note that approximately five percent of CAREER applicants (and awardees) chose not to report their race/ethnicity and are thus excluded from these calculations; as a result it is possible that the proportion of proposals received from or made to members of ethnic groups traditionally underrepresented in STEM may be slightly larger or smaller than shown in Exhibit 2.8.

Exhibit 2.8

Characteristics of CAREER proposals received versus awarded, 1995-2005

![Graph showing the distribution of CAREER proposals received and awarded by gender, membership in URM, prior NSF grantee, EPSCoR, and minority serving institution.]

Exhibit reads: Twenty-one percent of all CAREER proposals received between 1995-2005 were from women; of the CAREER proposals awarded (1995-2005), 24 percent were to women.

Notes:
Percentages in exhibit include multiple proposals from the same PI.
URM = Underrepresented Minority. In this report, URM is defined as African American, Hispanic, Native American, Alaskan Native, Hawaiian Native, Pacific Islander, or Multiracial individuals, including both men and women. Note that these URM figures exclude five percent of proposals that are received from PIs who choose not to report their race/ethnicity. Likewise, the reported percentage of proposals received/awarded to women excludes the 2.5 percent who choose not to report their gender.
Source: NSF Proposal data files.

The degree to which PIs’ home institutions focus on research also appears to be correlated with greater award success. CAREER proposals from PIs based at universities that devote 40 percent or more of their academic budgets to research are more likely to be awarded (Exhibit 2.9).
Percent research expenditures of CAREER applicants' and awardees' institutions

Note: Percent research expenditure = 100% x $\frac{\text{research}}{\text{(research + instruction)}}$.

Exhibit reads: Eleven percent of all CAREER proposals received come from PIs at institutions that spend less than 10 percent of their academic budget on research; six percent of all CAREER proposals awarded go to PIs at such institutions.

Source: NSF Proposal data files; Integrated Postsecondary Education Data System (IPEDS), maintained by the U.S. Department of Education, National Center for Education Statistics (NCES), http://nces.ed.gov/ipeds/

Program officer expectations regarding CAREER applications

While NSF program officers cannot change the stated goals or parameters of the CAREER program, their decisions about whether and how to fund CAREER awards send explicit and implicit messages to the field about whether junior faculty members are encouraged to apply for a CAREER award at all, as their first major NSF grant, or only after obtaining other research funding. Their direct interactions with potential CAREER awardees prior to submitting awards also make a difference.

In general, program officers across the Foundation encourage junior faculty members to apply for CAREER. Levels of encouragement range from programs where all eligible junior faculty are encouraged to apply, to those where eligible junior faculty are encouraged to apply as long as they have a planned program of research (not just an individual research project) and a creative commitment to their educational component, to programs which discourage junior faculty from applying to CAREER unless they are proposing an integrated program of research and education that is substantially more complex and innovative than a normal research grant proposal.

In the CISE, ENG, and MPS directorates, CAREER is seen as the primary starter grant for all talented junior faculty members. In these directorates, all junior faculty are encouraged to apply. In BIO, junior faculty are generally encouraged to apply, but program officers reported that they stress the importance of having a coherent five year research plan; sometimes new faculty are steered towards a regular research grant first. In the EHR directorate, similar concern was noted that faculty had to articulate a research plan.
that was sustainable across a five year (or longer) period, not just propose research on a single narrow topic. In SBE, where a single CAREER award is substantially larger than the average SBE research award, and one or two CAREER awards represent a large proportion of most research programs’ budgets, few CAREER awards are granted. Most programs are supportive of CAREER and encourage faculty to apply, but only when faculty fully commit to an integrated long-term plan of research and education; otherwise, faculty are encouraged to apply first for a smaller regular research grant. Finally, in GEO, most junior faculty are not encouraged to apply for CAREER. Rather, they are expected to apply for a regular research grant with which to establish their lab and demonstrate credibility, and only then, if interested, to apply for CAREER. The CAREER award in GEO is viewed as an elite grant intended only for those faculty who are integrating a “very creative, innovative, and out-of-the-box educational portfolio with their scientific objectives.”

These variations across directorates can be seen in data comparing the percent of CAREER proposals received from and awarded to prior NSF grantees, as illustrated in Exhibit 2.10. The GEO directorate receives the highest number of proposals from individuals who have won a previous NSF award (34 percent), and 44 percent of all GEO awards are given to prior NSF grantees. At the other end of the spectrum is the SBE directorate, where only 11 percent of applications and 21 percent of CAREER awards belong to prior NSF grantees.

### Exhibit 2.10

Percent of CAREER proposals received from and awarded to prior NSF grantees, by directorate, FY1995-2005

<table>
<thead>
<tr>
<th></th>
<th>% of CAREER proposals received from prior NSF grantees</th>
<th>% of CAREER awards to prior NSF grantees</th>
</tr>
</thead>
<tbody>
<tr>
<td>GEO</td>
<td>34%</td>
<td>44%</td>
</tr>
<tr>
<td>ENG</td>
<td>22</td>
<td>34</td>
</tr>
<tr>
<td>MPS</td>
<td>21</td>
<td>29</td>
</tr>
<tr>
<td>BIO</td>
<td>19</td>
<td>30</td>
</tr>
<tr>
<td>CISE</td>
<td>18</td>
<td>24</td>
</tr>
<tr>
<td>EHR</td>
<td>17</td>
<td>21</td>
</tr>
<tr>
<td>SBE</td>
<td>11</td>
<td>21</td>
</tr>
<tr>
<td>ALL</td>
<td>21</td>
<td>29</td>
</tr>
</tbody>
</table>

Exhibit reads: In the GEO directorate, 34 percent of CAREER proposals received were from prior NSF grantees; 44 percent of CAREER proposals awarded from the GEO directorate were to prior NSF grantees.

Source: NSF Proposal Data Files

Finally, currently eligible faculty members are allowed to submit up to three applications for CAREER. Between 1995 and 2005, 59 percent of awardees were successful on their first attempt; another 29 percent of awardees made two attempts before winning CAREER; the remaining 12 percent of awardees submitted three or more proposals (Exhibit 2.11).
CAREER awardees' number of attempts before success

<table>
<thead>
<tr>
<th># of CAREER attempts</th>
<th>Awardees who made this number of attempts before winning</th>
<th>% of total Awardees (N = 3881)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2283</td>
<td>59%</td>
</tr>
<tr>
<td>2</td>
<td>1114</td>
<td>29</td>
</tr>
<tr>
<td>3</td>
<td>404</td>
<td>10</td>
</tr>
<tr>
<td>4-6 **</td>
<td>80</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>3881</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

Table reads: 2,283 awardees (59 percent of all 3,881 awardees) were successful on their first attempt to win CAREER.

** In the early years of the program, individuals were allowed to apply more than 3 times.

Overall, 30 percent of PIs who apply win a CAREER award. There is some perception among faculty members that second and third attempts are weighted more positively at NSF, but multiple program officers disagreed, saying instead that repeat applicants have the benefit of receiving reviewers’ comments on previous submissions. However, as shown in Exhibit 2.12, the success rates for individuals who applied multiple times do not differ much from the success rate of those who applied only once, implying that being a repeat applicant does not, in fact, increase the likelihood of winning a CAREER award. That is, the percentage of those who make three attempts and win CAREER is roughly equivalent both to the percentage of those who make two attempts and win and the percentage of those who make one attempt and win.

CAREER Success Rates by Number of Attempts

<table>
<thead>
<tr>
<th># of CAREER proposal attempts</th>
<th>PIs who made this number of CAREER attempts</th>
<th>PIs who won CAREER after this number of attempts</th>
<th>Success rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>7752</td>
<td>2283</td>
<td>29%</td>
</tr>
<tr>
<td>2</td>
<td>3444</td>
<td>1114</td>
<td>32</td>
</tr>
<tr>
<td>3</td>
<td>1473</td>
<td>404</td>
<td>27</td>
</tr>
<tr>
<td>4-6 **</td>
<td>320</td>
<td>80</td>
<td>25</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>12989</strong></td>
<td><strong>3881</strong></td>
<td><strong>30</strong></td>
</tr>
</tbody>
</table>

Table reads: 7,752 individual PIs applied exactly once to CAREER. Among those who applied only one time, 2,283 won a CAREER award. This is equivalent to a 29 percent success rate (2283 ÷ 7752 = .29).

** In the early years of the program, individuals were allowed to apply more than 3 times.
Chapter 3: CAREER Awardees and Award Implementation

This chapter introduces the CAREER awardees, their characteristics, and the characteristics of the institutions from which they applied for CAREER and where they are currently employed. The chapter also examines the reasons why active awardees applied for the CAREER grant, how they have used the award funds, and whether they have pursued additional funding during their award period. Where available, we present data on the population of awardees funded between 1994 and 2005 (N = 3,881); in addition, we report findings from awardees who completed the study survey (N = 1,138); this sample was selected to be representative of awardees from all NSF directorates (sampling methods are detailed in Chapter 1 and Appendix A).

Overview of Chapter Findings

The highlights of the findings in this chapter include the following:

- Three-fourths of the population of CAREER awardees are male, and, of those reporting race/ethnicity 82 percent are white or Asian\(^1\). Eleven percent of all CAREER awardees come from EPSCoR states; two percent are from minority serving institutions.
- Ninety-seven percent of CAREER awardees surveyed are employed in academic positions, and of those, 81 percent have earned tenure.
- Awardees report having applied to CAREER because of CAREER's importance in tenure review (78 percent), prestige (66 percent), and/or emphasis on integrating research and education (60 percent).
- Over three-quarters of CAREER awardees said that winning a CAREER award would be a significant factor in their review, and about half (49 percent) reported that applying to CAREER is simply expected of all assistant professors.
- CAREER awardees receive the same levels of support as other junior faculty with grants. Departmental endorsement of the CAREER application and letters of commitment do not lead to an active partnership with awardees. Most chairpersons reported that they are equally involved with awardees as with other junior faculty who are writing grant proposals.
- Virtually all active awardees use CAREER funds to support graduate students, to travel to disseminate research findings, and to support themselves with a summer salary (97 percent, 94 percent, and 92 percent of awardees, respectively). Other uses of funds varied.
- Three-fifths of past CAREER awardees reported that their CAREER funds had been adequate to implement the activities they had proposed.
- Nearly all (95 percent) active CAREER awardees report that they applied for other grant funding during their CAREER award funding period. Research needs dominated the reasons

\(^1\) Because five percent of awardees do not report their race or ethnicity to NSF, the reported percentage of awardees who are white or Asian may under- or over-estimate the true percentage.
for seeking additional funds, including the desire to pursue additional research topics or collaborate with others, and the need to support additional graduate students.

**Who are the CAREER awardees?**

**Demographic characteristics of awardees**

About one-quarter of CAREER awardees are female; eight percent of those awardees who reported their race or ethnicity are members of an ethnic minority group traditionally underrepresented in STEM fields (Exhibit 3.1). The distribution of awardees by gender has remained stable since 2000. The percent of minority awardees has risen slightly from six percent in 1999 to nine percent in 2005; the 1997 cohort of awardees has had the highest proportion of minority PIs (12 percent). Almost half (48 percent) of awardees submitted proposals from institutions where research constitutes at least 40 percent of institutional expenditures. Just over 10 percent of awardees come from institutions in EPSCoR states, and two percent come from minority-serving institutions.

CAREER awards typically go to academics with some work experience. While the program solicitation allows individuals at museums or science institutes with significant educational responsibilities to submit CAREER proposals, nearly all CAREER awardees (97 percent) are employed in academic positions, and of those, 81 percent reported that they had earned tenure. Most CAREER awardees (87 percent) won their award three years or more after earning their highest academic degree, with the mean at 5.2 years. The importance of prior experience as an NSF Principal Investigator in winning a CAREER award has varied over time. In the first year (1995), 39 percent of awardees were prior NSF grantees. The percentage dropped to a low of 23 percent in 2002 and rose steadily to 34 percent in 2005. Overall, 59 percent of CAREER awardees were successful on their first attempt.

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2 Minority or ethnic groups traditionally underrepresented in STEM fields include Hispanics, African-Americans, Pacific Islanders, Hawaiian Natives, Alaskan Natives, American Indians, and those who classify themselves as multiracial. Five percent of awardees did not report their race or ethnicity on their CAREER proposal and are excluded from these calculations.

3 Dollars spent on research expenditures as a percentage of the institution’s total spending on research and education expenditures.

4 Awardees who earned tenure after Spring 2007 when the survey closed are not included in this figure.
Exhibit 3.1

At a Glance: Characteristics of CAREER Awardees FY1995-2005

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>CAREER Awardees ¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent having previously been PI on another NSF award</td>
<td>29%</td>
</tr>
<tr>
<td>Percent belonging to underrepresented minority (URM) group b</td>
<td>8%</td>
</tr>
<tr>
<td>Percent female</td>
<td>24%</td>
</tr>
<tr>
<td>Percent who applied from an EPSCOR state</td>
<td>11%</td>
</tr>
<tr>
<td>Percent who applied from a minority-serving institution</td>
<td>2%</td>
</tr>
<tr>
<td>Percent who applied from a &quot;research university&quot; c</td>
<td>48%</td>
</tr>
<tr>
<td>Mean number of years between prior degree and CAREER award</td>
<td>5.3 years</td>
</tr>
<tr>
<td>Percent who won CAREER on their first attempt</td>
<td>59%</td>
</tr>
<tr>
<td>Percent surveyed who are employed in academic positions d</td>
<td>98%</td>
</tr>
<tr>
<td>Percent surveyed who had earned tenure by Spring 2007⁰</td>
<td>81%</td>
</tr>
</tbody>
</table>

¹ Unless otherwise noted, figures are based on the population of awardees who received CAREER between 1995 and 2005 (N=3881).

² Minority or ethnic groups traditionally underrepresented in STEM fields include Hispanics, African-Americans, Pacific Islanders, Hawaiian Natives, Alaskan Natives, American Indians, and those who classify themselves as multiracial. Note that these URM figures exclude 5 percent of awardees who choose not to report their race/ethnicity. Likewise, the reported percent of awardees who are women excludes the 2.5 percent who choose not to report their gender.

³ In this context, we have defined a research university as one where at least 40 percent of its total research and instructional expenditures go for research. Expenditure information on each institution was obtained from IPEDS.

⁴ From PI Survey, N = 1104 (missing N = 34).

⁵ From PI Survey, N = 1101 (missing N = 11), item asked only of those who had ever held an academic position.

Sources: NSF Proposal data files; Survey of PIs

Profiles of CAREER awardees by directorate

CAREER awardees vary somewhat by directorate on several of the characteristics listed above, including gender, minority status, previous PI experience, and number of years between highest degree and CAREER award. Exhibit 3.2 summarizes key differences by directorate.
### Exhibit 3.2

**Characteristics of CAREER Awardees, 1995-2005, Overall and by Directorate**

<table>
<thead>
<tr>
<th></th>
<th>All Awardees</th>
<th>BIO</th>
<th>CISE</th>
<th>EHR</th>
<th>ENG</th>
<th>GEO</th>
<th>MPS</th>
<th>SBE</th>
</tr>
</thead>
<tbody>
<tr>
<td>% having previously been PI on another NSF award</td>
<td>29</td>
<td>36</td>
<td>19</td>
<td>60</td>
<td>23</td>
<td>30</td>
<td>22</td>
<td>37</td>
</tr>
<tr>
<td>% belonging to URM group</td>
<td>8</td>
<td>10</td>
<td>5</td>
<td>17</td>
<td>10</td>
<td>7</td>
<td>8</td>
<td>11</td>
</tr>
<tr>
<td>% female</td>
<td>24</td>
<td>36</td>
<td>19</td>
<td>60</td>
<td>23</td>
<td>30</td>
<td>22</td>
<td>37</td>
</tr>
<tr>
<td>% applied from an EPSCOR state</td>
<td>11</td>
<td>14</td>
<td>6</td>
<td>11</td>
<td>13</td>
<td>14</td>
<td>12</td>
<td>6</td>
</tr>
<tr>
<td>% applied from a minority-serving institution</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>6</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>% applied from a “research university”</td>
<td>48</td>
<td>36</td>
<td>50</td>
<td>41</td>
<td>52</td>
<td>48</td>
<td>45</td>
<td>44</td>
</tr>
<tr>
<td>Mean # of years between prior degree and CAREER</td>
<td>5</td>
<td>8</td>
<td>4</td>
<td>5</td>
<td>5</td>
<td>6</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>% won CAREER on their first attempt</td>
<td>59</td>
<td>76</td>
<td>62</td>
<td>76</td>
<td>50</td>
<td>77</td>
<td>58</td>
<td>81</td>
</tr>
<tr>
<td>% employed in academic positions</td>
<td>97</td>
<td>99</td>
<td>97</td>
<td>100</td>
<td>98</td>
<td>98</td>
<td>98</td>
<td>100</td>
</tr>
<tr>
<td>% who had earned tenure by Spring 2007</td>
<td>81</td>
<td>80</td>
<td>75</td>
<td>76</td>
<td>82</td>
<td>78</td>
<td>85</td>
<td>94</td>
</tr>
</tbody>
</table>

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**Notes:**

- Unless otherwise noted, figures are based on the population of awardees who received CAREER between 1994 and 2005 (N=3881). For such census data, no tests of statistical significance are appropriate.
- Minority or ethnic groups traditionally underrepresented in STEM fields include Hispanics, African-Americans, Pacific Islanders, Hawaiian Natives, Alaskan Natives, American Indians, and those who classify themselves as multiracial. Note that these URM figures exclude 5 percent of awardees who choose not to report their race/ethnicity. Likewise, the reported percent of awardees who are women excludes the 2.5 percent who choose not to report their gender.
- In this context, we have defined a research university as one where at least 40 percent of its total research and instructional expenditures go for research. Expenditure information on each institution was obtained from IPEDS.
- From PI Survey, N = 1104 (missing N = 34).
- From PI Survey, N = 1101 (missing N = 11); item asked only of those who had ever held an academic position. Note that directorate to directorate comparisons of raw data on tenure do not control for differences between directorates in the average number of years since earning the Ph.D.
- Descriptive data for directorates but no tests of statistical significance are presented because the study was not designed to produce reliable estimates of differences between directorates.

**Sources:** NSF Proposal data files, Survey of PIs.
Applying to CAREER

Reasons faculty apply to CAREER

Active CAREER awardees—that is, those whose award was active at the time of the survey (administered October 2006 to March 2007)—report having applied to CAREER for multiple reasons (Exhibit 3.3), most frequently because of:

- CAREER’s importance in tenure review (78 percent),
- CAREER’s prestige (66 percent), and
- CAREER’s emphasis on integrating research and education aligned with applicants’ goals (60 percent).

Faculty members in the departments and institutions visited corroborate the survey findings, and report that decisions to apply for CAREER are driven by multiple reasons related to the award’s contribution to professional advancement and tangible substantive benefits.

“It is the best opportunity for a junior faculty member to get a major support from a federal agency. The CAREER award is so important in that it first provides money needed to do research and to support graduate students and post docs. It also is an important recognition that your colleagues will take notice. Also, in the future for tenure evaluation, that is critical. CAREER award is the number one choice for any junior faculty member.” (CISE awardee)

Directorate differences in reasons faculty apply for CAREER

Active CAREER awardees differed by directorate in why they applied for the CAREER award. These differences may be a function of several factors: the number of CAREER awards in the directorate, the relative ease (or difficulty) in the discipline to integrate research and education, the availability of other grants of comparable size, and the typical career route of junior faculty, among others. Exhibit 3.3 illustrates how awardees in each directorate differ from the NSF-wide average. In particular:

- Over 60 percent of awardees in all directorates indicated that CAREER would be a significant factor in their tenure review and that CAREER was the most prestigious grant for which they were eligible; nearly 90 percent of active awardees in CISE, and 80 percent of those in both ENG and GEO cited the significant role CAREER would play in their tenure review.
- Eighty-five percent of active awardees from the BIO directorate indicated that CAREER’s emphasis on the integration of research and education aligned with their own goals; in contrast, 44 percent of those from CISE and 41 percent of those from SBE cited this emphasis as a reason for applying;
- About half of respondents in each directorate—with the exception of the GEO directorate—felt they would be more competitive in a program targeting junior faculty; in contrast only 28 percent of GEO awardees cited this as a motivation for applying.

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5 In this report, active awardees are those whose award period was still active at the time they completed the survey (between October 2006 and March 2007).

6 The results tally to more than 100 percent because respondents could check more than one response.
## Exhibit 3.3

**Reasons active\(^a\) awardees applied for CAREER funding (multiple reasons possible)**

<table>
<thead>
<tr>
<th>Item</th>
<th>Percentage of active awardees who cited this reason(^b)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Getting a CAREER grant would be a significant factor in my tenure review(^c)</td>
<td>78%</td>
</tr>
<tr>
<td>I thought CAREER was the most prestigious grant for which I was eligible</td>
<td>65 (68, 63, 64, 60, 57, 49, 15, 43, 49, 51, 34, 47)</td>
</tr>
<tr>
<td>CAREER’s emphasis on integrating research and education aligned with my goals</td>
<td>60 (85, 44, 79, 62, 72, 66, 79, 49, 51, 28, 37, 53)</td>
</tr>
<tr>
<td>The minimum CAREER grant award size was attractive</td>
<td>53 (57, 49, 71, 52, 68, 48, 71, 49, 51, 28, 37, 53)</td>
</tr>
<tr>
<td>All assistant professors in my department were expected to apply for a CAREER grant</td>
<td>49 (15, 79, 0, 59, 24, 37, 0, 15, 79, 0, 59, 24)</td>
</tr>
<tr>
<td>I felt that I was more competitive in a grant program targeting junior faculty</td>
<td>49 (43, 49, 50, 51, 28, 51, 53)</td>
</tr>
<tr>
<td>A senior colleague encouraged me to apply for CAREER</td>
<td>46 (53, 59, 42, 42, 40, 34, 47)</td>
</tr>
<tr>
<td>I attended a NSF-supported grant writing workshop</td>
<td>8 (9, 6, 7, 11, 8, 6, 18)</td>
</tr>
<tr>
<td>Other grants had more burdensome application and/or reporting requirements</td>
<td>5 (4, 8, 0, 5, 12, &lt;1, 0)</td>
</tr>
<tr>
<td>Getting a CAREER grant was required for my tenure review(^d)</td>
<td>2 (0, 5, 0, 2, 0, &lt;1, 0)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>BIO</th>
<th>CISE</th>
<th>EHR</th>
<th>ENG</th>
<th>GEO</th>
<th>MPS</th>
<th>SBE</th>
</tr>
</thead>
<tbody>
<tr>
<td>68</td>
<td>88</td>
<td>64</td>
<td>80</td>
<td>80</td>
<td>69</td>
<td>76</td>
</tr>
<tr>
<td>62</td>
<td>63</td>
<td>64</td>
<td>73</td>
<td>64</td>
<td>65</td>
<td>71</td>
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<tr>
<td>85</td>
<td>44</td>
<td>79</td>
<td>62</td>
<td>72</td>
<td>66</td>
<td>41</td>
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<tr>
<td>57</td>
<td>49</td>
<td>71</td>
<td>52</td>
<td>68</td>
<td>48</td>
<td>65</td>
</tr>
<tr>
<td>15</td>
<td>79</td>
<td>0</td>
<td>59</td>
<td>24</td>
<td>37</td>
<td>0</td>
</tr>
<tr>
<td>43</td>
<td>49</td>
<td>50</td>
<td>51</td>
<td>28</td>
<td>51</td>
<td>53</td>
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<tr>
<td>53</td>
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<td>40</td>
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<td>47</td>
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<tr>
<td>8</td>
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<td>11</td>
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<td>6</td>
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<tr>
<td>4</td>
<td>8</td>
<td>0</td>
<td>5</td>
<td>12</td>
<td>&lt;1</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>5</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>&lt;1</td>
<td>0</td>
</tr>
</tbody>
</table>

---

\(^a\) Of active CAREER awardees, 78 percent applied for CAREER funding because a CAREER grant would be a significant factor in tenure review.

\(^b\) N = 474 active awardees; Missing N = 4 (470 active awardees responded to the survey item). Active awardees are those whose awards were active at the time of survey completion.

\(^c\) Underlining appeared in the survey item.

\(^d\) Responses sum to more than 100% because respondents could select more than one answer.

\(^e\) Descriptive data for directorates but no tests of statistical significance are presented because the study was not designed to produce reliable estimates of differences between directorates.

**Sources:** PI Survey, Item F7. What initially influenced your decision to apply for the CAREER grant? (Check all that apply.)
In the next section, we elaborate on CAREER’s role in tenure, its prestige, and its award size based on visits to departments and institutions, while in the section that follows we explore more fully the reasons why awardees applied to CAREER because its emphasis on integrating research and education aligned with their goals.

**Reasons for applying: tenure, prestige, and award size**

While only 2 percent of awardees said that winning a CAREER award was required for tenure review, 78 percent said it would be a significant factor in their review. Reflecting this importance, 49 percent of awardees reported that applying to CAREER is simply expected of all assistant professors.

“[Why did you apply?] Because people like me were supposed to get one. [At this institution] you are supposed to be a leader in your field. You’ve got six years to prove it and if you don’t, you’re out. The CAREER award, or Young Investigators or Army, that is something you’re supposed to get. Being a leader in something means that you would get highly coveted awards, such as the CAREER award.” (CISE awardee)

“On the negative side, while not required by the rules, it was made clear to me that I was expected to get the grant for tenure.” (CISE awardee)

The substantive benefits of CAREER include not just the dollars that the awardees receive, but the circumstances of the dollars that appeal to junior faculty. The following factors were important:

- Described as capacity to concentrate on their own research rather than working on projects of senior faculty;
- Freedom from the need to write grant proposals constantly; and
- Sufficient resources to purchase equipment and support graduate students.

**Odds on winning – success rates**

One frequently mentioned reason for applying was the probability of success. In some departments, the odds are considered favorable primarily because the department has experienced success in the past. This is a two-edged sword; departments with a winning track record put considerable pressure on young faculty to apply:

“Faculty are pretty much expected to apply. We’ve won more than our fair share in engineering in general. Unfortunately it became an expectation that junior faculty would win one, and as a consequence, CAREER has lost some of its [internal] prestige. It’s a check box.” (ENG faculty member, site visit interview)

In departments with lower success rates, the application process is more likely to be perceived as capricious. While young faculty members are still expected to apply, there is much less expectation of success. One Engineering department visited has one awardee and several failed applications. According to one respondent, “the expectations of reviewers change every year” and, “if they see you have other potential sources of funding, they are likely to turn you down.

A respondent in an Engineering school at another institution said, “Applying for funding is like throwing darts blindfolded. You throw as many darts as you can.” Another respondent in the same department used a different gambling analogy, “Roll the dice and see what happens.”
No matter the odds, almost all junior faculty in all visited departments were encouraged or were themselves motivated to apply for CAREER awards. One respondent, for example, said “I knew the chances were small, but I was doing it for myself, like a painting.”

Reasons for applying: desire to integrate research and education

Sixty percent of active awardees reported that CAREER’s emphasis on integrating research and education influenced their decision to apply for the CAREER grant. Faculty members who were interviewed perceive that NSF has increased its emphasis on education and the integration of research and education, both through CAREER and in NSF’s second merit review criterion (the “broader impact of the proposed activities”) for all research grants.

From the site visits it appears that the alignment of integration of research and education to awardees’ professional goals took one of two forms:

- for some, CAREER’s focus on the integration of research and education was consistent with something they were already doing or would have done, at least in part;
- for others, CAREER’s focus on the integration of research and education facilitated and validated their interest in education.

CAREER as extension of existing education activities

Many respondents across departments and institutions said that education is something that young faculty at a university do as part of their routines and consequently they had proposed something they would probably do anyway. Examples from three different disciplines in three different departments illustrate this point.

“The education component was something we were doing in any case, but now I could use NSF funding to support it.” [The site visitor noted that in the education component of the CAREER proposal, the awardee had proposed a continuation of his ongoing collaboration with a local community college to bring the community college students to [the university] and give them some exposure to research before they actually transferred to [the university].] (BIO awardee)

“It’s not clear to me that I did it because I promised to do it [in the CAREER proposal] or it would have been something I would have done anyway... I focused effort to enhance interactions between Mathematics and CS [Computer Science]. It was an easy thing to write because of the nature of my work/research; it’s likely this would have happened anyway.” (CISE awardee)

[Site visit report] One awardee integrated high school students into his research as soon as he arrived at [his university], so it seemed like a natural fit. Already having the network of teachers and high school students set up before he applied he thinks made him competitive for the CAREER award. (GEO awardee)

CAREER as validation of interest in education

For some awardees the CAREER award facilitated and validated their interest in and commitment to education beyond what they otherwise might have felt supported in doing, especially as an untenured faculty member. For these young faculty, the fact that NSF recognized the importance of education in so prestigious an award was an additional incentive to apply.

[Site visit report] For him, the focus of CAREER on integration of research and education was very important. It provided an opportunity for him to put into practice his strong belief that undergraduates should be involved with actual research, and having a “generation of students who would be interested in research centered around museum-type problems.” (BIO awardee)
“The education piece was important to me. I had taught ‘chemistry in literature’ before to see whether it could be done, and I wanted to do it again. I don’t think I would have done Science Café [a public lecture series on “hot” science topics] otherwise. I feel compelled to do that. It carries the spirit.” (MPS awardee)

“Yes, it (the education component) was very important. I had background in teaching …[and] I wanted to have students go through a discovery approach to learning.” (ENG awardee)

Their passion for teaching drew several awardees in departments around the country to the CAREER award.

[Site visit report] The focus on integration of research and education was important to her at the time of application because she was very focused on teaching at that point. She viewed the research as a “requirement,” but the teaching was where her “passion” lay. (SBE awardee)

[Site visit report] “I chose [this institution], because of the caliber of the undergraduates. [I wanted to be] a teaching professor at a place where I could also do research.” He got his CAREER award on the first try because of his “solid approach to the integration of education and research.” He proposed to spend 50 percent of his time on education and 50 percent on research. (CISE awardee)

Support for Awardees and Other Junior Faculty

In most departments, junior faculty members are provided multiple supports. According to department chairpersons and other senior faculty, there is no difference in supports provided to CAREER-eligible faculty, junior faculty with CAREER awards, and junior faculty with other grants. CAREER awardees are not provided more supports than other junior faculty with grants.

In the chairpersons’ survey, virtually all departments report providing some start-up supports for all junior faculty, with computer equipment heading the list (Exhibit 3.4). Lab facilities, other research instrumentation, and summer salaries are also typically provided to junior faculty, according to at least 80 percent of the department chairpersons surveyed. Three-quarters of the department chairpersons also reported providing graduate student stipends, formal mentoring from senior faculty, and release time.
Exhibit 3.4

Types of start-up support typically provided to junior faculty (multiple responses possible)

<table>
<thead>
<tr>
<th>Start-up Support</th>
<th>Percentage of Chairs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computer equipment</td>
<td>94%</td>
</tr>
<tr>
<td>Summer salary</td>
<td>85</td>
</tr>
<tr>
<td>Laboratory facilities</td>
<td>83</td>
</tr>
<tr>
<td>Other research instrumentation or equipment</td>
<td>82</td>
</tr>
<tr>
<td>Stipends for graduate students</td>
<td>80</td>
</tr>
<tr>
<td>Formal mentoring from senior faculty</td>
<td>78</td>
</tr>
<tr>
<td>Release time</td>
<td>78</td>
</tr>
<tr>
<td>Administrative staff support</td>
<td>64</td>
</tr>
<tr>
<td>Startup/Discretionary Funds</td>
<td>16</td>
</tr>
<tr>
<td>Travel Funds</td>
<td>8</td>
</tr>
<tr>
<td>Other (e.g., relocation expenses, informal mentoring)</td>
<td>6</td>
</tr>
</tbody>
</table>

N = 556  Missing N = 8

Notes: The total exceeds 100 percent because department chairs chose multiple responses.

Source: CAREER Department Chair Survey, Q5. Please indicate the start-up support that is typically provided to junior faculty in your department during the early stages of their careers. (Check all that apply.)

Department chairs also reported that supports were available to faculty as they wrote proposals. Ninety percent reported assistance with budgeting, and over 80 percent reported that senior faculty were available to review proposals. Half reported that NSF CAREER award winners were available to review proposals as well. Departments typically do not provide faculty members writing a CAREER proposal any additional support that is not provided to those writing other types of grant proposals; one in six department chairs (16 percent) reported such support (e.g., assistance from prior CAREER winners in the department; mock panel reviews of CAREER proposals; help with the educational component of the CAREER proposal).

Site visits confirmed survey results. Both junior and senior faculty commented that mentoring was usually informal, with junior faculty having to take the initiative in requesting assistance. In four departments where many CAREER awardees are on the faculty, past awardees:

- Shared their own winning applications;
- Commented on the draft CAREER application; and
- Advised on NSF expectations (especially about the education component) based upon their experience serving on NSF panels.

These departments (or their universities) also held workshops on how to write CAREER applications, and two departments provided travel funds to CAREER applicants to fly to Washington, DC to meet with individual NSF program officers.
Once they have received CAREER, awardees do not receive extra departmental support beyond that provided to junior faculty with other grant funding. The majority of department chairs reported providing all faculty with administrative staff support (67 percent of department chairs), followed by laboratory facilities (63 percent), formal mentoring by senior staff (59 percent), and computer equipment (54 percent). Forty-seven percent of department chairs reported providing release time for CAREER awardees, compared to 42 percent reporting release time for junior faculty with other grants.

There were the isolated instances (less than a handful) where winning a CAREER award meant a decrease in the university’s contribution to start-up costs. For example, instead of all junior faculty receiving the same start-up package, one CAREER awardee interviewed during a site visit noted that part of his start-up package was conditional on need. The department subsequently withheld part of it because he could be covered by grants.

Within Historically Black Colleges and Universities (HBCUs) and Minority Serving Institutions (MSIs), CAREER is especially important in providing essential funding for research and launching one’s career, primarily because of the lesser availability of start-up research funds in these institutions. CAREER awardees in HBCUs and MSIs also reported that their departments often have limited instrumentation and far less research capacity than other institutions of higher education. In addition, the culture in these institutions is often focused on teaching and is not always supportive of research.

**Uses and Adequacy of Award Funding for CAREER Awardees**

**Uses of CAREER award funds**

When asked how they are using their CAREER award funds, active awardees reported, on average, more than six categories of expenses, most of which relate to research costs (Exhibit 3.5). Virtually all active awardees were using funds to support graduate students, to travel to disseminate research findings, and to support themselves with a summer salary (97 percent, 94 percent, and 92 percent of awardees, respectively). Most active CAREER awardees (85 percent) report supporting one or two graduate students. About 80 percent were using award funds for supplies and equipment, and 70 percent were using award funds to support undergraduate students to collaborate on their research. Two-thirds of those who are supporting undergraduates fund one undergraduate with CAREER funds. Among active CAREER awardees, just over a third (36 percent) were using award funds to develop a new course or course module.

Across directorates, the four most frequently checked items were the same for NSF as a whole and for each directorate. There was more variability for less frequently checked items, and was related to the content of the discipline (e.g., awardees from BIO and GEO using funds for travel to conduct field-based research). Variations from the NSF average are presented in Exhibit 3.5.

Across all directorates, providing support for graduate students was the first or second most commonly cited use of CAREER funds. Across directorates, the next most highly cited uses of funds included summer salary, travel to disseminate research findings, supplies, and either equipment or instrument purchases or support for undergraduates. The GEO directorate had the highest percentage of active awardees reporting that they used CAREER funds to support undergraduates working on their research (88 percent). Larger proportions of active awardees in BIO, GEO, and SBE use funds.
How active\(^a\) awardees use CAREER funds (multiple reasons possible), by Directorate

<table>
<thead>
<tr>
<th>Item</th>
<th>Percentage of active awardees who cited this use(^b)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Support for graduate students to collaborate on my research</td>
<td>97% (n=47) 94 (n=130) 99 (n=14) 100 (n=121) 98 (n=25) 96 (n=116) 94 (n=17) 88 (n=88)</td>
</tr>
<tr>
<td>Travel to disseminate my research findings</td>
<td>94 (n=47) 91 (n=130) 96 (n=14) 100 (n=121) 98 (n=25) 100 (n=116) 87 (n=17) 88 (n=88)</td>
</tr>
<tr>
<td>Summer salary for myself</td>
<td>92 (n=47) 87 (n=130) 96 (n=14) 100 (n=121) 94 (n=25) 92 (n=116) 86 (n=17) 88 (n=88)</td>
</tr>
<tr>
<td>Supplies</td>
<td>83 (n=47) 91 (n=130) 71 (n=14) 100 (n=121) 87 (n=25) 88 (n=116) 85 (n=17) 82 (n=88)</td>
</tr>
<tr>
<td>Equipment or instruments</td>
<td>75 (n=47) 81 (n=130) 71 (n=14) 79 (n=121) 73 (n=25) 76 (n=116) 78 (n=17) 71 (n=88)</td>
</tr>
<tr>
<td>Support for undergraduates to collaborate on my research</td>
<td>70 (n=47) 77 (n=130) 56 (n=14) 78 (n=121) 71 (n=25) 88 (n=116) 76 (n=17) 76 (n=88)</td>
</tr>
<tr>
<td>Development of a new course or course module</td>
<td>36 (n=47) 38 (n=130) 35 (n=14) 36 (n=121) 42 (n=25) 48 (n=116) 25 (n=17) 35 (n=88)</td>
</tr>
<tr>
<td>Travel to acquire new knowledge or skills</td>
<td>29 (n=47) 36 (n=130) 24 (n=14) 57 (n=121) 24 (n=25) 44 (n=116) 32 (n=17) 24 (n=88)</td>
</tr>
<tr>
<td>Travel to engage in educational or outreach activities</td>
<td>21 (n=47) 30 (n=130) 15 (n=14) 29 (n=121) 22 (n=25) 32 (n=116) 22 (n=17) 18 (n=88)</td>
</tr>
<tr>
<td>Travel for a field-based component of my research</td>
<td>21 (n=47) 40 (n=130) 14 (n=14) 29 (n=121) 9 (n=25) 60 (n=116) 19 (n=17) 47 (n=88)</td>
</tr>
<tr>
<td>Other educational activities</td>
<td>19 (n=47) 17 (n=130) 8 (n=14) 29 (n=121) 24 (n=25) 28 (n=116) 23 (n=17) 18 (n=88)</td>
</tr>
<tr>
<td>Curricular reform activities in my field</td>
<td>11 (n=47) 15 (n=130) 12 (n=14) 14 (n=121) 11 (n=25) 24 (n=116) 5 (n=17) 18 (n=88)</td>
</tr>
<tr>
<td>Recruitment of human participants/acquisition of animal subjects</td>
<td>7 (n=47) 13 (n=130) 6 (n=14) 64 (n=121) 2 (n=25) 4 (n=116) 2 (n=17) 24 (n=88)</td>
</tr>
</tbody>
</table>

Exhibit notes:

\(^a\) N = 474 active awardees; Missing N = 3 (471 active awardees responded to the survey item). Active awardees are those whose awards were active at the time of survey completion.

\(^b\) Responses sum to more than 100% because respondents could select more than one answer.

\(^c\) Descriptive data for directorates but no tests of statistical significance are presented because the study was not designed to produce reliable estimates of differences between directorates.

Sources: PI Survey, Item F3. How are you using your CAREER award funds? (Check all that apply.)
for field-based component of research (40 percent, 60 percent, and 47 percent, respectively) than in other directorates. Active awardees from GEO were also more likely than those in other directorates to report using funds for curricular reform in their field (24 percent).

**Adequacy of CAREER funding**

Three out of five past CAREER awardees reported that their CAREER funds had been adequate to implement the activities they had proposed. This varied substantially by discipline. In the EHR and SBE directorates, over 80 percent of respondents found their CAREER funds adequate; in contrast, within the CISE directorate, 44 percent of respondents indicated that the funding amount was not adequate (Exhibit 3.6).

<table>
<thead>
<tr>
<th>CAREER award funding was adequate to implement the proposed activities</th>
<th>BIO</th>
<th>CISE</th>
<th>EHR</th>
<th>ENG</th>
<th>GEO</th>
<th>MPS</th>
<th>SBE</th>
<th>All past awardees</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>77%</td>
<td>50%</td>
<td>86%</td>
<td>61%</td>
<td>71%</td>
<td>66%</td>
<td>81%</td>
<td>63%</td>
</tr>
<tr>
<td>No</td>
<td>20</td>
<td>44</td>
<td>14</td>
<td>38</td>
<td>29</td>
<td>31</td>
<td>19</td>
<td>34</td>
</tr>
<tr>
<td>Don't remember</td>
<td>3</td>
<td>6</td>
<td>--</td>
<td>1</td>
<td>--</td>
<td>3</td>
<td>--</td>
<td>3</td>
</tr>
</tbody>
</table>

Exhibit reads: 77% of past awardees within the BIO directorate reported that CAREER funding was adequate to implement their proposed activities.

N = 613 Awardees who indicated their CAREER award was no longer active. Question asked of past awardees only.

Source: Survey of PIs. Questions F9. *Was the dollar amount you received as your CAREER award adequate to implement the activities you proposed?*

Note: Descriptive data for directorates, but no tests of statistical significance, are presented because the study was not designed to produce reliable estimates of differences between directorates.

**Pursuit of additional funding**

Having additional grant funds is of concern to almost all CAREER awardees. When active awardees were asked whether they had applied for other grant funding while they still had their CAREER award, almost all (95 percent) said yes. As shown in Exhibit 3.7, research needs dominated the reasons for seeking additional funds, and awardees checked multiple research-related items. Most awardees wanted to pursue additional research topics (90 percent of active awardees). About three-fourths of awardees applied for other grants because CAREER funds were not sufficient to support all their graduate students, they wanted to collaborate with other researchers or colleagues, or noted funds were not sufficient to meet the needs of their research agendas (74 percent, 73 percent, and 70 percent, respectively). Fewer than 20 percent of awardees reported that they applied for additional funding to support the integration of their research and teaching. Research interests may not be the only driver for other funding, given that funds are typically more available for research than for education, and some NSF avenues for education funds (e.g., Instructional Materials Development) are not well designed for individual principal investigators.
Active awardees who applied for more funding varied by directorate with respect to the reasons for seeking additional monies (Exhibit 3.7). In contrast to respondents from other directorates, fewer than half of active awardees from BIO, EHR, and SBE directorates said that CAREER was insufficient to support their graduate students. Fewer than 40 percent of active awardees in EHR and SBE thought CAREER funding was insufficient to meet their research agenda; in contrast, at least half of active awardees in other directorates needed additional funding to support their research agendas. At least three-quarters of the active awardees in each of the CISE, EHR, ENG, and GEO directorates sought funding sources that would allow them to collaborate with other researchers; this reason was cited by less than two-thirds of those in each of the other three directorates.
### Exhibit 3.7

Why active awardees applied for additional grants (multiple reasons possible)

<table>
<thead>
<tr>
<th>Item</th>
<th>Percentage of active awardees who cited this reason(^b)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>BIO(^c) (n=126)</td>
</tr>
<tr>
<td>I wanted to pursue additional research topics</td>
<td>90%</td>
</tr>
<tr>
<td>CAREER funding was not sufficient to support all of my graduate students</td>
<td>74</td>
</tr>
<tr>
<td>I wanted to collaborate with other researchers/colleagues</td>
<td>73</td>
</tr>
<tr>
<td>CAREER funding was not sufficient to meet the needs of my research agenda</td>
<td>70</td>
</tr>
<tr>
<td>My CAREER grant was ending</td>
<td>22</td>
</tr>
<tr>
<td>CAREER funding was not sufficient to support the full extent of the integration of research and teaching I wished to pursue</td>
<td>17</td>
</tr>
<tr>
<td>Other grants had fewer restrictions or conditions</td>
<td>8</td>
</tr>
<tr>
<td>CAREER funding was not sufficient to support the changes I wished to make in my teaching</td>
<td>6</td>
</tr>
<tr>
<td>Other grants were more prestigious</td>
<td>3</td>
</tr>
</tbody>
</table>

Exhibit reads: Ninety percent of active CAREER awardees who applied for additional grants did so because they wanted to pursue additional research topics. N = 449 (Percent reported only for active awardees who had applied for other grants)

- \(^a\) N = 449 active awardees (item asked only for active awardees who had applied for other grants). Active awardees are those whose awards were active at the time of survey completion.
- \(^b\) Responses sum to more than 100% because respondents could select more than one answer.
- \(^c\) Descriptive data for directorates, but no tests of statistical significance, are presented because the study was not designed to produce reliable estimates of differences between directorates.

Sources: PI Survey, Item Question F6a: Why did you apply for other grants? (Check all that apply.)
Chapter 4: CAREER Awardees as Teacher-Scholars

NSF supports CAREER faculty members who are “dedicated to stimulating the discovery process in which the excitement of research is enhanced by inspired teaching and enthusiastic learning.” CAREER awardees are expected to be exceptional “teacher-scholars”: individuals who engage in outstanding research and education activities, and integrate research and education as part of their professional activities, so that their research informs their teaching and vice versa.

This chapter describes active and past CAREER awardees’ research and educational activities, both generally as well as those supported directly by CAREER funding. It explores how awardees integrate research and education, the challenges (if any) they face in their integration activities, awardees’ perceptions of themselves as teacher-scholars and their perceptions of how CAREER activities affect their professional development. Data for this chapter come from survey responses and from interviews with CAREER awardees during site visits. Note that all information presented in this chapter applies to CAREER awardees only. Selected comparisons between CAREER awardees and non-awardees are presented in Chapter 5.

Overview of Chapter Findings

- CAREER awardees are active researchers who, since receiving their doctorate, have received, on average, 10 research awards from such sources as the NSF, NIH, their own institutions, and private foundations. Three in five awardees have received non-financial recognitions or awards honoring their research.

- CAREER awardees actively disseminate their work through publications and presentations. During the 2004-05 and 2005-06 academic years (a two year window) CAREER awardees report having an average of 10 articles in press or published in peer-reviewed journals, and an average of 8 conference publications.

- Awardees demonstrate research leadership: in 2004-05 and 2005-06, 61 percent were invited to give a presentation as the keynote speaker or other invited guest at a national meeting, 38 percent served as editor of a peer-reviewed journal, and 20 percent served as the editor or co-editor of an edited volume of research findings.

- Fifty-nine percent of CAREER awardees have received an honorary recognition or award honoring their research capabilities.

- Thirty-seven percent of CAREER awardees have received an honorary recognition or award honoring their teaching.

- Four out of five awardees describe themselves as research leaders in their respective fields; seven of ten also characterize themselves as being up to date about best teaching practices in their field, and over half report that colleagues consult them about teaching practices or mentoring students.

- Over 90 percent of awardees report that their research informs their teaching; nearly 60 percent report that their teaching informs their research.

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• Forty-three percent of past awardees report that CAREER gave them an opportunity to pursue an educational activity that subsequently benefited their research.

• Awardees report that their CAREER award enhanced their research productivity through: increased financial support for research; expanded capacity to pursue desired research topics; the opportunity to think more strategically about long-term research agendas; freedom from the pressure of obtaining research funding; validation of research topics; and enhanced prestige in the field.

• Nearly all (96 percent) CAREER awardees who have earned tenure believe that their CAREER grant positively influenced their receipt of tenure, and 62 percent said that their department chairperson or a member of their tenure review committee specifically mentioned that the CAREER grant was a positive factor in the decision to recommend them for tenure.

• Awardees who encountered challenges implementing their proposed activities cited insufficient departmental or institutional support, lack of preparation among undergraduate students for research, competing demands on awardees’ time or work overload, or difficulty successfully implementing outreach activities.

Professional Activities of CAREER Awardees

Engagement in research

CAREER awardees have received, on average, 10 research grants from sources including the NSF, other federal sources (59 percent), their own institutions (58 percent), and private foundations (41 percent). The median size of CAREER awardees’ largest research grant is $523,000. The NSF actively continues to support CAREER awardees; 46 percent of all awardees have won additional research funding from the NSF since their CAREER award, averaging two awards and a total of $713,282 in additional NSF grant funds.

Awardees are active participants in their research communities. Most CAREER awardees have served on a review panel or committee for NSF (85 percent) and/or another federal government funding agency (51 percent), and 13 percent have testified before local, state, or federal government representatives about their field. Over the course of their careers, 23 percent of awardees have held a visiting professorship at another institution, and 9 percent have held a summer faculty fellowship at a research organization or federal agency.

CAREER awardees actively disseminate their work through publications and presentations. During the two year window from 2004-05 through 2005-06, CAREER awardees report an average of 10 articles in peer-reviewed journals or in press and eight conference publications. Awardees are also active presenters, giving an average of three invited presentations at national meetings of professional associations, seven invited presentations at other forums outside their institution, and four peer-reviewed presentations at national meetings of professional organizations.

Awardees demonstrate research leadership in their fields: in 2004-05 and 2005-06, 61 percent were invited to give a presentation as the keynote speaker or other invited guest at a national meeting, 38 percent served as editor of a peer-reviewed journal, and 20 percent served as the editor or co-editor of an edited volume of research findings. Since beginning their careers, 15 percent have served as the assistant director or director of a research center. In recognition of their research expertise, 59 percent of awardees
have received non-financial recognitions or awards honoring their research capabilities, most commonly from their own institutions (55 percent of those with awards), national professional associations (38 percent), private foundations (26 percent), or NSF (23 percent).

Engagement in education

All awardees (99 percent) were actively engaged in educational activities during the 2005-06 academic year, in either instruction with undergraduate students (94 percent), instruction with graduate or professional students (94 percent), and/or conducting educational outreach (57 percent). Most CAREER awardees taught undergraduate and graduate courses (91 and 84 percent, respectively), as well as advised undergraduate and graduate students (74 and 93 percent). Thirty-seven percent of CAREER awardees have received an honorary recognition or award honoring their teaching, most commonly from their own institution (88 percent of those with awards), a private foundation (10 percent), or a national professional association (8 percent).

Perceptions of Awardees as Teacher-Scholars

Excellence in research and teaching

When asked about their own research and teaching abilities (Exhibit 4.1), awardees believe themselves to be up to date in the research methods and the disciplinary content of their field, and four out of five describe themselves as a leader in research in their field. Seventy percent of awardees believe they are up to date on best teaching practices in their field, and over half report that colleagues consult them about teaching practices or mentoring students.

Exhibit 4.1

<table>
<thead>
<tr>
<th>CAREER PI opinions on their research and teaching capacities</th>
<th>N ¹</th>
<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>I am up to date in research methods in my field</td>
<td>1094</td>
<td>95%</td>
<td>4%</td>
<td>1%</td>
</tr>
<tr>
<td>I am up to date on the disciplinary content of my field</td>
<td>1086</td>
<td>93%</td>
<td>5%</td>
<td>2%</td>
</tr>
<tr>
<td>I am a leader in my field (in research)</td>
<td>1088</td>
<td>83%</td>
<td>12%</td>
<td>5%</td>
</tr>
<tr>
<td>Colleagues consult me about best practices</td>
<td>1090</td>
<td>72%</td>
<td>20%</td>
<td>8%</td>
</tr>
<tr>
<td>I am up to date on best teaching practices in my field</td>
<td>1081</td>
<td>70%</td>
<td>25%</td>
<td>5%</td>
</tr>
<tr>
<td>Colleagues consult me on teaching or curricular issues</td>
<td>1079</td>
<td>59%</td>
<td>28%</td>
<td>13%</td>
</tr>
<tr>
<td>Colleagues consult me about mentoring of students</td>
<td>1080</td>
<td>54%</td>
<td>29%</td>
<td>18%</td>
</tr>
</tbody>
</table>

¹ N varies for each item due to missing responses.

Source: Survey of PIs, questions B5 and B6: “Please indicate your level of agreement with the following statements about your (a) research and (b) teaching.” Respondents answered on a five-point scale of 1 (“Disagree”) to 5 (“Agree”). For this table, responses 1 and 2 were collapsed into “Disagree”; 3 was coded as “Neutral”; and 4 and 5 were collapsed into “Agree”.

² Educational outreach is defined as talking with K-12 or community college students or teachers about ones’ research; collaborating with K-12 teachers on curricula; conducting research on K-12 student learning; or developing museum exhibits or events to foster public interest in STEM.
Department chairpersons were asked to assess the research and teaching abilities of CAREER awardees relative to other junior faculty members in the department (Exhibit 4.2). The areas in which chairpersons most often perceived distinctions favoring CAREER awardees over their peers were in awardees’ ability to quickly establish their research programs (a key objective of the CAREER award) and progress quickly towards tenure. Forty percent of chairpersons also described CAREER awardees as more capable of integrating research and education than their counterparts, and about one third regarded awardees as leaders within the department or institution.

**Exhibit 4.2**

Department chairpersons’ perception of how CAREER awardees compare to their peers

<table>
<thead>
<tr>
<th>Which group is best characterized by the following?</th>
<th>CAREER awardees</th>
<th>Their peers</th>
<th>Both groups equally well</th>
<th>Neither group well</th>
<th>Don’t know</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quickly establish their research program</td>
<td>53%</td>
<td>1</td>
<td>45%</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Progress quickly towards tenure</td>
<td>46%</td>
<td>0</td>
<td>50%</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Incorporate activities integrating research and education into their instruction</td>
<td>41%</td>
<td>0</td>
<td>51%</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Are regarded as leaders within this institution</td>
<td>36%</td>
<td>0</td>
<td>48%</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>Are regarded as leaders within the department</td>
<td>35%</td>
<td>1</td>
<td>56%</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>Conduct excellent research</td>
<td>24%</td>
<td>1</td>
<td>74%</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Attract graduate students</td>
<td>24%</td>
<td>1</td>
<td>72%</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Are effective educators</td>
<td>16%</td>
<td>1</td>
<td>77%</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Devote time to mentoring students</td>
<td>12%</td>
<td>1</td>
<td>82%</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

N ranges from 518 to 522. Missing ranges from 16 to 21. Percent for each item do not sum to 100% as three response categories.

Additional response choices ("Their peers", "Neither group well", "I don’t know") are omitted from this table.

**Source:** Survey of Department Chairpersons. Question 18. Please indicate whether each of the following statements about your department’s faculty members best characterizes NSF CAREER awardees, their peers, both equally well, or neither group well.

**Interplay between research and education**

Awardees were asked whether they agreed with a series of statements regarding the interplay between research and teaching (Exhibit 4.3). Nearly all awardees agree that their own research enhances their ability to teach graduate students, and three in four also reported that their own research enhances their ability to teach undergraduate students.
### Exhibit 4.3

<table>
<thead>
<tr>
<th>Self-perceptions</th>
<th>N</th>
<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>My research enhances my ability to teach graduate students</td>
<td>1068</td>
<td>94%</td>
<td>4%</td>
<td>2%</td>
</tr>
<tr>
<td>My research enhances my ability to teach undergraduate students</td>
<td>1078</td>
<td>77</td>
<td>16</td>
<td>7</td>
</tr>
<tr>
<td>My teaching informs my scientific knowledge</td>
<td>1081</td>
<td>70</td>
<td>20</td>
<td>11</td>
</tr>
<tr>
<td>My teaching informs my research</td>
<td>1082</td>
<td>58</td>
<td>24</td>
<td>18</td>
</tr>
</tbody>
</table>

N varies for each item due to missing responses.

Source: Survey of PIs, question B7: "Please indicate your level of agreement with the following statements about your research and teaching." Respondents answered on a five-point scale of 1 ("Disagree") to 5 ("Agree"). For this table, responses 1 and 2 were collapsed into "Disagree", 3 was coded as "Neutral", and 4 and 5 were collapsed into "Agree".

Roughly three in five awardees also believe that their teaching informs their own scientific knowledge (70 percent) and research (58 percent), as evidenced by the following open-ended survey comments:

"I taught an undergraduate seminar on aspects of my research; and I frequently use my research as the basis for examples. Teaching also often raises questions that I realize I should consider in my research!" (CISE awardee)

"I try to expose undergraduates both to the standard concepts of a field, and to the most recent key innovations, results and approaches (for instance, teaching them the most novel approaches to embedded software design and verification). Some of my papers were motivated by questions that arose during teaching." (CISE awardee)

"The research naturally informs the education and when we bring students in to see the research "live", they ask questions that help to formulate questions and challenge us. Designing tools for education can frequently create opportunities for us to improve our research through novel devices or techniques." (CISE awardee)

### Awardee’s Perceptions of the Effects of CAREER on Their Professional Development

All CAREER awardees report positive benefits from their CAREER award for their own professional development. The remainder of this chapter elaborates on awardees’ perceptions of how CAREER influences their research and educational productivity, prestige and external validation, and receipt of tenure. Chapter 5 discusses the impact of CAREER on the professional accomplishments and activities as examined using a comparison group of non-awardees.

Awardees whose grant period had ended as of the time of the survey were asked to describe the benefits of their CAREER funding. All past awardees reported at least one benefit, and most reported multiple benefits:

"The CAREER award was extremely important for enabling research at an early stage in my career and setting me on the right trajectory. Because of the prestige associated with the award, its
recognition value has lasted long after the money was spent. I can honestly say that I don’t think I could have reached the career status I currently enjoy without this award at such a crucial stage in my professional development.” (GEO awardee)

The benefits most frequently cited by awardees were support for their own research and enhancement of tenure review (Exhibit 4.4). Awardees also valued CAREER’s expansion of their research program by enabling them to pursue new research topics. When it came to pursuing additional funding, CAREER awardees reported both that CAREER freed them from having to apply for other research.

Exhibit 4.4

<table>
<thead>
<tr>
<th>Benefits of CAREER award as reported by past awardees</th>
<th>Percent of Past Awardees</th>
</tr>
</thead>
<tbody>
<tr>
<td>Support for research prior to a tenure decision</td>
<td>98%</td>
</tr>
<tr>
<td>Positively influenced my receipt of tenure</td>
<td>96</td>
</tr>
<tr>
<td>An opportunity to leverage other funds to support my research</td>
<td>58</td>
</tr>
<tr>
<td>Additional time because I did not need to spend time applying for other grants prior to tenure</td>
<td>51</td>
</tr>
<tr>
<td>Engagement in a new kind of research that I would not have otherwise been able to pursue</td>
<td>50</td>
</tr>
<tr>
<td>An opportunity to pursue an educational activity that subsequently benefited my research</td>
<td>43</td>
</tr>
<tr>
<td>An opportunity to form a partnership with industry</td>
<td>22</td>
</tr>
<tr>
<td>An opportunity to move to a more prestigious institution</td>
<td>15</td>
</tr>
<tr>
<td>In some other way(s), fostered my research productivity</td>
<td>69</td>
</tr>
<tr>
<td>In some other way(s), enabled me to pursue educational activities</td>
<td>47</td>
</tr>
</tbody>
</table>

N=613. Missing=0. Question asked only of CAREER awardees whose grant period had ended. Responses sum to greater than 100% because respondents could select multiple items. All respondents reported at least one benefit. Source: Survey of PIs. Question F8, Reflecting on your CAREER grant, which of the following (if any) benefits did you derive from your CAREER grant? (Check all that apply.)

funding and enabled them to leverage other funds to support their research. Reflecting CAREER’s emphasis on the integration of research and education, 43 percent of awardees noted that CAREER provided them with an opportunity to pursue an educational activity that subsequently benefited their research.

Support for research productivity

Awardees report that their CAREER award enhanced their own research productivity through:

- supporting the costs of research;
- enabling awardees to pursue desired research topics;
- providing awardees with the opportunity to think more strategically about their long-term research agenda;
- freeing awardees from the pressure of obtaining research funding;
• validating awardees’ research; and

• enhancing awardees’ prestige in the field (which facilitates the pursuit of additional funding for those who desire it).

Supporting the costs of research
As described in Chapter 3, awardees use CAREER funding to cover their own time, the time of graduate students, and a myriad of equipment and technological costs associated with conducting STEM research.

“It provides the much needed financial support for a junior faculty like myself to have a strong starting point and to build the initial momentum.” (MPS awardee)

“In many ways, it gave me the financial resources I needed to accomplish my research, as the department I am in provided relatively little support for junior faculty.” (SBE awardee)

Enabling the pursuit of desired research topics
Past CAREER awardees reported that their award provided them freedom to pursue their ideas in a relatively unfettered environment, because they did have to obtain departmental or other approval, and they could enjoy being able to research and implement their ideas from the start. Some awardees mentioned that the CAREER award funding allowed them to move their research in a new direction, while for others, it was a return to basic research, a luxury they had not been able to afford previously.

“[CAREER gave me the] independence to: pursue my own research trajectory…; to make my own decisions; to feel free to chart new methodologies; and, to dare to experiment with theory and practice.” (EHR awardee)

“Most importantly, it allowed me to fund an entirely new research project, in an area that I hadn’t previously worked.” (CISE awardee)

Freedom from pressure to pursue additional research funding
Just over half of past awardees valued the additional time gained by not having to apply for additional funding prior to tenure review. Appreciating this freedom does not mean awardees do not pursue other funding sources; of those awardees who valued having additional time, 59 percent also leveraged CAREER into additional funding. However, the award relieves pressure on junior faculty to constantly write grants and apply for funding, resulting in faculty members gaining valuable time for desired research and education activities, leading to greater productivity, which presumably enhances awardees’ portfolio during tenure review process at many universities.

In addition to spending time on research, awardees also indicated that CAREER enabled them to spend more time on networking and professional development. Awardees reported on the survey that the award had impacted their ability to travel to professional conferences, give guest lectures, and utilize other travel opportunities that enhanced their image in the field. These opportunities provide valuable venues for networking among other top scientists in the field. Several survey and interview respondents mentioned being introduced to others in connection with their CAREER award. Further, some mentioned that such networking opportunities can also lead to collaborations between professors and departments that otherwise would not have occurred, including interdisciplinary studies:

“Since the CAREER award frees up time that might otherwise be spent writing proposals, CAREER awardees have more opportunities to speak with their colleagues in other departments who they might not otherwise meet. This could have an impact in working on interdisciplinary research projects” (ENG awardee, site visit interview)
**Inspiring the conceptualization of awardees’ research program**
The application process provides awardees experience in preparing and often revising grant proposals. Many awardees interviewed during site visits claimed that the very process of applying for CAREER had an impact on their professional development, as they were forced to organize and present their ideas in a clear fashion, as well as develop a large-scale project that would take them through at least the next five years of their faculty careers.

"The application process encouraged me to think broadly about future contributions, and the awarding of the grant encouraged me to take action in developing both my research and my teaching." (MPS awardee)

**Validating awardees’ research**
One third of survey respondents explicitly wrote in their open-ended comments that receiving the CAREER award served to externally validate their research and their choice of careers, both within the institution and within their field. The CAREER award is viewed as a stamp of approval that indicated the work CAREER awardees are doing is respected and at the top of their field. This validation has a serious impact on their decision to continue doing their line of research, as well as to take risks with the work they do.

"CAREER provided the external recognition that my research was worthy of the department, which gave me more credibility in the department." (ENG awardee)

"My CAREER award made a big, big splash at my small undergraduate institution. It enabled me to pursue research projects I would have been otherwise unable to do. It allowed me to revise wholesale parts of the undergraduate curriculum most closely related to my research. It made me a lock for tenure, and is still helping me toward promotion to full professor." (ENG awardee)

**Enhancing awardees’ prestige**
CAREER is viewed by most as a prestigious award; indeed, 75 percent of department chairs identified CAREER as the most prestigious award for junior faculty members in their respective disciplines. Nearly one-third of CAREER awardees explicitly described in their open-ended comments the positive value of CAREER’s prestige for their careers. For many, having received the award enhanced their prestige, while for others the connection to other organizations and networks of scientists that developed as a consequence of the CAREER activities subsequently increased their own reputations. Many CAREER awardees reported being treated differently; as awardees, they were asked to sit on panels (including at the National Science Foundation), were recognized by other faculty members, and were encouraged to apply for tenure early by department heads. The CAREER award opens doors and career pathways to CAREER awardees, and continued to pay off in the form of grants, further collaborations, being invited to join review panels, and to take part in community service projects.

"The CAREER grant improved my confidence in myself, and enhanced my legitimacy within my institution and professional societies. The funding also gave me the freedom to pursue several research projects that I might not have been able to pursue otherwise." (SBE awardee)

"The most positive part of the CAREER proposal is that it does give you an immediate ‘credibility’ and ‘respect’ that you might have had to work harder to obtain. Therefore, it opens quite many doors (people from other universities seek collaboration with you, people from other departments in your university do too)." (ENG awardee)
Leveraging other funding
Finally, awardees credited CAREER’s prestige with helping them win subsequent research funding, commenting that other reviewers perceive a CAREER award as external demonstration that they are worthy of receiving substantial external funding.

“Being the first outside grant, it gave me confidence as a junior faculty and established my reputation within and outside of my department. I believe this reputation then made it easier to secure other funding... thereby virtually guaranteeing my tenure and a successful academic career.” (MPS awardee)

Support for educational productivity

Many awardees reported that their CAREER award stimulated their interest in education and outreach activities, validated existing attention paid to such activities, and increased their integration of education and research. Past awardees credited CAREER with providing time and funding with which to create innovative new courses for their graduate and undergraduate classes or conduct educational outreach activities, and with forcing them to consider their educational activities more deeply. Forty-three percent of past awardees explicitly drew attention to CAREER’s role in providing them with an opportunity to pursue an educational activity that subsequently benefited their research. Some awardees stated that by allowing them the time to go deep in their own studies, they were better able to understand their own research, and therefore could be better teachers to their students.

In addition to allowing me to pursue research, the CAREER award forced me to think about teaching and outreach systematically, in ways I would not otherwise have done.” (BIO awardee)

“The CAREER grant enabled me to work on educational and outreach activities that otherwise I think I would have been actively discouraged from working on as a junior faculty member at an R1.” (ENG awardee)

“Writing the proposal forced me to think carefully about how I would integrate my research and teaching and led me to develop new teaching methods which I would not have done with the CAREER grant.” (MPS awardee)

Influence on obtaining tenure

The CAREER award is intended to foster and support the developing careers of junior faculty members; achieving tenure is arguably the most important aspect of professional development for faculty members early in their careers. Past awardees uniformly believe that CAREER’s support for research prior to tenure was beneficial and influenced their receipt of tenure. Nearly all (96 percent) of tenured CAREER awardees, which includes both current and past awardees, believe that their CAREER grant positively influenced their receipt of tenure, and are most likely to attribute CAREER’s influence to the grant’s support of their own research (93 percent) and the award’s prestige (89 percent). Sixty-two percent said that CAREER’s support of their own education activities was also valued by their department (Exhibit 4.5).
Exhibit 4.5

Positive effects of CAREER award on receipt of tenure, as reported by tenured CAREER awardees

<table>
<thead>
<tr>
<th>My CAREER grant helped me earn tenure because...</th>
<th>Percent of Tenured Awardees</th>
</tr>
</thead>
<tbody>
<tr>
<td>the grant supported my research, which my department values</td>
<td>93%</td>
</tr>
<tr>
<td>my department values the prestige of the grant</td>
<td>89</td>
</tr>
<tr>
<td>my department values my ability to bring in external grant funding</td>
<td>87</td>
</tr>
<tr>
<td>the grant supported my educational activities, which my department values</td>
<td>62</td>
</tr>
<tr>
<td>the grant helped in some other way not listed here</td>
<td>18</td>
</tr>
</tbody>
</table>

N=873, Missing=19. This question was asked only of CAREER awardees who have achieved tenure. Percents sum to more than 100% because respondents could select multiple responses.

Source: Survey of PIs. Question F11: Did your CAREER grant influence your receipt of tenure in any of the following ways? Check all that apply.

Many respondents used the words “critical,” “instrumental,” and “crucial” to describe the impact CAREER had on their tenure decisions. Site visit interviewees commented that CAREER is especially valued in the tenure review process because it is a peer-reviewed external evaluation, a measure that academia relies on heavily to assess excellence. Correspondingly, 62 percent of tenured CAREER awardees said that their department chairperson or a member of their tenure review committee specifically mentioned that the CAREER grant was a positive factor in the decision to recommend them for tenure.

“The general opinion is that [CAREER] helps quite a bit. When you receive this award, people look at you a certain way and interact with you a certain way. You’ve sort of been ‘blessed’.”

(MPS awardee)

Only six percent of awardees reported that CAREER hindered their receipt of tenure in some way, either because they spent too much time on educational activities or outreach activities; they did not have sufficient funding to allow them to complete their research; or they spent too much time administering the grant.

Influence on institutional mobility

Fifteen percent of awardees reported that their CAREER award afforded them an opportunity to change institutions, often reporting that after receiving the CAREER award they were made offers by more prestigious institutions. For some, this offer was taken up on, while for others the offers were used to provide leverage during the tenure process at their home institutions.

Negative effects of CAREER

While all awardees reported some positive impact of CAREER on their professional development, 11 percent of awardees also described at least one negative consequence of the award, most commonly as follows:

- **Insufficient award size:** Some awardees commented that CAREER was insufficient to fully support their program (especially graduate students) and that it was not comparable to
funding available from other sources (such as the National Institutes of Health). Some of these respondents indicated that they were early recipients and thought that the new levels of funding would alleviate their concerns were they to have received the award more recently.

- **Inappropriate focus on education:** For some awardees, the education component of the CAREER award hindered their ability to further their research, and was not respected by the department or institution. Others were unprepared for the amount of work that mentoring students—especially undergraduate students—would take.

- **Too much to take on before tenure:** Several awardees reported feeling overwhelmed by their education and/or outreach activities, after initially feeling confident that they could fulfill their research, service and teaching obligations all at once, all the while keeping an eye on the tenure clock.

- **Misunderstanding of CAREER in the field:** A handful of CAREER recipients spoke of perceptions in their department or field that cast the award in a negative light, with colleagues viewing the award as “soft,” “political,” or too focused on “education.”

- **Creating an elite “club” of Awardees:** Applying for and not receiving an award can reflect poorly on non-winners, and some awardees spoke of jealousy and resentment both from those who did not receive the award and from the older guard who did not have the opportunity to apply for CAREER. Those who apply for and do not receive the award are perceived by CAREER awardees as treated differently by department members and others in the field.
Chapter 5: Impact of CAREER on Awardees

In this chapter we present the estimated impacts of the CAREER award on awardees. This component of the evaluation is designed to answer the following question: Did receiving the CAREER award change what recipients would have accomplished had they not received the award? We answer this question by comparing a set of outcomes for CAREER awardees with those for a comparison group of non-awardees. Using propensity score analysis, the non-awardees were selected to have characteristics highly similar to (and statistically indistinguishable from) those of awardees. The goal of the propensity score analysis is to approximate circumstances in which outcomes for this comparison group represent what would have occurred for awardees had they not received their CAREER awards.

As with all quasi-experiments, there is no method that can completely ameliorate the threat of selection bias, namely, the threat that unmeasured, pre-existing differences between the two groups are responsible for differential outcomes. Instead, propensity score analysis is a technique designed to mitigate selection bias. This technique can help assess whether differential outcomes for awardees and non-awardees are associated with the CAREER award. Only if individuals were randomly assigned to receive or not receive a CAREER award could an evaluation attribute outcomes to the award with certainty. Thus, there is a chance that any differences between awardees and non-awardees reported here could result not from the CAREER award itself, but from pre-existing differences not accounted for by the propensity score method.

Although the impact of CAREER on awardees may vary across NSF directorates, and even between disciplines within these directorates, the number of awardees and non-awardees per directorate was too small to permit separate impact analyses for each directorate. Instead, the impacts of CAREER were tested for awardees across the agency as a whole. Likewise, the sample was too small to test the differential impact of CAREER on subgroups of awardees (e.g., women; minorities; applicants from EPSCoR\(^1\) states; etc.).

Overview of Chapter Findings

CAREER awardees and non-awardees appear largely similar with respect to research and education:

- Awardees and non-awardees allocate the same proportion of time to research.
- Awardees and non-awardees produce equivalent numbers of publications, and research produced by awardees is neither more, nor less likely than that produced by non-awardees to be cited by others.
- With respect to their roles as educators, awardees and non-awardees are equally likely to publish a paper with an undergraduate, discuss their research in their undergraduate courses and to require undergraduates to engage in original research projects; they are just as likely to support an undergraduate on an NSF grant or publish a paper with an undergraduate.

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\(^1\) Experimental Program to Stimulate Competitive Research
In three important respects, however, awardees differ from non-awardees:

- CAREER awardees were significantly more likely to have earned tenure by the time they completed the survey than were non-awardees, despite the fact that the two groups, on average, had an equivalent amount of time to earn tenure.
- Among individuals who changed institutions after receiving funding from the NSF, CAREER awardees were more likely than non-awardees to move to a more research intensive institution.
- Awardees were more likely than non-awardees to report engaging with K-12 teachers or students, either by conducting research on how such students learn scientific or mathematical concepts, working with K-12 teachers to develop STEM instructional materials, or discussing their own research with these groups.

Caution is necessary in interpreting these results. Although the propensity score analysis can reduce the confounding effect of pre-existing differences on the comparison of awardees and non-awardees, this technique cannot eliminate the chance that some unmeasured pre-existing difference between the two groups accounts for differences in their outcomes.

Below, we present details of each of the impact estimates summarized here.

**Impact Analyses**

We tested the impact of CAREER on 15 different outcomes related to awardees’:

- Professional advancement;
- Research program; and
- Integration of research and education, including:
  - Engaging undergraduates in research activities;
  - Conducting outreach activities to non-collegiate students, teachers, or the public.

For each outcome, the impact of CAREER was estimated for each propensity stratum (which controls for a set of covariates listed in Appendix A). Additional covariates specific to the outcome being tested were added as needed. Then, the overall treatment effect was calculated by taking an average of the estimated treatment effects weighted by the number of treated observations (i.e., the number of awardees) within each stratum. Exhibits display the adjusted (estimated) means for awardees and non-awardees, the estimated impact, and the p-value for statistical significance (all p-values < .05 were considered statistically significant). For model specifications, standard error and effect size calculations, see Appendix A.

**Professional advancement**

What effect does CAREER have on awardees’ attainment advancement in their careers? We examined two key markers of professional advancement: the attainment of tenure and promotion to Full Professor. In addition, we examined the degree to which CAREER awardees were more likely than recipients of other funding to move to institutions with a greater (or lesser) research orientation.
Tenure
Winning a CAREER award appears to increase the likelihood of earning tenure. To examine the impact of CAREER on the achievement of tenure, the analysis was limited to those principal investigators surveyed who had ever held an academic position (N = 2,469). In addition, to avoid confounding opportunity to earn tenure with the rates of tenure achievement, the analysis controlled for the number of years that had elapsed from the time a PI received his/her first tenure-track position to the conclusion of the data collection period (March 30, 2007).²

CAREER awardees were more likely to have achieved tenure than non-awardees: Eighty-one percent of awardees, versus 70 percent of non-awardees (a difference of 11 percentage points) reported that they had achieved tenure by the time they completed the PI survey (Exhibit 5.1).

### Exhibit 5.1

**Impact of CAREER on achievement of tenure**

<table>
<thead>
<tr>
<th>Mean Percent⁵</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Outcome</strong></td>
</tr>
<tr>
<td>Percent with tenure by date of survey completion</td>
</tr>
</tbody>
</table>

Exhibit reads: Eighty-one percent of awardees and 70 percent of non-awardees reported that they had achieved tenure (as of the date of survey completion), an impact of 11 percentage points. This difference is statistically significant (p<.001).

Notes:

a Values shown are regression-adjusted for propensity strata and the number of years between 2007 and the date PI accepted first tenure-track position.

b N = 1101 of 1112 awardees who had ever held an academic position responded to this survey item; non-awardees: N = 1348 of 1357 non-awardees who had ever held an academic position responded to this item. Missing data: awardees, N= 11; non-awardees, N= 10.

Sources: PI Survey, Item A3: Are you now, or have you ever been, tenured?

Note that it would be improper to conclude from this analysis that a greater proportion of awardees than non-awardees ever achieve tenure. Both awardees and non-awardees who had not achieved tenure by the time they completed the survey may go on to achieve tenure in subsequent years. It is possible, then, that equal proportions of awardees and non-awardees eventually earn tenure. However, the present analysis does show that, given equal opportunity to earn tenure a greater proportion of awardees than non-awardees had done so.³

² The mean number of years since awardees (N=1,031) accepted the first tenure-track position is 9.9 (standard deviation = 3.4); for non-awardees (N=1,234) the mean number of years since accepting the first tenure-track position is 10.0 years, a difference that is not statistically different (standard deviation = 3.9). In addition, the percentages of Awardees (97.4) and Non-awardees (97.7) who have ever held a tenure track position are not statistically different (p = 0.63).

³ A survival analysis would be needed to test whether awardees earn tenure more or less quickly than Non-awardees.
**Promotion**

Winning a CAREER award appears to have no effect on achieving the rank of Full Professor.\(^4\) Controlling for years since acceptance of first tenure track position, 26 percent of awardees and 27 percent of non-awardees reported that they had earned the rank of Full Professor, a difference which is not statistically significant (Exhibit 5.2). This analysis was restricted to those who had ever held an academic position.

**Exhibit 5.2**

**Impact of CAREER on achieving the rank of Full Professor**

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Mean Percent(^a)</th>
<th>Awardees(^b)</th>
<th>Non-awardees(^b)</th>
<th>Estimated Impact</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent with rank of Full Professor(^c) by date of survey completion</td>
<td>27</td>
<td>26</td>
<td>1</td>
<td>0.79</td>
<td></td>
</tr>
</tbody>
</table>

Exhibit reads: 27 percent of awardees and 26 percent of non-awardees reported that they had earned the rank of Full Professor (as of the date of survey completion). The regression-estimated impact is 1 and is not statistically significant.

Notes:

\(a\) Values shown are regression-adjusted for propensity strata and the number of years elapsed between 2007 and the date PI accepted first tenure-track position.

\(b\) N = 1,112 of 1,112 awardees who had ever held an academic position responded to the Survey item; N = 1,357 of 1,357 non-awardees who had ever held an academic position responded to the Survey item.

\(c\) This analysis was based on PIs’ self-reported rank. Respondents could enter open-ended text. This open-ended text was coded into categories to account for the fact that many respondents listed an honorary title as part of their rank (e.g., John Doe Professor of Mathematics). For purposes of analysis a PI was coded as having achieved the rank of Full Professor if rank was coded as any of the following titles: Full Professor; Full Professor, Distinguished; Full Research Professor; Endowed Chair.

*Sources: PI Survey. Employment: Academic and Non-Academic Positions, Items A2d, A3d, … A7d. Please list all positions or titles you have held at this organization [listed in A2a], and specify the time spent at each position.*

Again, it is important to note that both awardees and non-awardees who had not achieved full professor by the time they completed the survey may go on to achieve this rank in subsequent years. It is possible, then, that equal proportions of awardees and non-awardees eventually become full professors; it also possible that different proportions of awardees and non-awardees ultimately achieve this rank.

**Institutional mobility**

Faculty members with a successful record of grant funding, a strong research or teaching portfolio, or an outstanding reputation in their field may seek to leverage their academic credentials to move to a more desirable institution\(^5\); and sometimes such faculty members are solicited directly by universities. Does

\(^4\) Respondents to the PI survey wrote in the title of each position they had held over their careers. In some cases, respondents listed an endowed chair or honorary title (e.g., “John Doe Professor of Computer Science” or “Endowed Chair”). Such responses were classified as “Full Professor, Distinguished” or “Endowed Chair.” The categories that were counted as equivalent to the rank of Full Professor were: “Full Professor;” “Full Research Professor;” “Full Professor, Distinguished;” and “Endowed Chair.”

\(^5\) By “desirable” we refer to the personal preferences of the individual PI; some may find an institution with a greater focus on research to be more desirable; others may view an institution with a greater focus on teaching to be more desirable; some may view factors other than research orientation (e.g., urban location; characteristics of departmental colleagues) as influential in deciding where to seek a faculty position.
the CAREER award affect awardees’ institutional mobility differentially than that of non-awardees? After receiving a CAREER award, do awardees migrate differentially to institutions with a stronger research orientation than do non-awardees who have obtained other NSF grant funding? To examine this question, we measured the research orientation of a university by calculating its overall percent research expenditure. Each year, universities provide financial information on research and academic revenues and expenditures to the Integrated Postsecondary Education Data System (IPEDS). To categorize the “research orientation” of institutions of higher education, we used these data to define the percent research expenditure of an institution as the ratio of expenditures on research to expenditures on research and instruction combined:

\[
\text{Percent Research Expenditure} = \frac{\text{\$research}}{\text{\$(research + instruction)}}
\]

Exhibit 5.3 below lists examples of universities that fall within discrete ranges on this measure. Note, however, that this analysis used a continuous measure of percent research expenditure.

<table>
<thead>
<tr>
<th>Exhibit 5.3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Percent Research Expenditure</strong></td>
</tr>
<tr>
<td>0 to &lt;10%</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>10 to &lt;20</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>20 to &lt;30</td>
</tr>
<tr>
<td>30 to &lt;40</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>40 to &lt;50</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>≥50%</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

For each PI who responded to the survey, we calculated the difference between the percent research expenditure of their current institution and that of the institution from which they submitted their winning grant proposal: for awardees, the CAREER award was the winning proposal; for non-awardees, the winning proposal was that of the Comparison grant which determined their eligibility for the study. The difference in research expenditures of these the post-award and pre-award institutions was used as the outcome measure in this impact analysis. It is important to note that 71 percent of awardees and 71

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6 This resource is maintained by the U.S. Department of Education’s National Center for Education Statistics.

7 Current institution as of the date of survey completion; for most respondents, Spring 2007.

8 Recall that this grant is defined as an NSF single-PI grant, excluding postdoctoral awards, travel grants, workshop or conference support, awarded either before, or within five years after, the non-awardee’s first CAREER submission.
percent of non-awardees remained at the same institution post-award.\textsuperscript{9} As a result, this analysis was limited to those PIs who changed institutions after winning CAREER or their Comparison NSF grant.

Results show that on average, those awardees who change institutions move to an institution that has a higher research expenditure than the one from which they applied for CAREER. Non-awardees who change institutions move to an institution that has, on average, a lower percent research expenditure than the one from which they applied for their Comparison NSF grant. The percent research expenditures of an awardee’s post-award institution is, on average, 6 percentage points higher than their pre-Award institution. In contrast, the percent research expenditures of a non-awardee’s post-award institution is, on average, 2 percentage points lower than their pre-award institution (Exhibit 5.4). This difference between awardees and non-awardees who change institutions is statistically significant, and suggests that awardees—to a greater extent than non-awardees—may be leveraging CAREER to move to a more research intense institution.

\textbf{Exhibit 5.4}

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Mean difference\textsuperscript{a}</th>
</tr>
</thead>
<tbody>
<tr>
<td>% research expenditure of Post-Award institution – % research expenditure of Pre-Award institution\textsuperscript{b}</td>
<td>6.07</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Notes:</th>
</tr>
</thead>
<tbody>
<tr>
<td>\textsuperscript{a} Values shown are regression-adjusted for propensity strata and the number of years elapsed between 2007 and the date of receipt of Ph.D.</td>
</tr>
<tr>
<td>\textsuperscript{b} This analysis is based on the employment histories of N = 262 awardees and N = 323 non-awardees who changed institutions post-award and whose pre- and post-award institutions' research expenditures could be determined.</td>
</tr>
</tbody>
</table>

\textit{Sources: PI Survey, Employment: Academic and Non-Academic Positions; Integrated Postsecondary Educational Data System (IPEDS)}

\section*{Research program}

Another important question about the CAREER program is the extent to which the award may affect PIs’ ability to complete and publish research. Although research grant funding in general gives PIs resources with which to conduct research, the CAREER award tends to provide funding for a longer period of time than other NSF grants. To estimate the impact of CAREER on awardees’ research productivity, we conducted bibliometric searches of the Science Citation Index (SCI) and the Social Science Citation Index (SSCI) for a subsample of 300 awardees and 300 non-awardees drawn from the sample of PIs who were invited to complete the PI survey\textsuperscript{10}. Of these 600 individuals, 147 failed to complete the survey, requiring

\textsuperscript{9} Values are computed based on those awardees and non-awardees with data available; data were missing for N = 141 awardees and N = 170 non-awardees.

\textsuperscript{10} Patent data were also collected by matching PI names against records of the United States Patent and Trademark Office and the European Patent Office. However, because patent data were located for only 67 awardees and 37 non-awardees, impact analyses were insufficiently powered to detect any differences.
that they be excluded from analyses\textsuperscript{11}; publication data for 11 other PIs could not be located in the citation indices. For the remaining individuals (n = 223 awardees, n = 219 non-awardees), we examined two outcomes:

- Total number of publications after the last CAREER application; and
- Mean number of citations per paper after the last CAREER application.

For the first of these outcomes, the impact analysis included as a covariate the PI’s number of publications prior to the date of the last CAREER application.\textsuperscript{12} Thus, the analysis tests the impact of the CAREER award on PIs’ subsequent publication histories, controlling for any preexisting differences between awardees and non-awardees in the number of publications.

Whereas the quantity of publications is one gauge of overall research productivity, scholars’ citations of published works is another indicator of an individual’s influence in his/her professional field(s). Citation data were collected to test the impact of CAREER on this indicator. For each PI, we determined the mean number of citations per paper by dividing the total number citations received by a set of publications by the total number (N) of publications. The impact analysis tested the difference between awardees’ and non-awardees’ mean number of citations per paper published after the date of the PI’s last CAREER application. The analysis included as a covariate the PI’s mean number of citations per paper published before the date of the last CAREER application.\textsuperscript{13} Thus, the analysis tests the impact of the CAREER award on PIs’ subsequent citation histories, controlling for any preexisting differences in the number of citations for works published before the last CAREER application.

Because PIs earned their Ph.D.s at different times, PIs have had varying lengths of time and opportunity to publish and receive citations of their works. For example, a PI who completed his doctorate in 2002 is likely to have accumulated fewer publications (and citations) than a PI who completed her doctorate in 1994. Thus, in models testing each of these two outcomes, an additional covariate, the number of years elapsed between receipt of the Ph.D. and 2007, was included to control for differences in the opportunity to accumulate publications and citations. Results are summarized in Exhibit 5.5a.

\textsuperscript{11} The impact model uses data from the PI survey (to calculate a propensity score); thus any PI without survey data must be excluded from impact analyses.

\textsuperscript{12} Bibliometric data were collected for each PI between 1990 and 2006. Thus, for each PI, the total number of publications between the year after the last CAREER application and 2006 was used as the outcome, while the total number of publications from 1990 through the year of the last CAREER application was included as a covariate.

\textsuperscript{13} Citation data were collected for each PI between 1990 and 2006. Thus, for each PI, the mean number of citations per paper between the year after the last CAREER application and 2006 was used as the outcome, while the mean number of citations per paper published from 1990 through the year of the last CAREER application was included as a covariate.
### Exhibit 5.5a

<table>
<thead>
<tr>
<th>Mean</th>
<th>Outcome</th>
<th>Awardees</th>
<th>Non-awardees</th>
<th>Impact</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total # of publications after Last CAREER application(^a)</td>
<td>23</td>
<td>21</td>
<td>2</td>
<td></td>
<td>0.45</td>
</tr>
<tr>
<td>Mean # of citations per paper after Last CAREER application(^b)</td>
<td>8.9</td>
<td>7.9</td>
<td>1.0</td>
<td></td>
<td>0.41</td>
</tr>
</tbody>
</table>

Exhibit reads: On average, awardees produced 23 publications after their last CAREER application, while non-awardees produced 21 publications. The estimated impact of the CAREER award is two publications and is not statistically significant.

**Sources:** Bibliometric searches of Science Citation Index and Social Science Citation Index, 1990 to 2006.

**Notes:**

\(^a\) Values shown are regression-adjusted for propensity strata, the total number of publications produced before and including the year of the last CAREER application and the number of years elapsed between 2007 and the date of receipt of Ph.D. Analysis sample: awardees, N = 223; non-awardees, N = 219.

\(^b\) Values shown are regression-adjusted for propensity strata, the mean number of citations per paper before and including the year of the last CAREER application, and the number of years elapsed between 2007 and the date of receipt of Ph.D. Analysis sample: awardees, N = 223; non-awardees, N = 219.

The CAREER award does not appear to have any significant impact on the subsequent number of publications awardees produce or on the average number of citations of published works.

Because these two outcomes could be examined only for a subsample of PIs (i.e., those selected for bibliometric data collection), the analyses may have had limited statistical power to detect any differences between awardees and non-awardees. In addition, the SCI and SSCI do not provide information on oral presentations of research at conferences or other forums, an important vehicle for the dissemination of research. Thus, we tested two additional outcomes using data from all those who responded to the PI survey:

- PIs’ self-reported total number of publications (excluding non-peer-reviewed), and
- Total number of peer-reviewed and invited presentations within the 2004-2005 and 2005-2006 academic years.

Results are summarized in Exhibit 5.5b.

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\(^{14}\) An additional analysis was run on mean citations per paper per year. This outcome was created to control for the fact that the "older" the paper, the more opportunity it has to be cited by others. Thus, each paper’s citations were divided by the paper’s age (the number of years between 2007 and its publication date) before calculating an individual PI’s mean number of citations per paper. This analysis showed no statistically significant impact of CAREER (Adjusted mean citations per paper year for awardees = 2.2, for non-awardees = 1.8. This difference of .4 was not statistically significant: p = .21)

\(^{15}\) To minimize reporting burden, particularly for PIs who had been publishing for many years, the PI Survey asked respondents to report total publications and total presentations for the past two academic years only.
### Exhibit 5.5b

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Mean</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total # of publications, 2004-2006</strong>&lt;sup&gt;a&lt;/sup&gt;</td>
<td>18.9</td>
<td>18.0</td>
<td>.9</td>
<td>.52</td>
<td></td>
</tr>
<tr>
<td><strong>Total # of presentations, 2004-2006</strong>&lt;sup&gt;b&lt;/sup&gt;</td>
<td>13.4</td>
<td>12.6</td>
<td>.8</td>
<td>.35</td>
<td></td>
</tr>
</tbody>
</table>

Exhibit reads: Between 2004 and 2006, the mean number of publications by awardees was 18.9; the mean number for non-awardees was 18.0. The estimated impact is .9 publications which is not a statistically significant difference.

Notes:

a Analysis sample: awardees, N = 1081; non-awardees, N = 1330. Values shown are regression-adjusted for propensity strata and the number of years elapsed between 2007 and the date of receipt of Ph.D.

b Analysis sample: awardees, N = 1074; non-awardees, N = 1322. Values shown are regression-adjusted for propensity strata and the number of years elapsed between 2007 and the date of receipt of Ph.D.

Sources: PI Survey, Item D1: Please indicate whether you authored any publications based on your own research during the last two academic years (2004-05 and 2005-06). Put 0 for publication types that do not apply. Number of publications: Published or in press articles in peer-reviewed journals; chapters in edited volumes; edited volumes (as Editor or Co-Editor); technical manuals or research monographs; textbooks; books other than textbooks based on your own research; conference publications.

PI Survey, Item D2: Please indicate whether you gave any oral presentations based on your research during the last two academic years (2004-05 and 2005-06). Put 0 for those that do not apply. Number of presentations given: Invited presentations (keynote speaker, etc.) at national meetings of professional organizations; peer-reviewed presentations at national meetings of professional organizations; invited presentations at seminars, symposia, or other forums outside your institution.

Results from the larger sample of PIs who completed the survey accord with the findings from the bibliometric data on a more limited sample of PIs. On average, awardees and non-awardees produce the same number of publications and deliver an equal number of public presentations describing their research.

**Time devoted to research**

One additional question about the CAREER award’s impact on recipients’ research is whether or not, and to what extent, it affects how awardees allocate their time to research and educational activities. Despite the fact that CAREER is a research award, its emphasis on education could cause awardees to reallocate time such that educational activities consume a larger proportion of their total time than non-awardees. Respondents to the PI survey were asked to report the percent time devoted to instructional activities and research. Impact analysis shows that awardees and non-awardees do not differ with respect to how they allocate their time. On average, awardees and non-awardees devote 35 percent and 36 percent of their time, respectively, to research; awardees and non-awardees both devote 42 percent of their time to instruction (with undergraduate or graduate students).
Exhibit 5.6

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Awardees</th>
<th>Non-awardees</th>
<th>Impact</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>% time on research</td>
<td>35</td>
<td>36</td>
<td>-1</td>
<td>.25</td>
</tr>
<tr>
<td>% time on instruction</td>
<td>42</td>
<td>42</td>
<td>-1</td>
<td>.25</td>
</tr>
</tbody>
</table>

Exhibit reads: On average, awardees spend 35 percent of their time on research and non-awardees spent 36 percent of their time on research. The difference is one and is not statistically significant.

Notes
a Values shown are regression-adjusted for propensity strata. Analysis sample: awardees, N = 1101; non-awardees, N = 1346.
b Due to rounding error, the estimate impact is -1 despite the fact that the rounded mean percents for awardees and non-awardees are equal.

Sources: PI Survey, Item B1 (a, b, c): Please allocate your total work time during the 2005-06 academic year into the following categories. These categories are not mutually exclusive (e.g., research may include teaching; preparing a course may be part of professional growth). Please allocate, as best you can, the percentage of your time spent in activities whose primary focus falls within the indicated categories:
   a. Instruction with undergraduate students
   b. Instruction with graduate or professional students
   c. Research/scholarship
   d. Professional growth
   e. Administration
   f. Service
   g. Other

Integration of research and education

Because CAREER applicants are encouraged to propose original and innovative education plans that integrate with their research plan, it was not possible to create a common rubric to measure the degree to which an individual PI is integrating research and education. In addition, as noted in Chapter 7, NSF program officers and awardees have a variety of definitions of activities which integrate research and education. When asked about how they integrate research and education, awardees most often cite one of four types of activities: integrating research into courses; mentoring graduate students; engaging undergraduates in research-based activities; and conducting outreach to K-12 teachers and students or to community colleges. Of these, the latter two are more closely aligned with examples of integration provided by NSF program officers and the CAREER program solicitation and least aligned with the normal responsibilities of faculty members. We examined the impact of CAREER on awardees’ engagement of undergraduates in research and on awardees’ participation in outreach to K-12 students and/or educators. Both current and past awardees were included in these analyses.

Engaging undergraduates in research
To test whether awardees were more or less likely than non-awardees to engage undergraduates in research, PIs were asked whether or not they had, within the 2005-06 year:

- Published (or submitted for publication) a paper with an undergraduate as an author;
• Discussed his or her current research in an undergraduate course;
• Required undergraduates in a course to design and carry out an original research project (beyond a literature review); and
• Supported an undergraduate on an NSF grant (either the CAREER or Comparison award)\textsuperscript{16}.

As shown in Exhibit 5.7, there were no statistically significant differences between awardees and non-awardees on these four outcomes. On average, awardees and non-awardees are equally likely to involve undergraduates in research activities.

### Exhibit 5.7

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Percent\textsuperscript{a}</th>
<th>Impact</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Published a paper with undergraduate as author\textsuperscript{b}</td>
<td>41</td>
<td>4</td>
<td>.13</td>
</tr>
<tr>
<td>Discussed current research in undergraduate course\textsuperscript{c}</td>
<td>75</td>
<td>2</td>
<td>.37</td>
</tr>
<tr>
<td>Required undergraduates to conduct original research project\textsuperscript{b}</td>
<td>30</td>
<td>3</td>
<td>.24</td>
</tr>
<tr>
<td>Supported undergraduate on NSF award\textsuperscript{d}</td>
<td>41</td>
<td>0</td>
<td>.85</td>
</tr>
</tbody>
</table>

Exhibit reads: Forty-one percent of awardees and 37 percent of non-awardees published a paper with an undergraduate as an author during the 2005-06 academic year. The impact is four percentage points, which is not statistically significant (p = .13).

Notes:
\textsuperscript{a} Values shown are regression-adjusted for propensity strata.
\textsuperscript{b} Analysis sample: awardees, N = 1015; non-awardees, N = 1249.
\textsuperscript{c} Analysis sample: awardees, N = 463; non-awardees, N = 549. Only PIs with a currently active CAREER award or Comparison grant were asked whether or not they were using funds to support undergraduates.

Sources: PI Survey, Item B2. In which of the following activities related to undergraduate education did you engage during the last academic year (2005-06)? Check all that apply.
PI Survey, Items F5 (awardees only): How are you using your CAREER award funds? Check all that apply.
PI Survey Item G3 (non-awardees only): How are you using your [NSF Comparison] award funds? Check all that apply.

### Outreach

To compare awardees' and non-awardees' involvement in K-12 science or mathematics education, we classified PIs who reported any of the following activities as having conducted K-12 outreach:

• Talked with elementary, middle, or high school students about their field or their research;
• Collaborated with elementary, middle, or high school teachers or staff on developing STEM curricula or teacher preparation; or

\textsuperscript{16} Only awardees with active CAREER awards (N=474) and non-awardees whose comparison grant was active (N=555) were asked if they were supporting undergraduates.
- Conducted research on how elementary, middle, or high school students learn science, mathematics or engineering.

Awardees were significantly more likely than non-awardees to engage in one or more of these activities in 2005-2006 (Exhibit 5.8). In a separate analysis, we tested whether awardees were more likely than non-awardees to have developed a museum exhibit or other event to foster public interest in science, technology, engineering, or mathematics. Less than 10 percent of awardees or non-awardees reported doing so, and there was no difference between the two groups.

<table>
<thead>
<tr>
<th>Exhibit 5.8</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Outcome</strong></td>
</tr>
<tr>
<td>Engaged in one or more activities with K-12 students or educators</td>
</tr>
<tr>
<td>Developed a museum exhibit or other event to foster public interest in STEM</td>
</tr>
</tbody>
</table>

Exhibit reads: An estimated 54 percent of awardees and 47 percent of non-awardees engaged in one or more outreach activities to K-12 student or educators. The difference of 7 percentage points is statistically significant (p < .05).

Notes:
- Values shown are regression-adjusted for propensity strata. Analysis sample: awardees, N = 1096; non-awardees, N = 1343.

Sources: PI Survey, Item B4. Did you engage in any of the following service or outreach activities during the last academic year (2005-06)? Check all that apply.
- Talked with elementary, middle or high school students about my field or my research
- Collaborated with elementary, middle or high school teachers or staff on developing science, technology, engineering, or mathematics curricula or teacher preparation
- Conducted research on how elementary, middle or high school students learn science, mathematics, or engineering
- Engaged local community college faculty or students in conversations or projects related to my field or my research
- Developed a museum exhibit or other event to foster public interest in science, technology, engineering or mathematics
- Testified or spoke before representatives of my local or state government about my field
- Testified or spoke before representatives of the federal government about my field
- None of the above

Summary

When appropriate measures are taken to control for selection bias, CAREER awardees and non-awardees in our sample appear largely similar with respect to research and education. They allocate the same proportion of time to research and produce equivalent numbers of publications. Research produced by awardees is neither more, nor less likely than that produced by non-awardees to be cited by others. With respect to their roles as educators, awardees and non-awardees are equally likely to publish a paper with an undergraduate, discuss their research in their undergraduate courses; require undergraduates to engage in original research projects; and support an undergraduate on an NSF grant.

In three important respects, however, awardees differ from non-awardees. First, CAREER awardees in our sample were significantly more likely to have earned tenure by the time they completed the survey than were non-awardees, despite the fact that the two groups, on average, had an equivalent amount of time to earn tenure. Awardees were also more likely than non-awardees to move to a more research-
intensive institution. Finally, awardees are more likely than non-awardees to report engaging with K-12 teachers or students, either by conducting research on how such students learn scientific or mathematical concepts, working with K-12 teachers to develop STEM instructional materials, or discussing their own research with these groups.

Caution is necessary in interpreting these results. Although the propensity score analysis can reduce the confounding effect of pre-existing differences on the comparison of awardees and non-awardees, this technique cannot eliminate the chance that some unmeasured pre-existing difference between the two groups accounts for differences in their outcomes.
Chapter 6: Perceptions of CAREER within Academic Departments

This chapter explores how the CAREER award is perceived within various departmental contexts. The specific topics include departmental supports for CAREER awardees and CAREER eligible faculty, the perceived effect of the CAREER award on departmental policies and culture, and the importance of CAREER in conforming to or adjusting organizational goals of departments. Data sources for this chapter include the survey of CAREER awardees, the survey of chairpersons of departments where awardees are employed; and site reports from our visits to 11 institutions and 22 departments with awardees.1

Overview of Chapter Findings

The highlights of the findings in this chapter include the following:

- According to department chairs, the presence of CAREER awardees in a department has a far stronger effect on the research side of the university culture than on the education and integration side, particularly in increasing departmental prestige, increasing the supply of funding for graduate students, and in improving the overall quality and quantity of faculty-led research. Its strongest effect on education and integration was perceived to be in driving the development of new courses.

- Applying for a CAREER award is essential for junior faculty in many departments and winning a CAREER award is perceived as a significant factor in tenure decisions. In the tenure and promotion process, the CAREER award is viewed as an endorsement of the quality of research, but it was not a factor in judging the candidate's capacity as an educator. For the majority of department chairpersons, education was synonymous with teaching, and its quality was measured by student evaluations and informal methods.

- The CAREER award is not perceived as a catalyst for change in institutional practices and policies, although when the CAREER award matches the organizational goals of the department or fills an organizational need, the award can subtly change the culture of departments, particularly those with a high proportion of awardees. CAREER awards were characterized as especially useful in departments whose faculty specialize in disciplines most heavily funded by NSF, were upgrading their emphasis on research, or were revamping or reorganizing their departments through their junior faculty.

Perceived Effects of CAREER on Research, Education, and Integration in Departments

Though CAREER awardees are the direct beneficiaries of the Faculty Early Career Development Program, departments may also derive benefits from the presence of awardees. Having a CAREER awardee on the faculty might enhance the prestige of the department and encourage other junior faculty to

1 In addition, telephone interviews were conducted with 12 current or past CAREER awardees at seven Historically Black Colleges and Universities (HBCUs) and Minority Serving Institutions.
apply; an awardee’s successful efforts to integrate research and education might spur others to attempt similar endeavors. Whether and how the presence of awardees affects host departments and institutions may depend on awardees becoming more established members of their respective departments and universities, or may depend on a department having a critical mass of CAREER awardees.

We surveyed department chairs about their perceptions of the effect that CAREER awards have had upon their respective departments and institutions, and we asked participants during site visits similar questions. Some CAREER awardees also described the effect of CAREER on their departments and institutions in answers to open-ended questions on the CAREER PI survey. This section synthesizes and describes these perceptions.

It is important to keep in mind that, unlike the impact data reported in Chapter 5, there are no comparison data for the findings reported in this chapter. As a consequence, it is impossible to know the counterfactual—i.e., whether other grants would have provided CAREER awardees and subsequently their departments and institutions with the same types or level of benefits described here in the absence of CAREER awards.2

The influence of CAREER awards on departments

Both site visit and survey data strongly suggest that where perceived effects are reported, the presence of CAREER awardees in a department has a far stronger impact on the research side of the university culture than on the education and integration side. Exhibit 6.1 shows the percentage of department chairs indicating that the presence of CAREER awardee(s) had a strong influence on a variety of possible departmental impacts listed in a closed-ended survey item.3 Four of the top five effects are related to the research culture of awardees’ departments.

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2 Note also that CAREER awardees and department chairs are not matched by department. Rather, each is a random sample of its own universe.

3 Strong influence is defined as the percentage of chairs who ranked the level of influence a 5 or 6 on a scale ranging from 0 = no influence to 6 = high influence.
Exhibit 6.1

Percent of department chairs who perceive that the presence of CAREER awardee(s) had a strong influence on their department

<table>
<thead>
<tr>
<th>Nature of Influence</th>
<th>Percentage of chairs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increasing the department's prestige</td>
<td>81%</td>
</tr>
<tr>
<td>Increasing the supply of funding for graduate students</td>
<td>57%</td>
</tr>
<tr>
<td>Improving the overall quality of faculty-led research</td>
<td>49%</td>
</tr>
<tr>
<td>Increasing the overall quantity of faculty-led research</td>
<td>49%</td>
</tr>
<tr>
<td>The development of new courses</td>
<td>45%</td>
</tr>
<tr>
<td>Increasing the value placed by departmental faculty on research</td>
<td>36%</td>
</tr>
<tr>
<td>Improving the overall quality of students' education</td>
<td>33%</td>
</tr>
<tr>
<td>Increasing the value placed by departmental faculty on the integration of research and education</td>
<td>30%</td>
</tr>
<tr>
<td>Improving departmental instruction overall</td>
<td>28%</td>
</tr>
<tr>
<td>Increasing the value placed by departmental faculty on education activities</td>
<td>19%</td>
</tr>
<tr>
<td>The development of new degree programs</td>
<td>7%</td>
</tr>
</tbody>
</table>

Notes: Department chairs rated items on a scale ranging from 0 = no influence to 6 = high influence. This table reports the percentage of chairs who ranked the level of influence 5 or 6. Question was only answered by those respondents who were familiar with the CAREER program (n=537). Missing N ranged from 31-38.

Source: Q20. Please indicate the extent to which, if at all, the presence of faculty members with NSF CAREER award(s) has influenced your department.

CAREER effect on departments’ prestige

The effect most widely perceived at the department level, by far, was CAREER’s strong influence in increasing departmental prestige. This type of influence is particularly important to institutions that are working to build their research capacity. CAREER is viewed as a substantial, prestigious research award, with 75 percent of department chairs reporting that the CAREER award is the most prestigious award in their discipline.

CAREER’s effect on departmental research capacity.

Over half of department chairs (57 percent) indicated that having one or more CAREER awardees in their departments strongly influenced the number of graduate students their department could support.

Almost half of department chairs credited the

INCREASING DEPARTMENTAL PRESTIGE

“The presence of an awardee in our department has been very good for us, both in terms of increasing our reputation (internally and externally) and in raising the overall level of research activity by exposing our faculty to quite a few active researchers who have visited our department. As we are some distance from a large urban area and have no internal source of travel/seminar funding, this latter effect has been important for us.”

(MPS department chair)

One senior faculty member credits CAREER awardees with revitalizing his department’s reputation and the quality of research being conducted and noted, in particular, its effects on helping research groups to coalesce around specific research areas, stating: “[Professor X] was a focus to gather around, before there was nothing to gather around him. Now there’s a core group here. You see groups forming and groups talking to each other. That’s new. Even at the master’s degree level they have an influence, not just in their own programs, but in what they do for us.”

(ENG senior faculty member. Site Visit Report)
presence of CAREER awardees with exerting a strong influence on improving the overall quality (49 percent) and quantity (49 percent) of faculty-led research. Beyond that, over one-third (36 percent) credited their presence with increasing the value placed by departmental faculty on research. Department chairs saw this effect on junior, mid-level and senior faculty.

**CAREER’s effect on other faculty**

Almost three-quarters (72 percent) of department chairs indicated that the presence of one or more CAREER awardees had the effect of encouraging other (as yet untenured) eligible faculty to apply for NSF CAREER awards themselves. In their open-ended comments on the survey, department chairs described a number of different forms of “encouragement.” Several chairs noted that getting the department’s first CAREER award had the effect of making other junior faculty view it as something to which faculty in their department could aspire. Indeed, some department chairs commented that the presence of CAREER awardees raised the general morale of the department itself, confirming that they were hiring the ‘right’ faculty. Others noted that junior faculty in their departments were also inspired to apply because they could see the positive impact it had on the career trajectories of those with CAREER awards. Several department chairs noted with approbation that the success of their junior faculty at winning prestigious CAREER awards had had a stimulating effect on mid-level and senior faculty as well.

When junior faculty were among the first cohorts of CAREER awardees, expectations for future faculty to apply for CAREER were likely to increase. Department chairs noted that the presence of CAREER awardees can shift the departmental culture because it ‘raises the bar’ for junior faculty members—so that even if they are not required to apply for a CAREER award, they feel pressure to apply for (and win) an award. One department chair, however, also noted that there can be a reverse trajectory. When early wins are not reinforced by subsequent success at securing CAREER awards, junior faculty can become discouraged and not apply.

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### INSPIRING JUNIOR AND SENIOR FACULTY MEMBERS

For the 1997 and 1999 awardees, CAREER was new, and the department had no expectations about it. After four faculty won CAREER awards and the Department gained more prestige from their winning a national competition, new junior faculty were expected to apply for CAREER for each of the three times they are eligible. (Site Visit Report)

“Our [computer science] department has one CAREER award in its history, which initially encouraged all junior faculty to apply. The optimism is however waning.” (CISE awardee)

“Our awardee has given other young faculty a high standard to match, and reminded older faculty that if you have good ideas and perform well, you WILL be rewarded by federal granting agencies.” (BIO department chair)

“We have 3 faculty with NSF CAREER and that has put more pressure on more senior faculty to seek more funding. It worked!!” (CISE department chair)

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4 The percent reflects the percentage of department chairs who marked either 5 or 6 on a six-point scale, with 0 as none and 6 as high influence.
**CAREER's effect on departmental education**

A minority of department chairs indicated that CAREER awardees had exerted a strong influence on education in their departments, including the development of new courses (45 percent), improving the overall quality of students’ education (33 percent), improving departmental instruction overall (28 percent), and increasing the value placed by departmental faculty on education activities (19 percent).

Both site visit interviews and survey responses acknowledged that the award’s emphasis on integration of research and education dovetails with their own departmental culture and goals. A department chair at a prestigious state university described such integration as part of the normal mission of his department, and further speculated that CAREER might facilitate integration by giving junior faculty more stability, which in turn could give them more time to work on developing a new undergraduate course (e.g., because they don’t have to spend as much time writing other grant proposals). Close to one third of chairs surveyed believe that CAREER awardees have played a strong role in increasing the perceived value placed on the integration of research and education.

**DEPARTMENTAL EDUCATION**

“A CAREER awardee worked with another faculty member and graduate student to develop a new undergraduate course in the department (another one is in the works). The course has been very successful: it has high enrollments which help the department; it attracts students from diverse fields on campus and so educates students about a lesser known field (linguistics); graduate students, as well as faculty, teach the course thus providing support and teaching experience to the GRAs.” (CISE department chair)

“One awardee’s emphasis on active and collaborative learning strategies has energized our curriculum committee.” (EHR department chair)

**INCREASING VALUE PLACED ON INTEGRATION**

“The NSF CAREER program has shown faculty the importance of introducing research as part of teaching for our undergraduate majors. Students become more interested in research projects. Many of our students become interested in research careers. Even those students planning to go to medical school apply for MD/PhD programs rather than just MD programs. We find that students are more interested in lab experiments which contain some of the faculty members’ research. Our faculty are able to attract more undergraduates to their labs and are able to publish with work done by these undergraduates. So, both students and faculty are benefiting, directly and indirectly from the NSF CAREER program.”

(BIO department chair)

Finally, while the development of new degree programs or concentrations was relatively rare, they are tangible and potent by-products of the educational efforts of CAREER awardees in 7 percent of the responding departments.

**Perceived Effects of CAREER on Tenure and Promotion Policies**

Virtually all department chairs view CAREER as a prestigious award (97 percent of department chairs), a funding source for junior faculty research (98 percent), and an important stepping stone to advancement within the department (93 percent). Winning a CAREER award is not, however, a requirement for tenure, an observation with which current CAREER awardees concurred. A few CAREER awardees

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5 The percent reflects the percentage of department chairs who marked either 5 or 6 on a six-point scale, with 0 as none and 6 as high influence.
were denied tenure in some of the visited departments. Nonetheless, having a CAREER award provides a "boost" or "feather in the cap" for junior faculty, and eight percent of department chairs say that applying for a CAREER award is a prerequisite for tenure. Though few (just two percent) of the current CAREER awardees reported that getting a CAREER award is required, more than three-quarters (78 percent) reported that getting a CAREER award would be a significant factor in the tenure process.

Nearly half of all current CAREER awardees reported that all junior faculty in their departments were expected to apply for CAREER, and, as discussed in Chapter 3. This expectation was strong in CISE and ENG but not pronounced in other directorates: almost 80 percent of current awardees in CISE and almost 60 percent of current awardees in ENG said that assistant professors were expected to apply, but less than 40 percent in BIO, GEO, and MPS, and none of those in EHR or SBE perceived this expectation. Although applying for CAREER was not necessarily regarded as an expectation, 72 percent of department chairpersons reported on the survey that the presence of CAREER awardees had a major influence on encouraging other faculty to apply for it. In some cases, as observed during site visits, junior faculty members were not seen as ambitious unless they applied for CAREER. In other departments, applying for CAREER was seen as a teaching tool, and an easy way to obtain multiple reviews and feedback from national experts in the field. Two departments visited encouraged junior faculty to apply repeatedly both to research grants and to CAREER.

In most departments visited, the criteria used to assess research in the tenure process were typically a combination of publications, presentations, success of doctoral students, external reviews by scientists in their field of expertise, and receipt of grant funds, preferably federal funds from a national competition. CAREER fit easily into the last criterion but other funding sources were often equally rated. Nor was receipt of a CAREER award seen as a criterion for providing high quality education. Education was usually synonymous with teaching and was measured by student evaluations and informal methods. Only four percent of all chairs surveyed described CAREER as having a positive effect on increasing the attention paid to education during tenure review. A similar pattern was found in the site visits.

How CAREER Matches the Organizational Goals of Departments

The discussion below examines whether and how departments have capitalized upon CAREER awardees to further or complement their own organizational goals. Data for this section come from site visit interviews. The extent of influence appears to vary based on the number of awardees in the department and the department’s reputation within and beyond the university. CAREER awards were especially useful to departments that:

- Specialized in those disciplines and sub-disciplines most closely aligned with NSF’s own substantive (and therefore financial) interests;
- Were upgrading their emphasis on research; or
- Were revamping or reorganizing their departments through their junior faculty.

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6 The percent reflects the percentage of department chairs who marked either 5 or 6 on a six-point scale, with 0 as none and 6 as high influence.
The award is highly valued in university departments linked with the NSF directorates that fund most CAREER awardees (ENG, CISE, and MPS), especially computer science, chemistry, and some sub-fields of engineering. Among the universities visited, most junior faculty in these departments or sub-fields had either won or remained eligible for CAREER awards. However, departments linked with NSF directorates that fund few CAREER awardees acknowledged its value for the awardee but often did not advertise the award more broadly. One exception was in a department where a junior faculty person won a CAREER award from SBE, a directorate that awards fewer CAREER awards. The CAREER award was four times the size of other NSF awards in this area, so was seen as highly desirable for both the awardee and the department.

CAREER awards were especially highly valued by state universities upgrading their emphasis on research. Faculty members in these institutions often described themselves as “emerging institutions,” and publicized their CAREER awardees to bring their departments external recognition and external validation. They used CAREER as a sign to the outside world that their department was staffed with high quality faculty. These university departments reported using the award to recruit other talented junior faculty, attract better graduate students, enhance future funding opportunities for the department, and gain more recognition for the department within the state.

For state universities that rely heavily on legislative appropriations, CAREER awards are sometimes used to bolster outreach or better prepare high school students for the university. In one state, for example, the state university does not draw the state’s elite students, so the science departments engage in various outreach activities to build the public’s commitment to science and to draw students with interest and background in the sciences. Another CAREER awardee ran town-hall meetings on cutting-edge science topics to stimulate the interest of undergraduates and townspeople to value science and support legislative action, and a third CAREER awardee is actively engaged in creating an Academy of Science charter high

school in the state’s largest city to upgrade the school system and better prepare students for the university.
CAREER at research intensive institutions
For research universities that already enjoy ample external validation, the CAREER award was valued more as an internal vehicle that enabled faculty to “delve deep into research” and to create “well-articulated, intellectually rigorous and exciting research.” One site visitor observed that in an Engineering department (for example), senior faculty see young faculty as the best generators of fresh ideas, and CAREER funding provides them with the stable support they need to delve deep. Among self-defined “prestigious” departments, faculty interviewed reported that CAREER’s emphasis on in-depth, cutting edge research furthered their organizational goals to reinforce or improve their top-ranked status.

Revitalizing departmental research
CAREER awards have also been used to revitalize or revamp university departments. One former administrator of a School of Engineering reported that CAREER awardees had played an instrumental role in revitalizing the department, both in terms of the department’s reputation and the quality of the research being conducted. At another institution (an HBCU), the department was launching a Ph.D./Masters program in physics, the first doctoral program at the institution. The presence of three CAREER awardees with overlapping substantive interests provided the essential resources to attract graduate researchers to the new doctoral program. The influence of the CAREER award in furthering department goals extends to liberal art undergraduate institutions as well (see text box).

CAREER awards have also begun to figure into faculty recruiting and hiring practices at some institutions, albeit in different ways. These comments were predominantly made by chairs representing the MPS and CISE directorates, although there are also examples from chairs representing the ENG and SBE directorates as well. In several instances, department chairs commented that having CAREER awardees on their faculty helped them to attract stronger tenure track faculty, and also served to validate the internal (departmental level) hiring processes. At one institution, in fact, potential applicants for junior faculty positions are assessed based on whether the department thinks their research program will merit a CAREER award.

In other departments, the award is seen as prestigious and a good source of income but its value lies with the awardee, not the department. At one university faculty explained that an award designed exclusively for junior faculty does not
carry much weight. As the site visitors reported, “in this math … department, nobody cares where you publish or what awards you win. This department is all about mathematics and the people in the department are completely confident in their ability to judge good math.”

CAREER also has little departmental value in another department where it reinforces the philosophical split within the faculty, as described by a site visitor: “The CAREER award is symbolic of the bifurcation of this department. The old guard sees the award as a powerful incentive leading in the wrong direction, that is, applied engineering. The university view, as embodied in the department chair, is that [the award] is validation that the department is going in the right direction, that is, becoming more research oriented.”

Summary

At the departmental level, the largest perceived effect of CAREER has been to enhance a department’s prestige: 81 percent of chairpersons cited this benefit. The CAREER award is primarily seen as a research award. Within engineering, chemistry, and computer science departments with a high proportion of awardees, new junior faculty are expected to apply for CAREER. In these departments, a CAREER award is perceived as a significant factor in tenure decisions, but not a requirement to earn tenure. In departments with a high proportion of awardees, CAREER supports the departments’ organizational goals, including enhancing the prestige of the department and its ability to attract highly qualified faculty, better graduate students, and additional financial support.

At research intensive universities, the award tends to ratify a pre-existing belief that junior faculty are among the best new researchers in the field. In universities and departments that are seeking to become more research-oriented, CAREER award enhances a department’s reputation, signals high quality research, and helps attract other faculty.

At minority-serving institutions, which typically have little institutional research capacity and often emphasize teaching more than research, CAREER awards provide much-needed resources. In these institutions, CAREER awards add significantly to research support for individual faculty and contribute to a shift in institutional culture.

CAREER has not affected departments’ relatively stronger emphasis on research than education in tenure and promotion decisions. Faculty reported that CAREER’s emphasis on the integration of research and education matched their own, pre-existing departmental goals, although 30 percent indicated that CAREER had increased the value that the department placed on this integration. The most often cited influence of CAREER on educational mission of the department was that it generated new courses (45 percent of chairpersons).
Chapter 7: Promoting the Integration of Research and Education

As well as to recognize the best (or most promising) junior researchers and to support their early career advancement, one of the primary goals of the CAREER program is to foster the integration of research and education. In this chapter, we synthesize findings from various evaluation components to examine how well the CAREER program is meeting that goal. This chapter revisits the topics in Chapters 2 through 6 and also presents some new information.

We begin by revisiting the process through which NSF articulates the goal of integrating research and education. We then examine how this goal is interpreted and implemented both by individual awardees and within the current institutions where awardees reside to learn whether recipients of the CAREER award share NSF’s understanding of what it means to integrate research and education.

What does the “integration of research and education” mean at NSF?

Defining the integration of research and education within the context of the CAREER program begins with the CAREER Coordinating Committee (CCC), which communicates and disseminates the goals of the program via two primary mechanisms: the program solicitations read by potential applicants; and guidance to NSF program officers about the program requirements, interpretation of these goals, and recommended review procedures. We briefly summarize how the program solicitations have articulated this goal and how program officers interviewed in Fall 2006 and Spring 2007 understood its meaning.

"Integration" in CAREER program solicitations

From its inception, the CAREER program has required potential awardees to describe how they will integrate research and education. However, what that integration means has evolved over time, as reflected in the language of the solicitations over the life of the program. In the earliest solicitations (e.g., 1994 and 1995), integration appears to refer to the development of “full, integrated academic careers which include both research and education” (NSF 95-64). Applicants were asked to include a career development plan that described a proposed research plan and a proposed education plan, each as a distinct entity. As the program evolved, more emphasis was placed on how research and education inform each other. For example, the 1997 solicitation states, “NSF aims to encourage integrated environments...in which education is infused with the joy of discovery and research is informed by the needs of the learning process.” In the most recent solicitation (NSF 05-579), applicants are asked to describe three components of their project: the proposed research; the proposed educational activities; and, “how the research and educational activities are integrated with one another,” explicitly drawing attention to the interaction between research and education (NSF 05-579, pg. 6, emphasis added).

Two meanings of the integration of research and education emerge from a review of CAREER program solicitations between 1994 and 2005.

1. The description of “integration” prominent in the earliest solicitations suggests that awardees should pursue a professional career that combines both high quality research and high quality education: that is, the awardee’s career should be an integrated one in which both research and education are valued and pursued with vigor. Awardees are expected to be both the most
promising researchers and the most promising educators, but excellence in these two spheres could be pursued separately.

2. The description of integration prominent in more recent solicitations is that awardees’ research and educational activities should themselves be mutually reinforcing: research should inform the learning process, and the learning process should inform the research agenda. Awardees should be not only the most promising researchers and the most promising educators, but should implement activities that facilitate synergies between research and education.

Despite the CCC’s apparent shift to a more explicit request for research and educational activities that are mutually reinforcing, the solicitation also makes clear that “there is no single formula for developing an integrated research and education plan” and that the determination of what “counts” as an integrated plan depends on within-disciplinary considerations, leaving individual program officers considerable latitude in implementing this aspect of the CAREER program. Rather than prescribe a particular approach (or set of approaches), the solicitation is more descriptive and allows faculty to propose innovative ideas that fit the particular needs of their respective field(s). This flexibility is not unique to CAREER but reflects the general approach at NSF to allow the field to propose the most grant-worthy ideas. It makes it more challenging, however, to assess in a program-wide evaluation the degree to which CAREER awardees have addressed the integration goal. We turned to program officers to provide more clarity.

How program officers understand “integration”

Because the CAREER solicitation explicitly acknowledges that the integration of research and education are defined differently across disciplines, individual program officers at NSF play a key role in further articulating what this goal means. Program officers advise potential applicants on a range of matters including whether or not to apply for CAREER, where to direct a particular proposal, and the criteria on which CAREER proposals are evaluated—including the requirement that applicants propose an integrated research and education plan. During the review phase, program officers educate panelists about the criteria on which CAREER proposals should be judged.

Interviews with NSF program officers in each of the directorates suggest several conclusions about how program officers interpret CAREER’s emphasis on the integration of research and education:

- Program officers widely agree that the integration of research and education is a distinguishing feature of the CAREER award that receives a strong emphasis in the review process;
- Program officers support CAREER’s encouragement of junior faculty to integrate research and education from the start of their careers, as a means of enhancing awardees’ abilities as teacher-scholars and to foster integration among the junior faculty members who will one day be leaders in their institutions and fields; and
- Program officers typically do not distinguish between the “education piece” of CAREER and the program’s intended integration of research and education.

We discuss each of these themes in turn.

CAREER’s Focus on Integration sets it Apart from Other Funding Opportunities

While all research proposals at NSF must address NSF’s “broader impacts” criterion, program officers state that CAREER’s emphasis on the integration of research and education is stronger than in regular
grant competitions. To win a CAREER award, a strong research proposal is necessary but not sufficient, which distinguishes CAREER from regular research grants. For example:

It's understood that CAREER is really different. In other grant programs researchers have to address broader impacts but they view it as something they have to pay lip service to. In CAREER, though, the education plan is one of two main planks. In CAREER and other grant programs, the excellent research component is necessary. In CAREER, excellent research plus a good education piece is needed; in other grant programs though, excellent research plus weak broader impacts piece will still get funded. (NSF program officer).

If they come in through a regular proposal ...it [the education plan] can be part of the regular proposal as a broader impact, but it doesn't need to have the meat that it does in the CAREER competition. You can have someone with a research proposal, where the research is going to have a broader impact to society. There are all sorts of broader impacts that can be addressed in a research proposal that don't correspond with the education, the integrated education plan of CAREER. (NSF program officer)

Effective Means of Encouraging Junior Faculty Members to Integrate Research and Education

Virtually all program officers endorse the CAREER award's focus on the integration of research and education, particularly for a program targeting junior faculty, and describe CAREER as a mechanism through which NSF encourages faculty members to focus on more than just research. Two program officers commented:

It's actually inappropriate to expect someone to behave in a particular way to achieve tenure and then only after tenure to change and behave in a different way. So we need to get junior faculty thinking about teaching from the beginning. Universities have as their mission, education. Plus, teaching helps you better understand a topic. (NSF program officer)

I want to see that they start giving back to the community very early in their careers. Service, Heading up review panels. Formulating symposiums. Someone who goes to Congress and advocates for the field. Don't just take the money and disappear into the lab. Pump out good graduate students who go on to become CAREER awardees themselves, grad students who value education. It's not enough to do good science if nobody else knows about it. (NSF program officer)

Some program officers also view CAREER’s emphasis on the integration of research and education as a way to bring about institutional change by recognizing those junior faculty members who are the new generation of teacher-scholars:

We are trying to change the culture [of institutions]. When [CAREER awardees] become the department chairs and the deans, then we've made progress. It's a gradual change and it's going to happen starting at this level moving forward. I think it makes sense to do it in this way. Anecdotally, ... people who have had CAREER awards and come back for the unsolicited grants have much stronger education components in those grants than people who have not had CAREER awards because they are in that mode, they are in that mindset. They got going from the very beginning when they are setting their habits as a faculty member. (NSF program officer)

With CAREER ... we are telling the community that we are taking education seriously, and we expect that to be a big part of what they are doing at the university. To do their own research and work on bringing up the next generation of scientists. (NSF program officer)

Despite widespread support for the integration component of CAREER, however, some program officers expressed doubts either about the level of expectations that CAREER places on junior faculty, or about
awardees' individual capacity to bring about institutional change. For example, one program officer indicated that "the focus of CAREER is on the individual, not on influencing the institution, unlike IGERT." Another program officer said that she advised faculty just getting started to apply for a regular research grant first, to "wait until you are more established and get the teaching plan figured out" before applying for a CAREER award. Such views were expressed infrequently.

Lack of Agency-wide Definition Regarding "Integration of Research and Education" versus "Effective Education"

Finally, although the CAREER solicitation explicitly calls for applicants to address three distinct components in their CAREER proposal—the proposed research project, the proposed educational activities, and how the research and educational activities are integrated with one another—program officers almost always spoke of awardees' plans for integrating research and education and their educational plans as interchangeable. For example, when describing how CAREER proposals are reviewed, one program officer said,

If we deem both of these components, not only the research piece, but also the educational piece as talented, then we make a CAREER award. (NSF program officer)

This was not an isolated comment, but is representative of the majority of those interviewed. Another program officer described at length a two-pronged review process in which the research components of CAREER proposals are reviewed by one group of panelists, while the education components are reviewed by a separate group of panelists selected for their knowledge of education. Although the two panels meet jointly, this two-panel approach evolved because those reviewing the research component "didn't know what an education plan was." Other program officers shared her impression that panelists "need more education themselves" about how to evaluate the education component of the CAREER award.

We note that NSF has acknowledged the challenge of distinguishing between education and integration. Both the 2001 and 2006 CAREER program Committees of Visitors cited the definition of "integration" as problematic:

NSF's message about the value of transferring knowledge in the classroom, as differentiated from research training, has not been made entirely clear to proposers. While the annual proposal guidelines have evolved to list many types of education activities for proposers to consider, the concept of integration needs further clarification. (COV report, May 2001, pg 8, emphasis added)

The panel was unclear on the meaning of integration of research and education components in the program announcement, . . . some disciplines readily permit integration of research, teaching, and public outreach (e.g., Web-casts of exploration in biology, physics, or the geosciences), whereas it is more difficult to achieve comparable integration in other disciplines. For some PIs, a synergistic approach to integrating research and education may be particularly effective . . . such that investments in the education component indirectly enhance also the research component. For other PIs a different model may best take advantage of personal strengths in research and education. (COV report, October 2006, pg. 8)

The same two models for the integration of research and education emerged from our interviews with NSF program officers as from our review of the CAREER solicitation: Some program officers described the goal of CAREER as encouraging the best young emerging researchers to apply equal effort to their educational as to their research endeavors. Others held that the goal of CAREER was to encourage faculty members to develop educational activities that are both informed by research and that inform research, such that the two types of activities become mutually interdependent. In this model, one aim
might be to give those who have traditionally been the consumers of research (e.g., undergraduate and K-12 students) an opportunity to participate in the production of research. This second type of synergy may be more achievable in some disciplines than in others.

**How do awardees implement the integration of research and education?**

The next step in assessing the integration of research and education in the CAREER program is to look at how awardees are interpreting this aspect of the CAREER program:

1. How do CAREER awardees define integration of research and education?
2. What types of activities integrating research and education do CAREER awardees implement?
3. Is there a difference between the types of integrative activities awardees are implementing and what they would have done had they not received CAREER?

**How do CAREER awardees define integration of research and education?**

Active CAREER awardees were asked to describe the activities integrating research and education that they implemented under their CAREER award. Among these descriptions, six types of activities were most common:

- Mentoring graduate and undergraduate students;
- Developing courses and/or incorporating research into courses;
- Engaging undergraduates in research-related activities;
- Working with students from underrepresented minority groups;
- Outreach to K-12 students or teachers; and
- Developing educational technologies.

Included below are several examples of awardees’ own descriptions of these types of activities, taken from site visit interviews and open-ended survey items.

**Mentoring, training, or supervising undergraduate or graduate students**

Some awardees describe a research faculty member’s job as integrating research and education in the instruction of graduate students. Awardees described mentoring, training, or supervising undergraduate or graduate students as a direct activity under their CAREER grant; a small number specifically cited their work mentoring or advising under-represented students when describing CAREER-related activities. Awardees talk to students about research, involve students in faculty research, and coach students on research techniques or presentation skills.

I maintain daily contact with my graduate and undergraduate students. Through lab meetings and weekly seminars, I help them develop research skills, statistical skills, programming skills, writing skills, and oral presentation skills. I’ve had three or four undergraduates whose work has led to publication, and have mentored students during the summer sessions in conjunction with a minority research opportunity program at [this institution]. (SBE awardee)
Developing courses and/or incorporating research results into courses

Approximately 75 percent of the active awardees who described an integration activity\(^1\) wrote about courses they had developed as part of their CAREER award or described how they are incorporating elements of their research into their courses. These courses were aimed at graduate or undergraduate students, and were based on their current research interests. Examples of ways in which CAREER awardees reported improving courses for students include:

- Incorporating research-related examples into courses;

  Many more research-related examples embedded within my courses, with greater emphasis on the scientists involved, and how and why they conducted the research in question. I also work my current research into the course in several ways, which makes the content immediate, relevant, and local, and has led to several undergraduates beginning research projects in my lab after the course. (BIO awardee)

- Adding hands-on activities to improve the learning techniques of their students;

  I introduce non-science majors to electronics and [other topics]; I give hands-on experience on [contemporary laboratory methods] to all our graduate students and a large fraction of them learn how to fabricate ... transistors during their lab rotations. (MPS awardee)

- Connecting research to what is being taught in the classroom and to the real world;

  In my undergraduate course, Introduction to Microbiology, I talk about current research on how microbes function in conjunction with the basic information that I teach. I also try to give the students an idea of how research discovered the things that I am teaching. I talk about current research related to class topics and current events. (BIO awardee)

- Modifying advanced material to be suitable for undergraduates;

  Defining simple projects based on my research that can be carried out by undergraduate students. Creating simpler versions of my talks that are more accessible to undergraduates. (CISE awardee)

- Developing courses with nontraditional topics;

  One CAREER awardee who is a professor of physics developed a course topic on the physics of music for non-scientists. The course was so popular that a number of non-Physics majors transferred into the department. (description of MPS awardee from Site Visit Report)

- Developing entire new courses and graduate programs.

  One CAREER awardee developed a series of mini-courses to improve the geometric literacy of graduate students. While these courses started out as small, four-week mini-courses, they quickly evolved into a large and vigorous graduate program in geometry that now boasts [number] of students. It truly revolutionized the way graduate students

\(^1\) In an open-ended survey item, active awardees were asked to describe how they were integrating research and education as part of their CAREER grant.
were taught in the department. The mini-course approach was so successful that it was 
adopted by several other departments in the university as well. The professor credits the 
CAREER award for his success. He reported to a site visitor that without the CAREER 
award, he would not have developed the mini courses. (description of MPS awardee 
from Site Visit Report)

**Involving undergraduates in research and/or training**

Active awardees described bringing undergraduate students into their lab to do hands-on work alongside 
gradient students. In their comments, some awardees specifically noted connecting the Research 
Experiences for Undergraduates (REU) programs at their institution with their education activities.

I actively engage undergraduate and graduate students into research within the framework of my 
CAREER project; undergraduate students involved in my research are often supported by external 
funding through NSF REU program. (BIO awardee)

I have developed a wide range of "openings" in my research on many levels. These openings are 
designed to allow people at different levels of expertise to have access to research experiences. 
This means that high school students, undergraduate students, graduate students, other faculty 
members can all enter into the work at an experience-appropriate level. (ENG awardee)

**Working with students from underrepresented minority groups**

Some CAREER awardees work specifically with students from HBCUs and MSIs, bringing them into 
their lab to do research or going to their institutions to give lectures and workshops. In some cases, this 
means conducting outreach activities with nearby HBCU without adequate research facilities; in other 
cases, this involves mentoring of underrepresented students from their own institutions.

[I] actively create opportunities for high school and undergraduate students from underrepresented 
groups to become involved in neuromuscular biomechanics research. (ENG awardee)

The research is the main ingredient providing the minority and underrepresented students to be 
involved in scientifically related activities. It enhances their real knowledge of physics, math and 
chemistry. The students obtain important hands on experience in research learning contemporary 
methods and approaches. (MPS awardee)

**Conducting outreach activities to non-collegiate students and teachers**

Survey results indicate that almost half of all CAREER awardees have talked about their research with K-
12 students, and nearly one-fifth have collaborated with K-12 teachers on STEM curriculum development 
or teacher preparation. Active awardees provided several rich descriptions of their outreach to these 
groups.

CAREER awardees who bring middle or high school students into the lab to see how experiments are 
conducted in person, or who create hands-on opportunities in schools, view these activities as ways to 
increase the pipeline of students majoring in STEM disciplines as well as to give back to the community. 
Some CAREER awardees described wanting to show middle and high school students what it actually 
means to be a scientist, and to engage in everyday activities in a lab to spark their interest.

I teach a 2-day module of a summer high school course that teaches students about cell biology 
applications of [my research] and has a hands-on demonstration in which students can feel the 
pulse of a cardiac [cell] using a custom interface that provides tactile and auditory feedback. I 
have also used this demonstration for a yearly Biomedical Engineering field trip that I coordinate 
with fifth-grade teachers and students from a local elementary school. (ENG awardee)
Participation in annual School of Engineering and Applied Science Open House event for high school students and parents across [my state]. Our lab is open to the public, and my graduate students and I describe our research and offer practical examples and hands-on experiments to motivate the importance of the work. (ENG awardee)

I am developing an internet-based method for enhancing science education for gifted high school students, allowing them to operate state-of-the-art instrument at my laboratory at [my university] from the comfort of their own classrooms. (MPS awardee)

CAREER awardees work with K-12 teachers and schools in a variety of ways, including bringing teachers into their laboratories to conduct research, developing modules and courses for K-12 teachers, or developing training programs to enhance teachers’ understanding of basic science and learn new educational concepts.

The programs involving high school teachers and students have been highly successful in introducing such interns to the types of research conducted in my lab and at my institution. The teacher training program has also allowed me to work with teachers on the development of activities in their classrooms that involve the subjects covered by my research program. (BIO awardee)

Developing products or software
A small number of active awardees described specific products, software or educational web sites aimed at enhancing the understanding of various STEM topics. One CAREER awardee developed an innovative technology to capture students’ real-time questions in class, which allowed them to send questions to him electronically while he was lecturing. He was able to immediately address students’ questions while maintaining their anonymity. This technology has become popular in other classes and departments in that university setting. An ENG awardee is building a biotechnology web site targeted to high school students and teachers. A third described developing software appropriate for multiple audiences:

I have developed two new software tools arising from my CAREER research... [and integrated them] into my graduate seminar curriculum. The graduate students perform projects using these software tools. I developed a new undergraduate course based on my CAREER research...that uses...[one of these software tools] as the basis for programming projects by the undergraduates.... All of our software tools have been or are being released as open source to aid all researchers and educators in my research field. (CISE awardee)

Challenges of Integrating Research and Education
Active CAREER awardees were asked to describe attempts to integrate research and education that were unsuccessful. Two-thirds (64 percent) did not respond; 15 percent wrote “None,” and 22 percent (N = 103) identified an unsuccessful activity. The most common challenges stemmed from insufficient departmental or institutional support, lack of preparation among undergraduate students for research, competing demands on awardees’ time or work overload, and difficulty successfully implementing outreach activities. Those with challenges tended to note single rather than multiple issues.

Examples of challenges include the following:

Early attempts to define meaningful research projects for undergraduates were not successful. The basic problem is that most undergraduates do not possess the necessary math and computational skill sets to understand and analyze complex systems requiring numerical simulation of partial differential equations. (ENG awardee)

It is hard to find the time to develop a module a year with the twin conflicts of regular teaching and research. I wish the proposal had come with some release time. (BIO awardee)
Lack of adequate infrastructure (money, personnel support etc.) prevented me from scaling up many of the outreach activities to the extent I would have liked to. (CISE awardee)

The research presentations aimed at recruiting women and minority graduate students have had no measurable impact on graduate applications or enrollment in my department. (ENG awardee)

**What types of integrative activities do CAREER awardees implement?**

In addition to describing the integrative activities implemented by CAREER awardees under their CAREER awards, we also examined the extent to which awardees, as a matter of course, integrate research and education as part of their professional activities. Exhibit 7.1 shows the types of activities reported by awardees for the 2005-06 academic year. These activities were presented as a predetermined list that corresponded to examples of educational or outreach activities culled from the CAREER program announcement and conversations with NSF. Awardees were asked to select any and all of the activities in which they had engaged. We highlight four findings:

- Over three-quarters of awardees either supervised undergraduate research and/or discussed their own research in an undergraduate course;
- Over two-fifths of awardees had published or submitted a paper co-authored with an undergraduate;
- Nearly half of awardees indicated that they had talked about their research with K-12 students; and
- Nearly twenty percent of awardees had collaborated with K-12 teachers or staff to develop STEM curricula or assist in teacher preparation.
### Exhibit 7.1

**Activities that integrate research and education reported by awardees in 2005-06 (selected from a pre-specified list)**

<table>
<thead>
<tr>
<th>Type of activity</th>
<th>Percent of CAREER awardees</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engage with graduate students</td>
<td></td>
</tr>
<tr>
<td>Publish or submit a paper with a graduate student as author</td>
<td>94%</td>
</tr>
<tr>
<td>Establish an industrial internship program for graduate students</td>
<td>8</td>
</tr>
<tr>
<td>Engage with undergraduate students</td>
<td></td>
</tr>
<tr>
<td>Supervise an undergraduate student research project or thesis</td>
<td>78</td>
</tr>
<tr>
<td>Discuss current research in an undergraduate course</td>
<td>74</td>
</tr>
<tr>
<td>Publish or submit a paper with an undergraduate student as author</td>
<td>41</td>
</tr>
<tr>
<td>Require undergraduates in a course to design and carry out an original research project (beyond a literature review)</td>
<td>28</td>
</tr>
<tr>
<td>Conduct research on how undergraduates learn STEM concepts</td>
<td>7</td>
</tr>
<tr>
<td>Establish an industrial internship program for undergraduate students</td>
<td>6</td>
</tr>
<tr>
<td>Engage in outreach beyond the university</td>
<td></td>
</tr>
<tr>
<td>Talk with elementary, middle, or high school students about own field or research</td>
<td>46</td>
</tr>
<tr>
<td>Collaborate with elementary, middle, or high school teachers or staff on developing STEM curricula or teacher preparation</td>
<td>19</td>
</tr>
<tr>
<td>Engage local community college faculty or students in conversations or projects related to my field or research</td>
<td>16</td>
</tr>
<tr>
<td>Develop a museum exhibit or event to foster public interest in STEM</td>
<td>9</td>
</tr>
</tbody>
</table>

Exhibit reads: 94% of active and past awardees reported that they had published or submitted a paper with a graduate students as author in 2005-06.

Notes: Respondents include both active and past CAREER awardees (Ns range between 1015 to 1096)

Sources: PI Survey, Item B2. In which of the following activities related to undergraduate education did you engage during the last academic year (2005-06)? Check all that apply.

PI Survey, Item B3. In which of the following activities related to graduate education did you engage during the last academic year (2005-06)? Check all that apply.

PI Survey, Item B4. Did you engage in any of the following service or outreach activities during the last academic year (2005-06)? Check all that apply.

The activities shown in Exhibit 7.1 were not labeled explicitly on the survey as integrative, yet they represent activities that both program officers and awardees characterize as examples of integrating research and education. As with program officers, awardees often spoke of their educational plans and the integration of research and education interchangeably. In contrast to program officers, however, who rarely mentioned training graduate students as an example of integrated research and education, multiple awardees interviewed cited their work with graduate students as examples of their integration of research and education. For example, one MPS awardee credited the CAREER award as a catalyst for developing
a series of short courses to help graduate students become more literate in his sub-discipline; these short courses changed the way his own and other departments at his university approached graduate training.

**Did awardees integrate research and education more than they would have without CAREER?**

Awardees had mixed perceptions of the impact of CAREER on their efforts to integrate research and education. The following statements from awardees illustrate two contrasting views of the impact of CAREER:

- CAREER's emphasis on integration is key. Junior faculty members have a hard time balancing research, education and service activities.....CAREER taught me how to balance these. I don't think a regular research award would have allowed integration across the two. (BIO awardee)

- I don't buy into this. This [integration of research and education] should happen naturally at a research university. You draw examples in class naturally from your own work or work in the field. You don't have to be told to do that. And, to go beyond that, would be unrealistic. (MPS awardee)

Some awardees commented that CAREER enabled them to engage in a set of activities that would not otherwise have been possible. In particular, there were awardees who reported that CAREER gave them license to pursue a pre-existing passion for teaching, which they otherwise would not have been able to do. For example, several awardees at large research universities indicated that, within the culture of their department, they would not have been able to justify investing as much time in educational activities without the CAREER award:

- The CAREER grant enabled me to work on educational and outreach activities that otherwise I think I would have been actively discouraged from working on as a junior faculty member at an R1. (ENG awardee)

- I want to do education but don't get credit for it. CAREER gives me another excuse to actually [do education activities]. Going the extra mile on teaching isn't typically rewarded as much as going the extra mile on research, at least at a research university. (MPS awardee)

In contrast, other awardees reported that they would have engaged in these types of integrative activities even in the absence of the CAREER award. Many of these particular awardees were referring specifically to their work mentoring and training graduate students; these individuals conceived of integration as a natural part of their work and not something that stems from CAREER:

- In research, we generate knowledge and conveying it into our classes is a natural thing to do. (ENG awardee)

- It [integration of research and education] just comes naturally – a big part of research is through grad students. (CSE awardee)

Using survey data from awardees and non-awardees and applying statistical methods to control for the pre-existing differences between these two groups (detailed in Chapter 5 and Appendix A), we estimated the impact of CAREER on several indicators of integration of research and education. Given the wide variation in the types of activities awardees could propose as integrative, it was not possible to formulate a single measure of the impact of CAREER on awardees' integration of research and education. Exhibit 7.2 reviews the impact findings for six outcomes tested to assess the relative engagement of awardees in integrative activities. (These findings are discussed in greater detail in Chapter 5 of this report.)
### Exhibit 7.2

#### Impact of CAREER on awardees’ integration of research and education

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Percent&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Published a paper with undergraduate as author&lt;sup&gt;b&lt;/sup&gt;</td>
<td>41</td>
</tr>
<tr>
<td>Discussed current research in undergraduate course&lt;sup&gt;b&lt;/sup&gt;</td>
<td>75</td>
</tr>
<tr>
<td>Required undergraduates to conduct original research project&lt;sup&gt;b&lt;/sup&gt;</td>
<td>30</td>
</tr>
<tr>
<td>Supported undergraduate on NSF award&lt;sup&gt;c&lt;/sup&gt;</td>
<td>41</td>
</tr>
<tr>
<td>Engaged in one or more activities with K-12 students or educators&lt;sup&gt;d&lt;/sup&gt;</td>
<td>54</td>
</tr>
<tr>
<td>Developed a museum exhibit or other event to foster public interest in STEM&lt;sup&gt;e&lt;/sup&gt;</td>
<td>10</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Awardees</th>
<th>Non-awardees</th>
<th>Impact</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Published a paper with undergraduate as author&lt;sup&gt;b&lt;/sup&gt;</td>
<td>41</td>
<td>37</td>
<td>4</td>
<td>.13</td>
</tr>
<tr>
<td>Discussed current research in undergraduate course&lt;sup&gt;b&lt;/sup&gt;</td>
<td>75</td>
<td>73</td>
<td>2</td>
<td>.37</td>
</tr>
<tr>
<td>Required undergraduates to conduct original research project&lt;sup&gt;b&lt;/sup&gt;</td>
<td>30</td>
<td>27</td>
<td>3</td>
<td>.24</td>
</tr>
<tr>
<td>Supported undergraduate on NSF award&lt;sup&gt;c&lt;/sup&gt;</td>
<td>41</td>
<td>41</td>
<td>0</td>
<td>.85</td>
</tr>
<tr>
<td>Engaged in one or more activities with K-12 students or educators&lt;sup&gt;d&lt;/sup&gt;</td>
<td>54</td>
<td>47</td>
<td>7</td>
<td>.02</td>
</tr>
<tr>
<td>Developed a museum exhibit or other event to foster public interest in STEM&lt;sup&gt;e&lt;/sup&gt;</td>
<td>10</td>
<td>8</td>
<td>2</td>
<td>.29</td>
</tr>
</tbody>
</table>

Exhibit reads: Forty-one percent of awardees and 37 percent of non-awardees published a paper with an undergraduate as an author. The impact is four percentage points, which is not statistically significant (p = .13).

**Notes:**
- Values shown are regression-adjusted for propensity strata
- Analysis sample: awardees, N = 1015; non-awardees, N = 1249.
- Analysis sample: awardees, N = 463; non-awardees, N = 549. Only PIs with a currently active CAREER award or Comparison grant were asked whether or not they were using funds to support undergraduates.
- Analysis sample: awardees, N = 1096; non-awardees, N = 1343

**Sources:** PI Survey, Item B2. In which of the following activities related to undergraduate education did you engage during the last academic year (2005-06)? Check all that apply.
PI Survey, Item B4. Did you engage in any of the following service or outreach activities during the last academic year (2005-06)? Check all that apply.

Two conclusions emerge:

- Awardees were no more likely than non-awardees to report engaging undergraduates in research or to engage in outreach to foster greater public interest in STEM findings;
- Awardees were more likely than non-awardees to report engage in one or more activities with K-12 students or educators (and this difference was statistically significant).

These findings suggest that the CAREER award increases awardees’ outreach to K-12 students, but does not alter their engagement with undergraduates. As training graduate students is a standard part of all research faculty members’ jobs, we did not test CAREER’s impact on graduate training activities. As is true in any quasi-experiment, these results must be interpreted with caution. Although the statistical techniques used can reduce the confounding effect of pre-existing differences between awardees and non-awardees, there is a chance that some unmeasured pre-existing difference between the two groups, rather than the CAREER award itself, accounts for differences in their outcomes.
Has CAREER increased the value institutions place on the integration of research and education?

CAREER awards are granted to individual PIs, yet the program is intended to effect change at the institutional level as well: “The CAREER program embodies NSF’s commitment to encourage faculty to practice, and academic institutions to value, integration of research and education” (NSF 05-579, emphasis added). All CAREER applicants must obtain a letter of support from their department that endorses the PI’s proposed activities and describes how the department will “ensure the appropriate mentoring of the PI, in the context of …his/her efforts to integrate research and education throughout the period of the award and beyond.”

Most department chairs who participated in this evaluation value CAREER much more for the prestige it brings to the department and for its support of faculty research than for its emphasis on the integration of research and education. For example, only 30 percent of department chairs reported that CAREER awards had increased the value the departments placed on integrating research and education, compared to 81 percent of department chairs who reported that the presence of CAREER awardee(s) had enhanced their department’s prestige, and 49 percent who reported that the presence of CAREER awardee(s) had improved the overall quality and quantity of faculty-led research. Site visits confirmed these data. Department chairs and other senior faculty tended to report either that the integration of research and education was something that the department had always valued, independently of CAREER, or that junior faculty should focus on their research first, and education second.

At this point in their careers, junior faculty just need to be effective in the classroom—not come up with new ideas. They need to build their research labs. To tell them to come up with something innovative—that’s a bit of a stretch. That’s what we did as a team—and that’s a much better way of doing it. You have to do it as a department. (ENG department chair)

NSF is trying to do the right thing. All of their proposals request [integration and educational innovation], but … it seems redundant. We educate students. It’s what we do. We train graduate students. We’ve had a successful REU [Research Experience for Undergraduates] program as well. People feel like they have to write something ‘original’ that sounds right to an NSF panel as opposed to saying ‘this is what we do.’ Walk around our labs. Everything is done by the students. They learn by doing. But especially young faculty cannot write that [on a CAREER proposal],…they feel like they have to cook up something—there’s a lot of [expletive deleted] when they write that section. As opposed to just making the case [that] if it’s important research then students will be in demand when they come out. What’s good for graduate students is to be involved in cutting edge research. (ENG department chair)

Some doubted that an award given to individual investigators could effect institution-wide change—

A CAREER award is really a personalized award. It is really about helping an individual develop his career. Now you want to project out to changing the institution? I don’t know how you move from one to the other. (ENG department chair)

This view was shared by at least one program officer at NSF:

CAREER is not going to change tenure requirements. The focus of CAREER is on the individual, not on influencing institution, unlike IGERT. (NSF program officer)
Department chairs and other senior faculty interviewed during site visits generally described graduate training as the type of integrative activity CAREER should be fostering, and were more skeptical of asking junior faculty to develop innovative educational plans that extended beyond doctoral students:

NSF needs to communicate to Congress that research is education. When you invest in a doctoral student you're carrying out one of the greatest kinds of education – handing down the tools to the next generation. This is the best use of an NSF dollar. (ENG senior faculty member)

There were exceptions to this general trend. For example, one senior faculty member credited CAREER with energizing junior faculty to become public advocates for science:

It's extremely important to integrate research and education to get the younger generation excited about science. [CAREER's integration of research and education] is a dividend for us. [One of our CAREER awardees] continues her [CAREER] education on a variety of topics (job talks, resumes). [Another awardee] is doing the Science Café on hot topics. This makes folks think. We need to go to nonclassical avenues to get science to the general public. Why? To get more money into science. Science is important.... Also, we need to generate new courses. Science is growing so we need teachers to incorporate those advances. CAREER is a good mechanism for that. (MPS senior faculty)

Survey data are inconclusive about whether that department chairs view CAREER awardees as any more or less likely than their peers (i.e., non-awardee junior faculty) to integrate research and education. Although 41 percent of department chairs reported that CAREER awardees were more likely than their peers to incorporate integrative activities into their instruction, 51 percent felt that this was equally characteristic of awardees and their peers (Exhibit 7.3).

In contrast, three-quarters of department chairs indicated that there is no difference between awardees’ and their peers’ ability to conduct excellent research. With respect to educational effectiveness, the majority of department chairs perceive awardees as similar to their peers: 77 percent indicate that both awardees and their peers are effective educators; 82 percent that it is characteristic of both awardees and their peers to spend time mentoring students. Thus, there is some evidence that in at least some departments, CAREER awardees are perceived as more integrative than other faculty members.
### Exhibit 7.3

Percent of department chairs who rate various qualities as characteristic of CAREER awardees and/or their peers

<table>
<thead>
<tr>
<th>Percent of chairpersons surveyed reporting that quality best characterizes:</th>
<th>CAREER awardees</th>
<th>Non-awardee peer faculty</th>
<th>Both groups equally well</th>
<th>Neither group</th>
<th>Don’t know</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incorporate activities integrating research and education into their instruction</td>
<td>41%</td>
<td>0%</td>
<td>51%</td>
<td>4%</td>
<td>4%</td>
</tr>
<tr>
<td>Conduct excellent research</td>
<td>24</td>
<td>1</td>
<td>74</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Are effective educators</td>
<td>16</td>
<td>1</td>
<td>77</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Devote time to mentoring students</td>
<td>12</td>
<td>1</td>
<td>82</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

Exhibit reads: 41 percent of department chairs indicated that the phrase “incorporate activities integrating research and education into their instruction” best characterizes CAREER awardees; 0 percent indicated this statement best characterizes non-awardee peer faculty; 51 percent indicated that it characterizes both CAREER awardees and their non-awardee peers equally well; 4 percent indicated that it characterizes neither awardees nor their peers; and 4 percent did not know.

**N** ranges from 518 to 522. Missing ranges from 16 to 21.

Source: Survey of Department Chairpersons. Question 18. Please indicate whether each of the following statements about your department’s faculty members best characterizes NSF CAREER awardees, their peers, both equally well, or neither group well.

### Does the CAREER program promote the integration of research and education?

Because the integration of research and education has multiple meanings both within NSF and among awardees, it is difficult to assess how well CAREER is meeting this goal. Instead, we have compared how this goal is interpreted and valued within NSF, among awardees, and within institutions where awardees reside.

Within NSF, program officers perceived the CAREER award’s emphasis on integration as a feature that distinguishes CAREER from other NSF research grants. Some program officers also cited the CAREER program’s emphasis on the integration of research and education as an important precursor to the agency-wide implementation of the “broader impacts” criterion, suggesting that CAREER “paved the way” for all NSF awards to have some integrative focus. In contrast, senior faculty at institutions with active CAREER awardees did not necessarily distinguish this aspect of CAREER from the broader impacts criterion on which regular NSF research proposals are judged.

Our interviews with program officers suggest that NSF intends CAREER to have an impact beyond the graduate research training typically conducted by research faculty members:

Education is not just working with graduate students. We need them to do more. We got spoiled after World War II. A lot of people immigrated here; they compensated for our lack of focus on STEM in the United States. The early 1960s and 70s were an anomaly. Now, there’s not much high school interest in science but now the competition is much higher. There are growing economies in the East. We’re much less likely to get [immigrants] to come to the U.S. Faculty
think that money grows on trees, but it depends on public support. It's self-destructive to isolate oneself in research. (NSF program officer)

We are really interested in curriculum change. The most effective plans target undergraduate classes. The very creative ones are in K-12 education, working with natural history museums, the Girl Scouts, etc. (NSF program officer)

However, a substantial proportion of awardees and their colleagues suggested that, even in the absence of the CAREER program, STEM researchers naturally integrate research and education via their training of doctoral students.

At the level of individuals, awardee PIs are no more or less likely than non-awardee PIs (who have received other NSF funding) to engage undergraduates in research activities. On the other hand, a significantly greater proportion of awardees than non-awardees report some type of outreach to the K-12 educational community, and some awardees credited the CAREER program with allowing them to pursue educational activities that their institutions would otherwise have not supported. In addition, 64 percent of past awardees reported that at least one element of the educational and integrative aspects of their CAREER award had persisted beyond the period of the award; most frequently, this sustained element was a course they had developed as part of their award that continued to be taught, either by themselves or by other faculty in their department.

We think there are two useful views of integration that emerge from this report. One view is that CAREER's emphasis on the integration of research and education is intended to encourage the top researchers in STEM fields to be equally effective as educational ambassadors. Another view is that the CAREER program should reward those individuals who can articulate a clear and compelling relationship between a research project and an educational plan, a relationship in which the research agenda not informs, but is informed by the processes or outcomes of the educational activities. The finding that awardees are more likely than non-awardees to engage in outreach to the K-12 educational community suggests that CAREER is well positioned to advance the former interpretation of this goal.

To clarify the meaning of integrated research and education, it may be important to consider what STEM research and education look like when they are not sufficiently integrated. What does NSF want CAREER awardees to do that they are not already doing? For example, if NSF wants the CAREER program to foster something beyond strong doctoral training, the program announcement may need to incorporate a more deliberate message for those awardees who see graduate training in and of itself as sufficient evidence of integrating research and education. On the other hand, clarifying the definition of integration of research and education may result in a definition that does not apply equally to all fields/disciplines. Moreover, too strict a definition could potentially inhibit the types of innovative proposals for integrating research and education that CAREER is intended to spark.
Chapter 8: Summary of Findings and Implications for the CAREER Program

This study was designed to learn how individuals in host departments and at the NSF perceive CAREER’s value and purpose, as well as to assess the impact of CAREER on awardees. In the course of our study, respondents provided substantial feedback about the CAREER program in general and other issues they thought were germane. In this chapter, we summarize recommendations from study respondents for the CAREER program, highlight study findings and discuss the implications of these findings for NSF.

Impact of CAREER on awardees

Awardees highly value their CAREER award and report a wide range of benefits for their research productivity, professional advancement, education productivity, and integration of research and education. Comparison with a matched set of non-awardees confirmed that winning a CAREER award has a positive impact in some areas, including achieving tenure and conducting educational outreach.

Research activities

Most awardees report that their CAREER award accelerated their ability to establish a research program, a perception shared by a majority of department chairs (53 percent) who reported that CAREER awardees establish their research program more quickly than their peers (a key objective of the CAREER program). All awardees report that their CAREER award enhanced their own research productivity in some way, through some combination of financial support for research; increased capacity to pursue desired research topics; the opportunity to think more strategically about long-term research agendas; freedom from the pressure of obtaining research funding; validation of research topics; and enhanced prestige in the field.

Winning a CAREER award does not appear to increase time spent on research: awardees and non-awardees reported that they allocate the same proportion of time to research. We also found no evidence that the CAREER award increases research productivity as measured by publications and presentations. Awardees and non-awardees produce equivalent numbers of publications, and research produced by awardees is neither more nor less likely than that produced by non-awardees to be cited by others.

Career advancement

Tenure and promotion
Awardees uniformly believe that CAREER’s support for their research and the award’s prestige are beneficial and positively influence their early career advancement, especially their receipt of tenure. Awardees characterized the effect of the CAREER award on their tenure reviews as “critical,” “instrumental,” and “crucial”, and 62 percent indicated that tenure review committee members had specifically mentioned the CAREER grant as a positive factor in the decision process. By the time they completed the survey, awardees were statistically more likely than a similar group of non-awardees to

1 Nearly all of the remaining department chairs reported that CAREER awardees establish their research programs at the same pace as their peers.
have achieved tenure, controlling for the number of years since beginning their first tenure-track position, but not any more likely than non-awardees to have achieved the rank of Full Professor.

Institutional mobility

Winning a CAREER award appears to have helped a modest proportion of awardees change institutions: 15 percent of past awardees reported that winning CAREER afforded them an opportunity to "move to a more prestigious institution." Supporting this, impact results show that on average, CAREER awardees who change institutions tend to move to a more research-intensive institution than the one from which they applied for CAREER, while non-awardees who change institutions, on average, move to a less research-intensive institution.

Education productivity

Awardees and non-awardees allocate the same proportion of time to education. Winning a CAREER award does not increase time that awardees spend on education, but awardees report that it did change their interest in or focus on educational activities. Some awardees credit their CAREER award with stimulating their interest in education and outreach activities; others reported that they already cared about education and outreach and that CAREER validated or enabled them to do what they wanted to do already. For some, the process of thinking about educational component(s) to propose forced them to think about themselves as educators; for the few who were not very interested in education to begin with, writing a CAREER proposal did not change this lack of interest.

Integration of research and education

Most awardees report having implemented some activities under their CAREER award that integrate research and education. Awardees often cite one of four types of activities to describe their integration of research and education: incorporating research into courses; mentoring graduate students; engaging undergraduates in research-based activities; and conducting outreach to K-12 teachers and students or to community colleges. Nine of ten awardees are using their CAREER awards to develop new courses based on their own research or to incorporate their research into their classes. Half are mentoring, training, and/or supervising undergraduate or graduate students, and two-fifths are involving undergraduates in research. About one-third of awardees are providing outreach to non-collegiate students, students from other colleges and universities, teachers, and other community and business professionals.

We examined the impact of CAREER on awardees' engagement of undergraduates in research and on awardees' participation in outreach to K-12 students and/or educators. Awardees and non-awardees are equally likely to publish a paper with an undergraduate, discuss their research in their undergraduate courses and to require undergraduates to engage in original research projects; they are just as likely to support an undergraduate on an NSF grant or publish a paper with an undergraduate. Awardees are more likely than non-awardees to report engaging with K-12 teachers or students, either by conducting research on how such students learn scientific or mathematical concepts, by working with K-12 teachers to develop STEM instructional materials, or by discussing their research with these groups.
Relationship of CAREER to the research and educational missions of host departments

CAREER is viewed as a substantial, prestigious research award by faculty members in departments hosting CAREER awardees: 75 percent of department chairs report that the CAREER award is the most prestigious award in their respective disciplines. Applying for a CAREER award is essential for young faculty in many departments and winning a CAREER award is perceived as a significant factor in tenure decisions. In tenure and promotion reviews, the CAREER award is often viewed as an endorsement of the quality of a faculty member’s research, but is not typically a factor in judging the candidate’s capacity as an educator. For the majority of department chairpersons, education was synonymous with teaching, and its quality was measured by student evaluations and other, less formal, methods.

Awardees receive the same levels of support as do other junior faculty with grants, and most chairpersons reported that they are equally involved with awardees as with other junior faculty who are writing grant proposals. Departmental endorsement of the CAREER application and letters of commitment do not lead to an active partnership with awardees.

According to department chairs, the presence of CAREER awardees in a department has a far stronger effect on the research side of the university culture than on the education and integration side, particularly in increasing departmental prestige, increasing the supply of funding for graduate students, and in improving the overall quality and quantity of faculty-led research. CAREER’s strongest effect on education and integration was perceived to be in driving the development of new courses. The presence of CAREER awardees has not substantially catalyzed changes in departmental practices or policies related to the tenure or promotion process.

In some cases, especially in departments with a high proportion of awardees, the CAREER award is used to support the department’s organizational goals, including enhancing the prestige of the department and by increasing its ability to attract highly qualified faculty, better graduate students, and additional financial support. CAREER awards were characterized as especially useful in departments whose faculty specialize in disciplines most heavily funded by NSF (such as Engineering); were upgrading their emphasis on research; or were revamping or reorganizing their departments through their junior faculty. CAREER awards have a special place in HBCUs and MSIs, which typically have little institutional research capacity, and often emphasize teaching more so than research. In these institutions, CAREER awards add significantly to research support for individual faculty and contribute to a shift in institutional culture.

NSF stakeholder perceptions of the CAREER program and its relationship to the mission of NSF

The vast majority of the NSF program officers interviewed describe the CAREER program as a highly successful effort to support the early careers of STEM faculty members, although they acknowledge that it might benefit from a few minor changes. A small minority of program officers commented that the structure of the CAREER program was misaligned with the nature of research in those disciplines where most new researchers do not have significant educational responsibilities, and cited two concerns: (1) such program officers feel pressured to make CAREER awards when the CAREER program does not match the needs of their field, and (2) PECASE awardees are selected solely from among CAREER
awardees, thus preventing many of the most promising researchers in their disciplines from being considered for PECASE.

**Purposes of CAREER awards**

Program officers adopt one of two strategies when making CAREER awards: (1) supporting promising researchers and launching the careers of as many talented new scientists and engineers as possible; or (2) rewarding the best, most exceptional rising leaders in the field. To some extent, adoption of one or the other of these goals appears to be correlated with the cost of doing research in different disciplines and the overall size of program budgets within directorates. In disciplines where CAREER is significantly larger than a regular research grant and/or where research program budgets are small (EHR, GEO, SBE, some programs within MPS), a single CAREER award might represent a large proportion of a research program’s total budget and/or be equivalent to three or four regular awards. In these disciplines, CAREER awards are usually made only to the very best and brightest, and often, to faculty members who have already proven their research merit by winning some other research grant. In other disciplines where an average CAREER award is about the same size (or smaller) than a regular disciplinary research grant, and/or where program budgets are larger (ENG, CISE, BIO) program officers are capable of making more CAREER awards, and tend to support the goal of supporting as many promising, talented researchers as possible.

**Proposal review**

Most research programs at NSF accept CAREER applications and review CAREER proposals during their regular review panels, either alongside other proposals or separated into their own session. There is no agency-wide communication about how to review CAREER proposals. The CAREER Coordinating Committee has prepared instructions for CAREER proposal reviewers, although not all program officers were aware that such instructions were available. Several program officers (usually newer to NSF) reported that they would like more training regarding the purposes of CAREER and how they should make decisions about funding CAREER awards. Given that many NSF program officers rotate into NSF from academic positions, it might be beneficial to have more frequent orientation of program officers about CAREER program and review processes specifically.

**Issues and conclusions**

The PI and department chair surveys, site visit interviews, and interviews with NSF program officers offered respondents opportunities to comment on the CAREER program in general or other issues that they thought were germane. In general, there was overwhelming praise and support for the CAREER program across all respondent types. Often cited was the critical need for research dollars for faculty in the early stages of their careers to get their research programs up and running.

Still, respondents identified some concerns about overarching NSF policy as well as policies specific to the CAREER program, and provided comments and recommendations on how CAREER awards are funded, the peer review process, and NSF program management. Two key questions emerged upon which there is not consensus in the field:

1. Is CAREER the right way to support the early career development of junior faculty?

2. Should NSF promote the integration of research and education through CAREER?
Is CAREER the right way to support the early career development of junior faculty?

Respondents had opinions regarding CAREER award success rates, duration and funding amount.

Success rates
A number of faculty members and administrators noted a trend towards decreasing funding rates for the CAREER award over time. Analysis of NSF proposal data files indicates that this decline in funding rates is due to an increased number of applications in relation to a relatively unchanging number of awards. This decline is perceived as so substantial in some directorates that administrators and senior faculty in some institutions have begun to question the wisdom of expecting young faculty members to invest so much of their time in developing a CAREER proposal when the odds of winning are so low. Some contrasted the odds of winning a CAREER grant with the odds of winning funding from other federal and private sources, commenting that the chances of securing other sources of funding were sometimes more favorable for applicants. There was fairly widespread support for the idea that NSF should award more CAREER awards; a smaller proportion of respondents feared that increasing the number of awards would dilute its prestige.

Award amount
Program officers report frequent discussion at NSF over CAREER’s minimum award amount, with no clear consensus emerging. There is disagreement, both from those who characterize the award as too large (and who would prefer to support increased numbers of faculty with smaller awards) and those who characterize the award as too small (who would argue that reducing it would render it indistinguishable from other research grants). There is much less dissent among researchers in the field, the vast majority of whom believe that NSF should increase the size of the awards (although there is some variation by discipline). While a majority of past awardees (63 percent) reported that their CAREER award funding was adequate to implement their proposed activities, many current awardees noted that the current award size will support only one graduate student at many institutions, which they believe is insufficient to pursue their research agenda. Given that NSF program officers also disagree as to whether the award amount is suitable for their fields, the question of whether award amount should be set agency-wide or allowed to vary among individual directorates remains an important issue for NSF’s consideration.

Award duration
There was generally strong support for the current five-year duration of the CAREER award. As noted in Chapter 4, CAREER awardees attested to its importance in freeing them from the proposal-writing process so that they could focus on establishing their research program. Many deans, department chairs, and senior faculty favor the duration of the grant for that reason as well. A few dissenters suggested that a shorter duration is more reasonable, fearing that CAREER awardees could become lax, or somehow less able to compete for subsequent grants. Others noted that if CAREER was a faculty member’s only pre-tenure grant and it carried them through tenure, then the tenure panel would have no evidence that awardees would continue to be successful grant-seekers.

Should NSF promote the integration of research and education through CAREER?

The biggest unresolved issue related to the CAREER program is the appropriateness of CAREER’s emphasis on the integration of research and education. Respondents are unclear as to how to define “integration of research and education,” and disagree as to whether NSF should require CAREER awardees to integrate research and education.
Defining integration of research and education

All CAREER awardees are expected to conduct innovative, integrative education activities in addition to their research as part of their CAREER award, yet neither the program solicitation nor NSF program officers provide a specific definition of integration. We found that both NSF program officers and faculty members described various educational activities when reflecting on the meaning of integration. In this sense, there appears to be a shared understanding that what is meant by the integration of research and education is that awardees should pursue innovative research and innovative education, even if the educational activities are not necessarily tightly linked with awardees’ research agenda. On the other hand, this conflation of integration with educational innovation appears to conflict with language in the solicitation, which suggests that the educational activities must inform the awardee’s actual research. Only some program officers defined integration as a synergism, in which research informs teaching and teaching informs research. In addition, while most awardees report that their research enhances their ability to teach graduate students (94 percent) or undergraduate students (77 percent), fewer report that their teaching informs their own scientific knowledge (70 percent) or research (58 percent). Furthermore, only two in five past awardees felt that their CAREER award specifically provided them with an opportunity to pursue an educational activity that subsequently benefited their research. Thus even among CAREER awardees, the majority believe that research generally informs education rather than the other way around.

There was one source of potential discord between NSF program officers and awardees. Some awardees (and department chairs) expressed the belief that their role in mentoring graduate students and producing the next generation of new doctoral scientists is prima facie evidence of their integration of research and education. Program officers may or may not share this belief; few cited graduate mentoring as an example of an integrative activity and at least one indicated explicitly that “Education is not just working with graduate students. We need them to do more.”

In keeping with the notion that integration is defined as educational innovation, many program officers spoke of the educational and integrative components of CAREER as aligned with NSF’s “broader impact” review criteria, and the research component as “intellectual merit,” and argued that the adoption of a broader impact criterion for all research grants has put pressure on CAREER applicants to propose education and integration activities that are measurably more “innovative” or “outside the box” than before. The end result is that activities that might have been considered a strong educational component a few years ago may now no longer be viewed as such.

Furthermore, some program officers commented that the definition of “innovative” may differ from institution to institution. There is internal debate at NSF as to whether the review of CAREER applications should take into consideration the type of institution from which applicants are applying when reviewing the educational plan, under the assumption that what might count as “innovative” at a research university may not viewed as “innovative” at an institution that emphasizes undergraduate education. Program officers acknowledged this issue but found it challenging to define flexible standards. There is also acknowledgement that different universities place different emphases on research and education, and that CAREER’s dual emphasis on both and the integration of the two may lie counter to the pressures faculty members face when preparing for tenure review.

Should CAREER promote the integration of research and education?

More than any other feature of CAREER, there were decidedly mixed opinions among respondents with regard to the education component of the CAREER grant award, particularly its focus on the integration
of research and education. On one side are a smaller cadre of respondents philosophically in tune with CAREER’s dual focus on research and education; on the other side are respondents who feel strongly that CAREER should focus on awardees’ research alone.

*Arguments for CAREER’s promotion of integration*

There was some strong support for CAREER’s focus on the integration of research and education, particularly when it aligns with an institutions’ or departments’ philosophical approach. Some faculty members particularly like the CAREER program because so few grant programs make the effort to link education and research. Most of the support for integration or research and education came from respondents in BIO, MPS, and EHR directorates. There was more mixed support from respondents in the ENG directory and relatively little support from CSE.

In some instances respondents supported the education component, yet raised concerns that NSF is placing too much emphasis on educational *outreach*. Outreach in particular was singled out as a laudable goal, but one that would better fulfill a service function than an education function in the tenure review process. With the exception of institutions where outreach was considered a critical institution-wide mission, outreach was frequently perceived as requiring too much time from junior faculty members with too little payoff in the tenure review process.

Despite these perceptions, there is a strong belief that NSF review panels resonate towards outreach activities and expect a single CAREER proposal to address multiple aspects of education.

“Keep the education component, but don’t go over the top. It’s no longer enough to do one of the broader impacts cold; many panels are saying you need to do it all: socially relevant, K-12 outreach, underrepresented minorities, undergraduates. If you’re missing one, someone will say, ‘they don’t do anything to target K-12 outreach.’ It’s better to do one thing well than five things poorly.” (MPS awardee)

Supporting the perception that CAREER panels may favor outreach activities, results from this evaluation indicate that CAREER has a statistically significant impact on awardees’ engagement with K-12 teachers and students: 54 percent of awardees, compared to 47 percent of non-awardees talked with elementary, middle, or high school students about their field or their research; collaborated with elementary, middle, or high school teachers or staff on developing STEM curricula or teacher preparation; and/or conducted research on how elementary, middle, or high school students learn science, mathematics or engineering.

*Questions about CAREER’s promotion of integration*

Some respondents assert that the NSF should focus exclusively on its mission to fund basic research in science, and believe that congressional mandates to fulfill a broader social agenda dilute the agency’s central mission. Faculty members and department chairs offered several reasons to exclude educational components from CAREER, including the importance of junior faculty developing their research agendas, the relative inexperience of junior faculty as educators, the corresponding perception that innovative educational activities are better left to more experienced faculty who can draw from both their research and teaching experiences, and the common conception that being a good researcher automatically means bringing research into teaching.

Some asked whether it is appropriate for all individual grants be held to the same merit review process criterion about broader impacts when the grants are actually focused on specific substantive or disciplinary questions. Respondents expressed concerns that faculty feel required to propose either increasingly exaggerated activities, or to include boilerplate language about educational outreach in hopes
that it will be sufficient to satisfy the panel. Finally, multiple awardees commented that it did not matter whether they actually followed through on their proposed integration activities, because there is no accountability to NSF; awardees do not have to report on the outcomes of their educational activities as they do with their research outcomes.

Respondents generally agreed that in a limited way writing a CAREER proposal likely makes most junior faculty reflect on their teaching, which is beneficial given that most junior faculty members received very little, if any, training during graduate school in how to teach. Inspired or creative educational activities conducted by awardees under CAREER are viewed as valuable, but only in some cases does winning a CAREER award change awardees’ perceptions of education. There is little evidence that the presence of CAREER awardees to date has influenced the culture or priorities of most host departments, which is not surprising given that in many departments awardees constitute a small proportion of the faculty.

In summary, there is no consensus either at NSF or in the field about what it means to integrate research and education, whether this is an appropriate expectation for junior faculty, and whether it should be a component of CAREER specifically. As CAREER heads into its second decade, there is room for continued dialogue and debate regarding the appropriateness of its education and integration components.

**Implications for NSF**

The results of this evaluation suggest several areas which NSF may wish to consider further.

1. Should PECASE awardees be selected solely from among CAREER awardees?
2. Should the minimum award size be set agency-wide or allowed to vary among individual directorates?
3. Is it sufficient for awardees (and by extension, their institutions) to “integrate” research and education by pursuing excellence in each domain separately, or must awardees pursue a unified research and educational agenda in which these two domains are interdependent, such that the activities in one could not advance without activities in the other domain?
4. At what level(s)—graduate, undergraduate, or K-12—should awardees be targeting the development of integrated research and educational agendas?
5. What activities count as integration of research and education?
6. How accountable should CAREER awardees be for conducting and reporting to NSF on the outcomes of their proposed education and integration activities?
Appendix A: Detailed Description of Impact Analysis

This appendix describes the methodology used to estimate the effects of the CAREER award on its recipients. First, key features of the quasi-experimental design are reviewed in order to provide context for a general discussion of the use of propensity score analysis (PSA) in mitigating selection bias. Next, a first-stage PSA used to select the sample of participants is presented in detail, including the estimated logistic model and the resulting distribution of awardees and non-awardees in the propensity strata. Finally, specifications of the impact models are presented. Before fitting impact models, a second-stage PSA was used to stratify the respondents to the PI Survey; details of this second PSA are included.

Study Design

The evaluation uses a quasi-experimental design to estimate program impacts on awardees by comparing outcomes for CAREER awardees (treatment group) with outcomes for a comparable group of non-awardees (comparison group). Each individual who applied to the CAREER program was “selected for” one of two conditions, either award or no award. The goal of the impact evaluation is to determine whether or not CAREER awardees would have exhibited the same set of outcomes even if they had not received a CAREER award. The ideal approach to determining the impact of a treatment is to randomly assign individuals to treatment (award receipt) or control (no award) status. However, because awardees were chosen based on the merit of their CAREER proposals, random assignment was not feasible (nor desirable). Instead, the evaluation estimates these impacts by assembling a group of individuals whose expected outcomes should be the same as the expected outcomes for awardees had they not received the CAREER award. This comparison group was constructed using Propensity Score Analysis (PSA) to identify non-awardees who were statistically similar across a number of characteristics to awardees. PSA is a quasi-experimental technique for reducing the threat of selection bias.

Selection bias can occur when treatment and comparison groups differ systematically prior to the receipt of a treatment (the CAREER award); as a result, outcome differences could be due to these pre-existing differences rather than to the treatment itself. Without appropriate controls for this selection bias, we could mistakenly attribute differences between CAREER awardees and non-awardees to the award, when in fact, the differences in outcomes might have resulted even in the absence of the award because of pre-treatment differences.

To reduce the risk of selection bias, we used propensity score analysis in two ways: first, we used PSA to construct a sample of CAREER awardees and an appropriate comparison group of non-awardees who were invited to complete the Principal Investigator (PI) survey; and second, to stratify similar awardees and non-awardees in the analysis sample (i.e., those who completed the PI survey) prior to estimating impact models. The goal of PSA is to select a comparison group that is indistinguishable from the treated group—except for award status (receipt or non-receipt)—on a set of observed pre-treatment characteristics. PSA uses these pre-treatment characteristics to determine the conditional probability (the propensity score) that an individual is in the treated group (CAREER awardee) or the untreated group (CAREER non-awardee). After assigning propensity scores to individuals, awardees and non-awardees can be

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1 In this context, “selection” refers not to selection for the study but rather to the process NSF uses to select recipients of the CAREER award. By default, those applicants who do not receive the CAREER award are “selected for” the non-awardee group.
placed into blocks such that awardees and non-awardees in each block have equal propensity to be in the treated group. That is, within propensity blocks, awardees and non-awardees are statistically indistinguishable. The advantage of the propensity score approach (over other approaches to reduce selection bias) is that it forces the researcher to explicitly test the extent to which the treatment and comparison group have overlapping characteristics related to award receipt, and to restrict analyses to subsets of data with sufficient overlap of groups. Below, we describe this method in more detail.

Propensity Score Analysis

As described above, we employed PSA to address the issue of selection bias in our study. Straight comparisons of awardees and non-awardees would potentially lead to biased estimates of the programs effect. Using PSA, outcomes for treatment cases are compared to outcomes for comparison group cases that have a similar probability of selection into treatment. Several methods of adjustment using propensity scores were considered, including matching, stratification, weighting, and regression adjustment. After careful consideration, we decided to use stratification as our method of adjustment. This strategy was chosen because it provides for the inclusion of the largest number of cases and does not impose a functional form (e.g., linear) on the relationship between propensity to be in the treated group (CAREER awardee) and treatment effect.

Propensity score analysis depends on having data on a set of pre-existing measured variables. For this study, such data came from two sources. First, NSF routinely collects information from recipients (Principal Investigators) of its funding. These data provided information on characteristics (e.g., gender, minority status, resources of the PI’s institution) that might affect both receiving or not receiving a CAREER award and the outcomes of interest (e.g., research productivity); this information was used in a first round of PSA to identify a sample of awardees and non-awardees who were invited to complete the PI survey. Second, those awardees and non-awardees who responded to the PI survey provided additional data on their educational, employment, and grant funding histories. This information was incorporated into a second round of PSA to further improve the accuracy of impact models used to estimate the effect of the CAREER award. Below, we describe the two different ways we used PSA – to construct a sample, and to group respondents into equal-propensity strata in preparation for impact analyses.

Sampling

After determining an appropriate sample size for the study (see Appendix B), we used PSA to predict, for each individual, a propensity or likelihood that an individual would be found in the treated (i.e., awardee) group using a set of observed characteristics other than award status. This propensity score is the estimated probability of CAREER award receipt conditional upon pre-treatment characteristics. The propensity score can be used to balance non-equivalent groups using matching, stratification, covariance adjustment, or weighting on the propensity score; here, we used the propensity score as a stratification variable. To assign propensity scores to awardees and non-awardees, we calculated a logistic regression model with independent variables derived from the existing NSF data and treatment assignment (dummy-coded as 0 or 1) as the dependent variable. Once propensity scores were assigned, we divided individuals into strata within which awardees and non-awardees had a statistically equivalent mean propensity score. Within each of these strata we then tested for significant differences between awardees and non-awardees on any variable. We continued adjusting the model until all such differences were removed. One non-

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2 Based on level p<0.01 t-tests.
3 We used the Intercooled STATA9 pscore process to obtain propensity score balance.
awardee could not be matched with any of the awardees in the resulting blocks and was dropped from the sampling frame. The resulting sampling frame consisted of 3,495 awardees and 3,228 non-awardees.

The observed characteristics used in the sampling PSA were derived from an NSF-maintained database on all individuals who had ever applied for NSF funding as of October 1, 2004. Variables of interest were those on which there might have been systematic differences between awardees and non-awardees, including demographic characteristics of PIs (gender, ethnicity), characteristics of PIs' institutions (Carnegie classification), and other relevant indicators such as prior receipt of NSF funding. Missing values were imputed using internet searches (e.g., to determine gender, year in which PI received Ph.D.), by assigning the mean of the non-missing observations' values for that variable, or by assigning a value of zero (for dichotomous variables). In general, we did not exclude variables from the logistic model merely because of lack of significance. All pretest variables were included regardless of whether they predicted award receipt. We accepted collinearity among the predictors because the model was not intended to predict anything outside the sample space. Definitions of the variables in the model, along with details of their construction, are found in Exhibit A.1.

The awardees and non-awardees were divided into nine strata based on their propensity scores. Research has indicated that at least five strata are generally sufficient for removing 90 percent or more of the bias due to the covariates.4 Exhibit A.2 displays the resulting model. Exhibit A.3 shows the distribution of awardees and non-awardees by propensity score strata.

In preparation for drawing the study sample, we collapsed these nine propensity strata into three (High, Medium, and Low propensity). These three strata were crossed with eight directorates (BIO, CSE, EHR, ENG, GEO, MPS, SBE, and OPP/OD) to form a total of 24 propensity x directorate strata. We then drew a sample of 1,400 awardees and 1,800 non-awardees across these 24 strata proportional to the size of the stratum relative to the sampling frame.5 For example, the number of CAREER awardees from the High-Propensity Engineering stratum was 13 percent of the total number of CAREER awardees in the sampling frame; thus, High-propensity Engineering awardees represented 13 percent of the total number of CAREER awardees in our sample. This sampling method produces a self-weighted design wherein all PIs have an equal probability of selection.

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5 Prior to sampling, the PIs were sorted by the effective date of their award, division managing their proposal, state of the institution associated with the proposal, institution type and Carnegie rating of the institution associated with the proposal. Systematic sampling after sorting by these variables increases the likelihood of having a wide distribution across these variables in the selected sample.
## Exhibit A.1

### Variables used in PSA Model 1 (Sampling Frame)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Scale</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Directorate</td>
<td>Categorical</td>
<td>NSF directorate from which PI received CAREER or Comparison Award</td>
</tr>
</tbody>
</table>
| **Gender**                            | Dichotomous| 1 = Male  
0 = Female  
Missing data were replaced with values based on examination of names; for gender-neutral names data were replaced based on examination of photographs from web-based searches (n = 123 cases, 111 of which were male) |
| **Member of underrepresented minority**| Dichotomous| 1 = PI is a member of a minority or ethnic group traditionally underrepresented in STEM fields: includes Hispanics and any non-white and non-Asian individual.  
0 = PI is white or Asian.  
Missing data were set to 0 (n = 203 non-awardees, 266 awardees) |
| **Academic degree**                   | Dichotomous| 1 = Ph.D.  
0 = other (M.D., MD/PhD)  
Most recent highest degree PI earned prior to receipt of CAREER or Comparison award.  
Missing values were replaced using web-based searches to locate individual CVs from which the most recently-earned post-secondary degree was confirmed (n=44) |
| Years between degree and award receipt | Continuous  | Number of years between date of most recent highest degree earned and date that PI received CAREER or Comparison award.  
Values of 1 were replaced with zero (n=10). Outliers were replaced with information obtained from web-based searches to determine the correct year that the PhD was obtained (n=2) |
| **Prior NSF award**                   | Dichotomous| 1 = PI had, prior to receipt of CAREER or Comparison award, been a PI on an earlier NSF award;  
0 = CAREER or Comparison award was first NSF award |
| **EPSCoR**                            | Dichotomous| 1 = the proposal for CAREER or Comparison award originate from an EPSCoR state. |
| Minority-serving institution           | Dichotomous| 1 = the proposal for CAREER or Comparison award originate from a minority-serving institution. |
| Carnegie ranking                      | Dichotomous| 1 = Doctoral-research university-Extensive;  
0 = other  
Carnegie ranking of institution from which the CAREER or Comparison award proposal originated. |
| Percent research expenditure-proposal | Dichotomous| 1 = 50 percent or above; 0 = less than 50 percent.  
Percent research expenditure of the institution from which the proposal originated in the year that the proposal was submitted (CAREER or Comparison award).  
Percent research expenditure was calculated as the ratio of total research expenditures to the sum of research and instructional expenditures. These data were derived from IPEDS for each institution in the year that the PI's proposal originated from that institution.  
Missing data (n = 113 awardees, n= 204 non-awardees) were set to 0. |
| **Mean rating of proposal**           | Categorical| Mean of ratings assigned to CAREER or Comparison proposal by reviewers.  
Ratings were converted into points: Excellent = 5, Very Good = 4, Good = 3,  
Fair = 2, Poor = 1.  
A sum of assigned ratings was divided by the number of ratings assigned to determine the mean, which was then rounded to 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, or 5. |

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6 Integrated Postsecondary Education Data System (IPEDS) is maintained by the Department of Education's National Center for Educational Statistics.
### Exhibit A.2

**Propensity Score Logistic Model (Sampling Frame)**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>Prob &gt;</th>
<th>z</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>0.0776</td>
<td>0.0382</td>
<td>0.042</td>
<td></td>
<td></td>
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<tr>
<td>Doctoral Degree</td>
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<td>0.7539</td>
<td>0.614</td>
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<tr>
<td>Years between Ph.D. and Award</td>
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<td>0.0654</td>
<td>0.600</td>
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<tr>
<td>Underrepresented minority</td>
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<td>0.0608</td>
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<td></td>
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<tr>
<td>Prior NSF award</td>
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<td>0.0367</td>
<td>0.000</td>
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<td>Mean rating score of proposal</td>
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<td>0.000</td>
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<td></td>
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<td>Institution in EPSCOR state</td>
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<td>0.0485</td>
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<tr>
<td>Institution percent research expenditure</td>
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<td></td>
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<tr>
<td>Institution is minority-serving</td>
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<td>0.1125</td>
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<td></td>
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<tr>
<td>Institution Carnegie rating</td>
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<td>0.000</td>
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<tr>
<td>CSE dummy</td>
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<td>0.000</td>
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<tr>
<td>EHR dummy</td>
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<tr>
<td>GEO dummy</td>
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<td>0.001</td>
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<tr>
<td>MPS dummy</td>
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<td>OPP_OID dummy</td>
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<td>0.000</td>
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<tr>
<td>SBE dummy</td>
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<td>ENG dummy</td>
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<tr>
<td>Gender x Institution is minority-serving</td>
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<tr>
<td>Underrepresented minority x GEO dummy</td>
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<td>Underrepresented minority x SBE dummy</td>
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<tr>
<td>constant</td>
<td>-2.3902</td>
<td>0.7698</td>
<td>0.002</td>
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</tr>
</tbody>
</table>

**Number of observations = 6,722**

**Pseudo R² = .0791**

**Log-likelihood = -4285.8183**

**LR chi² (21) = 736.35**

**Prob > chi² = 0.000**

**Notes**

In estimating the propensity score through a probability model, the choice of which interaction term to include is determined solely by the need to condition fully on the observable characteristics that make up the assignment mechanism. When covariates are not balanced within a particular stratum, the solution adopted is to divide the stratum into finer strata and test again for no difference in the distribution of covariates within the finer strata. If however, some covariates still remain unbalanced, the score may be poorly estimated which suggests that additional terms (interaction or higher-order terms) of the unbalanced covariates should be added to the logistic specification to control better for these characteristics. This procedure is repeated until the covariates are balanced. See Dehejia & Wahba (2002). Propensity score-matching methods for non-experimental casual studies. The Review of Economics and Statistics, 84(1): pg 161.
Exhibit A.3

Distribution of Nonawardees and Awardees in Sampling Frame by Propensity Score and Strata

<table>
<thead>
<tr>
<th>Propensity Strata</th>
<th>Propensity score</th>
<th>Nonawardees</th>
<th>Awardees</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>0.0 - 0.2</td>
<td>280</td>
<td>59</td>
</tr>
<tr>
<td></td>
<td>0.2 - 0.3</td>
<td>251</td>
<td>92</td>
</tr>
<tr>
<td></td>
<td>0.3 - 0.4</td>
<td>456</td>
<td>253</td>
</tr>
<tr>
<td>Medium</td>
<td>0.4 - 0.5</td>
<td>726</td>
<td>540</td>
</tr>
<tr>
<td></td>
<td>0.5 - 0.55</td>
<td>433</td>
<td>395</td>
</tr>
<tr>
<td></td>
<td>0.55 - 0.6</td>
<td>389</td>
<td>540</td>
</tr>
<tr>
<td>High</td>
<td>0.6 - 0.7</td>
<td>518</td>
<td>1,044</td>
</tr>
<tr>
<td></td>
<td>0.7 - 0.8</td>
<td>169</td>
<td>503</td>
</tr>
<tr>
<td></td>
<td>0.8 - 1.0</td>
<td>6</td>
<td>69</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>3,228</strong></td>
<td><strong>3,495</strong></td>
<td></td>
</tr>
</tbody>
</table>

Estimating impacts of the CAREER award

Before fitting impact regression models, we conducted a second propensity score analysis on awardee and non-awardee respondents to the PI survey. Because these individuals formed the analytic sample on which conclusions about the impact of the CAREER award would be based, we used this second PSA to further reduce the threat of selection bias. Using a modified set of variables from the NSF data and variables derived from the PI survey, we could predict with more accuracy the propensity to win a CAREER award (Exhibit A.4). The results of this second PSA were used in regression models to estimate the effects of winning a CAREER award on the outcomes of interest.

Variables included in this PSA again included those on which there might have been systematic differences between awardees and non-awardees; in this second round, data from the PI survey provided additional information on PIs’ graduate and postdoctoral training prior to applying for the CAREER award. Missing values were imputed using internet research, and/or by assigning the mean of the nonmissing observations’ values for that variable.7

---

7 Information about the percent research expenditure of non-U.S. institutions was not readily available. Consequently, for PIs who had obtained their doctoral degree from a non-U.S. university, a proxy measure was used, whereby we estimated each international institution’s percent research expenditure by multiplying the mean percent research expenditure of nonmissing U.S. institutions by the ratio of a given nation’s percent of GDP spent on research and development (R&D) to the U.S. percent GDP spent on R&D.
As in the PSA used to construct the sampling frame, we used a logistic regression model to assign propensity scores to awardees and non-awardees, and then divided individuals into strata such that significant differences between awardees and non-awardees on any variable were removed. One non-awardee could not be matched with any of the awardees in the resulting strata and was dropped from the analytic sample. The resulting analytic sample consisted of 1,138 awardees and 1,393 non-awardees.

The combined groups of comparison and treatment respondents were divided into seven strata based on their propensity scores. Exhibit A.5 displays the resulting model. Exhibit A.6 shows the distribution of awardees and non-awardees in the analytic sample by propensity score strata.

We included terms for these strata in our regression models to estimate treatment effects on outcomes within each stratum as shown in the following equations for Impact Model 1 or Impact Model 2.

**Impact Model 1 (Fitted if treatment effect does not vary across PSA blocks)**

\[
Y = \beta_0 + \beta_1(CareerDummy) + \sum_{i=1}^{6} \beta_{i+1}(PSA\text{Stratum}_i) + \sum_{j=1}^{n} \beta_{j+7}(Co\text{ variate}_j) + \epsilon
\]

In this model, \(Y\) is our outcome of interest. The error term, \(\epsilon\), is assumed to be conditionally independent and identically distributed normally with mean zero and variance \(\sigma^2\). *CareerDummy* is an indicator of whether a PI is in the awardee or Non-awardee group. *PSA\text{Stratum}_i* is an indicator that a PI is in the \(i^{th}\) stratum and *Covariate_j* is a covariate/control variable in our model. Each covariate was centered at the grand mean. The estimated parameters for this model are interpreted as follows:

\[
\hat{\beta}_0 = \text{Covariate-adjusted mean for non-awardee PIs in PSA stratum 7}
\]

\[
\hat{\beta}_0 + \hat{\beta}_1 = \text{Covariate-adjusted mean for non-awardee PIs in PSA stratum 1}
\]

\[
\hat{\beta}_0 + \hat{\beta}_2 = \text{Covariate-adjusted mean for non-awardee PIs in PSA stratum 2}
\]

\[
\hat{\beta}_0 + \hat{\beta}_3 = \text{Covariate-adjusted mean for non-awardee PIs in PSA stratum 3}
\]

\[
\hat{\beta}_0 + \hat{\beta}_4 = \text{Covariate-adjusted mean for non-awardee PIs in PSA stratum 4}
\]

\[
\hat{\beta}_0 + \hat{\beta}_5 = \text{Covariate-adjusted mean for non-awardee PIs in PSA stratum 5}
\]

\[
\hat{\beta}_0 + \hat{\beta}_7 = \text{Covariate-adjusted mean for non-awardee PIs in PSA stratum 6}
\]

The average overall treatment effect is estimated as follows:

\[\text{Estimated } impact = \hat{\beta}_1 = \text{the average difference between CAREER awardees and non-awardees across PSA blocks.}\]

The overall covariate-adjusted mean for non-awardee PIs is given by:

---

8. We used the Intercooled STATA9 pscore process to obtain propensity score balance.

9. The outcomes used for the impact analysis are described in Chapter 5.
\[
\bar{Y}_{\text{AdjComp}} = \\
(\frac{n_1}{N})(\hat{\beta}_0 + \hat{\beta}_2) + (\frac{n_2}{N})(\hat{\beta}_0 + \hat{\beta}_3) + (\frac{n_3}{N})(\hat{\beta}_0 + \hat{\beta}_4) + (\frac{n_4}{N})(\hat{\beta}_0 + \hat{\beta}_5) + (\frac{n_5}{N})(\hat{\beta}_0 + \hat{\beta}_6) + (\frac{n_6}{N})(\hat{\beta}_0 + \hat{\beta}_7)
\]
\[
= \hat{\beta}_0 + (\frac{n_1}{N})(\hat{\beta}_2) + (\frac{n_2}{N})(\hat{\beta}_3) + (\frac{n_3}{N})(\hat{\beta}_4) + (\frac{n_4}{N})(\hat{\beta}_5) + (\frac{n_5}{N})(\hat{\beta}_6) + (\frac{n_6}{N})(\hat{\beta}_7)
\]

The overall covariate-adjusted mean for awardee PIs is given by:

\[
\bar{Y}_{\text{AdjCareer}} = \bar{Y}_{\text{AdjComp}} + \text{Estimated _impact}
\]

To determine the statistical significance of the estimated impact, we must calculate the standard error of the estimated impact. The standard error of the overall treatment effect (i.e., the estimated impact) is given by:

\[
SE_{\text{Est._impact}} = \frac{\text{Estimated _impact}}{T - Value}
\]

for the estimated parameter \( \hat{\beta}_1 \). In practice, the actual computations for the standard error are based on the Student's t-statistic for the indicated linear combination of estimated parameters, which is provided by the SAS software. The significance test is based on the T-statistic for the estimated parameter \( \hat{\beta}_1 \).
### Exhibit A.4

**Definitions of variables used in PSA Model 2 (PI Survey Respondents)**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Scale</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Directorate_2</td>
<td>Categorical</td>
<td>NSF directorate from which PI received CAREER Award or to which PI submitted most recent CAREER application</td>
</tr>
<tr>
<td>Gender</td>
<td>Dichotomous</td>
<td>1 = Male 0 = Female</td>
</tr>
<tr>
<td>Member of underrepresented minority</td>
<td>Dichotomous</td>
<td>1 = PI is a member of a minority or ethnic group traditionally underrepresented in STEM fields: includes Hispanics and any non-white and non-Asian individual. 0 = PI is white or Asian.</td>
</tr>
<tr>
<td>Years between degree and award receipt</td>
<td>Continuous</td>
<td>Number of years elapsed between date most recent highest degree earned and date that PI received CAREER or Comparison award.</td>
</tr>
<tr>
<td>Prior NSF award_2</td>
<td>Dichotomous</td>
<td>1 = PI had, prior to receipt of CAREER award or last CAREER application, been a PI on an earlier NSF award.</td>
</tr>
<tr>
<td>EPSCOR_2</td>
<td>Dichotomous</td>
<td>1 = The most recent CAREER proposal originated from an EPSCoR state.</td>
</tr>
<tr>
<td>Minority-serving institution_2</td>
<td>Dichotomous</td>
<td>1 = The most recent CAREER proposal originated from a minority-serving institution.</td>
</tr>
<tr>
<td>Percent research expenditure-proposal_2</td>
<td>Continuous</td>
<td>Percent research expenditure of the institution from which the most recent CAREER proposal originated in the year that the proposal was submitted. Percent research expenditure was calculated as the ratio of total research expenditures to the sum of research and instructional expenditures. These data were derived from IPEDS for each institution in the year that the PI's proposal originated from that institution. Missing data: 43 PIs were from institutions not indexed within IPEDS (e.g., museums, research foundations). For these cases, data were imputed by assigning the mean Percent Research Expenditure of the PIs within the sample group (awardee or non-awardee) who had submitted CAREER proposals in the same year and for whom data were nonmissing. In 46 instances, IPEDS lacked data on the institution's research expenditures for the given year of the proposal; in these cases data on the institution's research expenditures from the previous year were used. For one institution, the research expenditure data for 1993-1994 was the only year available non-missing; for one other institution data on the year after the proposal year was used.</td>
</tr>
<tr>
<td>Mean rating of proposal_2</td>
<td>Categorical</td>
<td>Mean of ratings assigned to most recent CAREER proposal by reviewers. Ratings were converted into points: Excellent = 5, Very Good = 4, Good = 3, Fair = 2, Poor = 1. A sum of assigned ratings was divided by the number of ratings assigned to determine the mean, which was then rounded to 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, or 5.</td>
</tr>
<tr>
<td>Number of advanced degrees</td>
<td>Dichotomous</td>
<td>1 = 2 or more doctoral degrees; 0 = 1 doctoral degree</td>
</tr>
<tr>
<td>Graduate training support</td>
<td>3 dichotomous</td>
<td>Reported type of graduate support received: Three dummy variables were created. Dummyvar1: = 1 if PI received:  a graduate fellowship or traineeship from graduate institution that did not require work (other than on own research);  a nationally-recognized graduate fellowship or traineeship that could be used at any graduate institution; or  a dissertation or paper award recognizing own research Dummyvar2: = 1 if PI received a teaching award during graduate school Dummyvar3: = 1 if PI held a teaching assistantship during graduate school Number of postdoctoral fellowships</td>
</tr>
<tr>
<td>Nonacademic work</td>
<td>Dichotomous</td>
<td>1 = held one or more nonacademic positions prior to CAREER award or date of</td>
</tr>
</tbody>
</table>

**Abt Associates Inc.  Appendix A: Methodology  A-9**
### Exhibit A.4

**Definitions of variables used in PSA Model 2 (PI Survey Respondents)**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Scale</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>history</td>
<td>Last application</td>
<td></td>
</tr>
<tr>
<td>Number of CAREER submissions</td>
<td>Dichotomous</td>
<td></td>
</tr>
<tr>
<td>Percent research expenditure – Doctoral-</td>
<td>Continuous</td>
<td></td>
</tr>
<tr>
<td>granting institution</td>
<td></td>
<td>Percent research expenditure of institution where PI received most recent</td>
</tr>
<tr>
<td></td>
<td></td>
<td>doctoral degree.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Percent research expenditure was calculated as the ratio of total research</td>
</tr>
<tr>
<td></td>
<td></td>
<td>expenditures to the sum of research and instructional expenditures. These</td>
</tr>
<tr>
<td></td>
<td></td>
<td>data were derived from IPEDS for each institution in the year that the PI's</td>
</tr>
<tr>
<td></td>
<td></td>
<td>received the doctorate from that institution.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Missing data: For 507 cases, data on research expenditure for an institution,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>or for an institution in the year that the doctorate was earned, were not</td>
</tr>
<tr>
<td></td>
<td></td>
<td>available. For these cases, data were imputed as follows:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>In one case, the degree-granting institution was a joint program, so the mean</td>
</tr>
<tr>
<td></td>
<td></td>
<td>of the percent research expenditures for these two universities was used;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>In 80 cases, data on the institution's research expenditure for the year</td>
</tr>
<tr>
<td></td>
<td></td>
<td>immediately prior to the year the PhD was earned was used;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>In 263 cases, missing values were replaced by assigning the mean Percent</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Research Expenditure of the PIs within the sample group (awardee or non-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>awardee) that had earned their Ph.D.s in the same year;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Direct data on 243 foreign institutions was not available. For these</td>
</tr>
<tr>
<td></td>
<td></td>
<td>institutions we imputed data as follows:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1. Identify the country in which the institution was located;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Determine, for each country the percent of Gross Domestic Product (GDP)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>spent on Research &amp; Development (R&amp;D)(^a);</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Divide the result by the United States' percent of GDP spent on R&amp;D;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4. Multiply this ratio by the mean percent research expenditure of all</td>
</tr>
<tr>
<td></td>
<td></td>
<td>U.S. institutions in our respondent pool for which we had non-missing data.</td>
</tr>
</tbody>
</table>

As a result, all foreign institutions from a single country have the same percent research expenditure imputed.

**Sources:**

### Exhibit A.5

**Propensity Score Logistic Model (PI Survey Respondents)**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>Prob &gt;</th>
<th>z</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>0.0823</td>
<td>0.0667</td>
<td>0.287</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Years between Ph.D. and Award</td>
<td>0.0603</td>
<td>0.0728</td>
<td>0.408</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Underrepresented minority</td>
<td>0.2855</td>
<td>0.1204</td>
<td>0.015</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prior NSF award</td>
<td>0.6312</td>
<td>0.0683</td>
<td>0.000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean rating score of CAREER proposal</td>
<td>2.1381</td>
<td>0.1356</td>
<td>0.000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of CAREER proposals</td>
<td>0.5364</td>
<td>0.6548</td>
<td>0.413</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of postdoctoral positions</td>
<td>−0.0844</td>
<td>0.0485</td>
<td>0.082</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nonacademic employment history</td>
<td>0.3117</td>
<td>0.0824</td>
<td>0.000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of doctoral degrees</td>
<td>−2.0957</td>
<td>1.0174</td>
<td>0.399</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Graduate research assistantship</td>
<td>−0.0004</td>
<td>0.1498</td>
<td>0.998</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Graduate teaching award</td>
<td>−0.1217</td>
<td>0.1043</td>
<td>0.243</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Graduate teaching assistantship</td>
<td>−0.0260</td>
<td>0.0727</td>
<td>0.720</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ph.D. institution percent research expenditure</td>
<td>−0.0010</td>
<td>0.0026</td>
<td>0.689</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Institution in EPSCOR state</td>
<td>0.3032</td>
<td>0.0959</td>
<td>0.001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Institution percent research expenditure</td>
<td>0.0010</td>
<td>0.0021</td>
<td>0.623</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Institution is minority-serving</td>
<td>0.0767</td>
<td>0.2149</td>
<td>0.721</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BIO dummy</td>
<td>−0.1524</td>
<td>0.1942</td>
<td>0.433</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CSE dummy</td>
<td>0.9603</td>
<td>0.1760</td>
<td>0.000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EHR dummy</td>
<td>1.0430</td>
<td>0.3322</td>
<td>0.002</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GEO dummy</td>
<td>−0.0074</td>
<td>0.2035</td>
<td>0.632</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MPS dummy</td>
<td>−0.4064</td>
<td>0.1740</td>
<td>0.019</td>
<td></td>
<td></td>
</tr>
<tr>
<td>OPP. O/D dummy</td>
<td>0.8021</td>
<td>0.5064</td>
<td>0.113</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ENG dummy</td>
<td>0.1504</td>
<td>0.1698</td>
<td>0.375</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number doctoral degrees x SBE dummy</td>
<td>0.1489</td>
<td>1.1047</td>
<td>0.893</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number doctoral degrees x ENG dummy</td>
<td>1.0283</td>
<td>0.9238</td>
<td>0.265</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender x BIO dummy</td>
<td>0.1925</td>
<td>0.2027</td>
<td>0.342</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number doctoral degrees x Years between PhD and Award</td>
<td>0.2685</td>
<td>0.1341</td>
<td>0.045</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean rating score of CAREER proposal x Years between PhD and Award</td>
<td>−0.0290</td>
<td>0.0190</td>
<td>0.128</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean rating score of CAREER proposal x Number of CAREER proposals</td>
<td>−0.1947</td>
<td>0.1624</td>
<td>0.230</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Graduate research assistantship x Years between PhD and Award</td>
<td>0.0022</td>
<td>0.0222</td>
<td>0.923</td>
<td></td>
<td></td>
</tr>
<tr>
<td>constant</td>
<td>−6.0665</td>
<td>0.5576</td>
<td>0.000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Number of observations = 2,531  
LR chi² (30) = 1553.72  
Prob > chi² = 0.000  
Pseudo R² = .446  
Log-likelihood = −964.627

**Notes**

In estimating the propensity score through a probability model, the choice of which interaction term to include is determined solely by the need to condition fully on the observable characteristics that make up the assignment mechanism. When covariates are not balanced within a particular stratum, the solution adopted is to divide the stratum into finer strata and test again for no difference in the distribution of covariates within the finer strata. If, however, some covariates still remain unbalanced, the score may be poorly estimated which suggests that additional terms (interaction or higher-order terms) of the unbalanced covariates should be added to the logistic specification to control for better these characteristics. This procedure is repeated until the covariates are balanced. See Dehejia & Wahba (2002). Propensity score-matching methods for non-experimental causal studies. The Review of Economics and Statistics, 84(1): pg 161.
Exhibit A.6

Distribution of Nonawardees and Awardees in Analytic Sample by Propensity Score

<table>
<thead>
<tr>
<th>Propensity score</th>
<th>Nonawardees</th>
<th>Awardees</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 – 0.1</td>
<td>627</td>
<td>20</td>
</tr>
<tr>
<td>0.1 – 0.2</td>
<td>223</td>
<td>27</td>
</tr>
<tr>
<td>0.2 – 0.4</td>
<td>249</td>
<td>97</td>
</tr>
<tr>
<td>0.4 – 0.6</td>
<td>148</td>
<td>157</td>
</tr>
<tr>
<td>0.6 – 0.8</td>
<td>95</td>
<td>258</td>
</tr>
<tr>
<td>0.8 – 0.9</td>
<td>36</td>
<td>192</td>
</tr>
<tr>
<td>0.9 – 1.0</td>
<td>15</td>
<td>387</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1,393</strong></td>
<td><strong>1,138</strong></td>
</tr>
</tbody>
</table>

Impact Model 2 (Fitted if treatment effect varies across PSA blocks)

\[ Y = \beta_0 + \beta_1 (\text{CareerDummy}) + \sum_{i=1}^{s} \beta_{i,1} (\text{PSAStratum}_i) + \sum_{j=1}^{t} \beta_{j,1} (\text{CareerDummy} \times \text{PSAStratum}_j) + \sum_{k=1}^{u} \beta_{k,13} (\text{Covariate}_k) + \epsilon \]

In this model, \( Y \) is our outcome of interest. The error term, \( \epsilon \), is assumed to be conditionally independent and identically distributed normally with mean zero and variance \( \sigma^2 \). \text{CareerDummy} is an indicator of whether a PI is in the awardee or non-awardee group. \text{PSAStratum}_i \) is an indicator that a PI is in the \( i \)th stratum and \text{Covariate}_k \) is a covariate/control variable in our model. Each covariate was centered at the grand mean. The estimated parameters for this model are interpreted as follows:

\[ \hat{\beta}_0 = \text{Covariate-adjusted mean for non-awardee PIs in PSA stratum 7} \]
\[ \hat{\beta}_0 + \hat{\beta}_2 = \text{Covariate-adjusted mean for non-awardee PIs in PSA stratum 1} \]
\[ \hat{\beta}_0 + \hat{\beta}_3 = \text{Covariate-adjusted mean for non-awardee PIs in PSA stratum 2} \]
\[ \hat{\beta}_0 + \hat{\beta}_4 = \text{Covariate-adjusted mean for non-awardee PIs in PSA stratum 3} \]
\[ \hat{\beta}_0 + \hat{\beta}_5 = \text{Covariate-adjusted mean for non-awardee PIs in PSA stratum 4} \]
\[ \hat{\beta}_0 + \hat{\beta}_6 = \text{Covariate-adjusted mean for non-awardee PIs in PSA stratum 5} \]
\[ \hat{\beta}_0 + \hat{\beta}_7 = \text{Covariate-adjusted mean for non-awardee PIs in PSA stratum 6} \]

\[ \hat{\beta}_1 = \text{Treatment effect in PSA stratum 7 (difference between awardee and non-awardee PIs in PSA stratum 7)} \]
\[ \hat{\beta}_1 + \hat{\beta}_8 = \text{Treatment effect in PSA stratum 1 (difference between awardee and non-awardee PIs in PSA stratum 1)} \]
\( \hat{\beta}_1 + \hat{\beta}_9 = \text{Treatment effect in PSA stratum 2 (difference between awardee and non-awardee PIs in PSA stratum 2)} \)

\( \hat{\beta}_1 + \hat{\beta}_{10} = \text{Treatment effect in PSA stratum 3 (difference between awardee and non-awardee PIs in PSA stratum 3)} \)

\( \hat{\beta}_1 + \hat{\beta}_{11} = \text{Treatment effect in PSA stratum 4 (difference between awardee and non-awardee PIs in PSA stratum 4)} \)

\( \hat{\beta}_1 + \hat{\beta}_{12} = \text{Treatment effect in PSA stratum 5 (difference between awardee and non-awardee PIs in PSA stratum 5)} \)

\( \hat{\beta}_1 + \hat{\beta}_{13} = \text{Treatment effect in PSA stratum 6 (difference between awardee and non-awardee PIs in PSA stratum 6)} \)

\( \hat{\beta}_8 = \text{Difference between treatment effect in PSA stratum 1 and stratum 7 (difference between awardee and non-awardee differences in PSA stratum 1 and 7)} \)

\( \hat{\beta}_9 = \text{Difference between treatment effect in PSA stratum 2 and stratum 7 (difference between awardee and non-awardee differences in PSA stratum 2 and 7)} \)

\( \hat{\beta}_{10} = \text{Difference between treatment effect in PSA stratum 3 and stratum 7 (difference between awardee and non-awardee differences in PSA stratum 3 and 7)} \)

\( \hat{\beta}_{11} = \text{Difference between treatment effect in PSA stratum 4 and stratum 7 (difference between awardee and non-awardee differences in PSA stratum 4 and 7)} \)

\( \hat{\beta}_{12} = \text{Difference between treatment effect in PSA stratum 5 and stratum 7 (difference between awardee and non-awardee differences in PSA stratum 5 and 7)} \)

\( \hat{\beta}_{13} = \text{Difference between treatment effect in PSA stratum 6 and stratum 7 (difference between awardee and non-awardee differences in PSA stratum 6 and 7)} \)

The overall treatment effect was estimated by taking an average of the estimated treatment effects weighted by the number of treated observations within each stratum as shown below:

\[
\text{Estimated impact} = \frac{\hat{\beta}_1}{N}(\hat{\beta}_1 + \hat{\beta}_8) + \frac{\hat{\beta}_9}{N}(\hat{\beta}_1 + \hat{\beta}_9) + \frac{\hat{\beta}_1}{N}(\hat{\beta}_1 + \hat{\beta}_{10}) + \frac{\hat{\beta}_{10}}{N}(\hat{\beta}_1 + \hat{\beta}_{10}) + \frac{\hat{\beta}_1}{N}(\hat{\beta}_1 + \hat{\beta}_{11}) + \frac{\hat{\beta}_{11}}{N}(\hat{\beta}_1 + \hat{\beta}_{11}) + \frac{\hat{\beta}_1}{N}(\hat{\beta}_1 + \hat{\beta}_{12}) + \frac{\hat{\beta}_{12}}{N}(\hat{\beta}_1 + \hat{\beta}_{12}) + \frac{\hat{\beta}_1}{N}(\hat{\beta}_1 + \hat{\beta}_{13}) + \frac{\hat{\beta}_{13}}{N}(\hat{\beta}_1 + \hat{\beta}_{13})
\]

\[
\hat{\beta}_1 + \frac{\hat{\beta}_9}{N}(\hat{\beta}_9) + \frac{\hat{\beta}_8}{N}(\hat{\beta}_8) + \frac{\hat{\beta}_{10}}{N}(\hat{\beta}_{10}) + \frac{\hat{\beta}_{11}}{N}(\hat{\beta}_{11}) + \frac{\hat{\beta}_{12}}{N}(\hat{\beta}_{12}) + \frac{\hat{\beta}_{13}}{N}(\hat{\beta}_{13})
\]

where \( N \) is the total sample size and \( n_i \) is the number of PIs in stratum \( i \) (i = 1, 2, 3, 4, 5, 6, and 7)

The overall covariate-adjusted mean for non-awardee PIs is given by:
\[ \bar{y}_{\text{AdjComp}} = \]
\[ \left( \frac{n_0}{N} \right) (\hat{\beta}_0 + \hat{\beta}_2) + \left( \frac{n_2}{N} \right) (\hat{\beta}_0 + \hat{\beta}_1) + \left( \frac{n_4}{N} \right) (\hat{\beta}_0 + \hat{\beta}_2) + \left( \frac{n_0}{N} \right) (\hat{\beta}_0 + \hat{\beta}_4) + \left( \frac{n_1}{N} \right) (\hat{\beta}_0 + \hat{\beta}_1) + \frac{n_3}{N} \hat{\beta}_0 \]
\[ = \hat{\beta}_0 + \left( \frac{n_1}{N} \right) (\hat{\beta}_2) + \left( \frac{n_2}{N} \right) (\hat{\beta}_1) + \left( \frac{n_4}{N} \right) (\hat{\beta}_1) + \left( \frac{n_0}{N} \right) (\hat{\beta}_4) + \left( \frac{n_2}{N} \right) (\hat{\beta}_0) + \frac{n_3}{N} \hat{\beta}_0 \]

The overall covariate-adjusted mean for awardee PI's is given by:
\[ \bar{y}_{\text{AdjCareer}} = \bar{y}_{\text{AdjComp}} + \text{Estimated impact} \]

To determine the statistical significance of the estimated impact, we must calculate the standard error of the estimated impact. The standard error of the overall treatment effect (i.e., the estimated impact) is given by:
\[ SE_{\text{Estimated impact}} = \frac{\text{Estimated impact}}{T-value} \]

where the T-value is the test that the linear combination of estimated parameters is 0. In practice, the actual computations for the standard error are based on the Student’s t-statistic for the indicated linear combination of estimated parameters, which is provided by the SAS software. The significance test is based on the T-statistic for the linear combination of estimated parameters.

We expect that the use of PSA reduced the selection bias associated with the use of the comparison group, because it makes full use of the measured variables to distinguish between awardees and non-awardees. The NSF data and PI survey have produced a rich set of variables about respondents’ backgrounds, research training, and available institutional-level resources that allowed for the development of a robust predictor of award receipt. In addition, we measured the goodness-of-fit of the model by examining the correlation between predicted and actual probabilities. Nonetheless, it is important to note that if any unmeasured variables significantly affect both the likelihood of award receipt and outcomes of interest, then PSA does not protect against selection bias from that source.
Appendix B: Sample Size, Power, and Minimum Detectable Effect Sizes

A primary goal of this study was to compare CAREER awardees and non-awardees to determine if these two groups differed on a set of outcomes. Because available resources rarely allow inclusion of entire populations of interest, representative samples of individuals from the populations are selected. When selecting a sample from a population, a statistical power analysis is used to determine an acceptable sample size. The power analysis indicates the likelihood that a given sample size will be sufficient to detect a difference of a particular size between the two groups. The components of a power analysis include:

- Statistical power: the likelihood that the study will detect a difference between the two samples assuming such a difference exists in the underlying populations;
- Minimum detectable effect size (MDE): a standardized measure of the size of the difference between two groups that the study will be able to detect;
- The alpha-level: the probability that a difference detected between the two samples is a chance finding and does not represent a real difference between the two populations; and
- The sample size: the number of units that will be selected to represent the underlying population.

Typically, a sample size is chosen that will allow sufficient power to detect a meaningful effect size, with a small (e.g., 0.05) alpha-level. The following describes the power analysis conducted for the current study. Note that the actual response rates achieved were higher than those on which the power analysis was based (84 percent for the awardee group versus an estimated 77 percent response rate for the power analysis; 80 percent actual response rate for the non-awardee group versus an estimated 60 percent response rate assumed for the power analysis). As a result, the study was powered to detect even smaller differences than those shown here.

Awardee Sampling Frame

The awardee sample frame was composed of principal investigators (PIs) who had received a CAREER Award between the start of the program and prior to October 1, 2004. Only awardees with at least one non-awardee match were retained in the sampling frame. This match was determined using propensity score methods that matched each awardee with at least one non-awardee on a set of covariates. These covariates are defined in Appendix A.

Non-awardee Sampling Frame

The non-awardee sample frame was composed of PIs who had applied for and not received CAREER funding as of October 1, 2004, but who had received other NSF funding as Principal Investigator on another NSF grant\(^1\) either before applying to the CAREER program, or within 5 years after their first submission to the CAREER program. Only non-awardees with at least one awardee match were retained in the sampling frame. This match was determined using propensity score methods that matched each non-awardee with at least one awardee on a set of covariates. These covariates are defined in Appendix A.

\(^{1}\) Excludes postdoctoral awards, travel grants, workshop or conference support.
Sampling Method

A stratified systematic sample of PIs from each of the 8 strata (NSF directorates) was selected. Prior to sampling, the PIs were sorted by the institution type and the effective date of the award. Systematic sampling after sorting by these variables increases the likelihood of having a wide distribution of institution type and effective date in the selected sample. The number of PIs sampled from each stratum was proportional to the population number of PIs within each stratum (that is, within each directorate). This sampling method produces a self-weighted design wherein all units have equal probability of selection.

MDEs for comparing two sample means were calculated based on the two-sample test of means shown below.

Two-Sample Test of Means

Let \( \mu_1 \) denote the population mean in the awardee group and let \( \mu_2 \) denote the population mean in the non-awardee group.

\[
H_0 : \mu_1 - \mu_2 = 0 \quad \text{vs.} \quad H_A : \mu_1 - \mu_2 \neq 0
\]

Let \( \bar{\mu}_1 \) denote the estimated mean in the awardee group and let \( \bar{\mu}_2 \) denote the estimated mean in the non-awardee group. Let \( n_1 \) and \( n_2 \) be the sample sizes of the awardee and non-awardee groups respectively and \( \sigma_1^2 \) and \( \sigma_2^2 \) be the sample variances of the awardee and non-awardee groups respectively.

Then \( \bar{\mu}_1 - \bar{\mu}_2 \) can be used as an estimator for \( \mu_1 - \mu_2 \):

\[
\bar{\mu}_1 - \bar{\mu}_2 \sim \mathcal{N}(\mu_1 - \mu_2, \frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2})
\]

The formula that relates effect size, power and sample size is

\[
|\mu_1 - \mu_2| = Z_{\alpha/2} \sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}} + Z_{\beta} \sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}
\]

is the variance under the alternative hypothesis.

If we assume that \( n_1 = n_2 = \frac{n}{2} \) then

\[
|\mu_1 - \mu_2| = (Z_{\alpha/2} + Z_{\beta}) \sqrt{\frac{2(\sigma_1^2 + \sigma_2^2)}{n}}
\]
\[ n = \frac{2(\sigma_1^2 + \sigma_2^2)(Z_{\alpha/2} + Z_\beta)}{(|H_1 - H_2|^2)} \]

hence

Abt Associates’ earlier evaluation of the CARER program achieved 77 percent response rate for awardees. For non-awardees, we estimated a 60 percent response rate. Exhibit B.1 illustrates how different sample sizes affect the MDEs at different levels of power, assuming response rates of 77 percent for awardees and 60 percent for non-awardees.

**Exhibit B.1**

**Minimum detectable effect sizes (MDEs) associated with variations in power, alpha and sample sizes**

<table>
<thead>
<tr>
<th>Alpha</th>
<th>Power</th>
<th>MDE</th>
<th>Size of Analysis sample</th>
<th>Sample size needed*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Awardee N</td>
<td>Non-awardee N</td>
</tr>
<tr>
<td>.05</td>
<td>.80</td>
<td>.1</td>
<td>1570</td>
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</tr>
<tr>
<td>.05</td>
<td>.80</td>
<td>.2</td>
<td>393</td>
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<tr>
<td>.05</td>
<td>.80</td>
<td>.3</td>
<td>175</td>
<td>175</td>
</tr>
<tr>
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<td>.1</td>
<td>1796</td>
<td>1796</td>
</tr>
<tr>
<td>.05</td>
<td>.85</td>
<td>.2</td>
<td>449</td>
<td>449</td>
</tr>
<tr>
<td>.05</td>
<td>.85</td>
<td>.3</td>
<td>200</td>
<td>200</td>
</tr>
</tbody>
</table>

Exhibit reads: Assuming response rates of 77 percent for awardees and 60 percent for non-awardees a sample of 2,039 awardees and 2,617 non-awardees would yield an analysis sample of 1,570 awardees and 1,570 non-awardees. With this analytic sample size, the study would have 80 percent power to detect a minimum standardized effect size of .1.

Notes

a The sample size needed to yield the analysis sample size shown in the same row is based on assumed response rates of 77 percent for awardees and 60 percent for non-awardees.

The study was budgeted to invite approximately 1400 awardees and 1800 non-awardees to participate in the study. An awardee sample of 1,400 would yield an awardee analysis sample size of 1,078 (i.e., .77 * 1,400 = 1,078). A non-awardee sample of 1,800 would yield a non-awardee analysis sample size of 1,080 (0.60*1,800 =1,080). With these analysis sample sizes, the minimum detectable standardized effect size we expected to detect with 80 percent power and an alpha-level of .05 was 0.12. Because actual response rates exceeded our estimates, the study was powered to detect MDEs even smaller than .12.

The minimum detectable difference between two sample proportions was calculated based on the two-sample test of proportions shown below.

**Two-Sample Test of Proportions**

Let \( \pi_1 \) denote the population proportion of “success” on a particular outcome in the awardee group (e.g., the proportion of awardees who published a paper with an undergraduate) and let \( \pi_2 \) denote the population proportion of “success” in the non-awardee group.
\(H_0 : \pi_1 - \pi_2 = 0\) vs. \(H_\alpha : \pi_1 - \pi_2 \neq 0\)

Let \(P_1\) denote the estimated proportion of “success” in the awardee group and let \(P_2\) denote the estimated proportion of “success” in the non-awardee group. Let \(n_1\) and \(n_2\) be the sizes of the analysis samples of the awardee and non-awardee groups respectively, and let \(\frac{\pi_1(1-\pi_1)}{n_1}\) and \(\frac{\pi_2(1-\pi_2)}{n_2}\) be the sample variances of the awardee and non-awardee groups respectively.

Then \(P_1 - P_2\) can be used as an estimator for \(\pi_1 - \pi_2\);

\[
P_1 - P_2 \sim N\left(\pi_1 - \pi_2, \frac{\pi_1(1-\pi_1)}{n_1} + \frac{\pi_2(1-\pi_2)}{n_2}\right)
\]

The formula that relates effect size, power and sample size is

\[
|\pi_1 - \pi_2| = Z_{\alpha/2} \sqrt{\sigma_0^2 + \sigma_\alpha^2} \quad \text{where} \quad \sigma_0^2 \quad \text{is the variance under the null hypothesis and} \quad \sigma_\alpha^2 \quad \text{is the variance under the alternative hypothesis.}
\]

Assume that \(n_1 = n_2 = \frac{n}{2}\)

Under \(H_0\), \(\pi_1 = \pi_2 = \pi\) (common null, which by convention is set to \(\frac{\pi_1 + \pi_2}{2}\) hence \(\sigma_0^2 = \frac{4\pi(1-\pi)}{n}\) and \(\sigma_\alpha^2\) is \(\frac{2\pi_1(1-\pi_1) + 2\pi_2(1-\pi_2)}{n}\)

So \(|\pi_1 - \pi_2| = Z_{\alpha/2} \sqrt{\frac{4\pi(1-\pi)}{n} + \sigma_\alpha^2} \sqrt{\frac{2\pi_1(1-\pi_1) + 2\pi_2(1-\pi_2)}{n}}\)

hence \(n = \left[\frac{Z_{\alpha/2}^2 \sqrt{\pi(1-\pi)} + \sqrt{2\pi_1(1-\pi_1) + 2\pi_2(1-\pi_2)}}{|\pi_1 - \pi_2|}\right]^2\)

The study was budgeted to invite approximately 1400 awardees and 1800 non-awardees to participate in the study. Abt Associates’ earlier evaluation of the CAREER program achieved 77 percent response rate for awardees. For non-awardees, we estimated a 60 percent response rate. An awardee sample of 1,400 would yield an awardee analysis sample size of 1,078 (i.e., 0.77 * 1,400 = 1,078). A non-awardee sample of 1,800 would yield a non-awardee analysis sample size of 1,080 (0.60 * 1,800 = 1,080). With these analysis sample sizes, the minimum detectable difference in proportions we expected to detect with 80 percent power and an alpha-level of .05 is six percentage points. Because
actual response rates exceeded our estimates, the study was powered to detect minimum detectable differences in proportions even smaller than six percentage points.

**Bibliometric subsample**

To insure that all PIs whose publication and citation records examined would have had sufficient opportunity to publish and to have those publications indexed in the relevant citation indexes, we limited the population of PIs from which we drew the bibliometric sample to those who: were among the sample drawn for the PI survey; and had last applied for CAREER in 1995, 1996, 1997, 1998 and/or 1999.

As a result, the bibliometric sample was drawn from a target population of 589 awardees and 730 non-awardees. We expected to draw a sample of 300 awardees and 300 non-awardees. Because the anticipated subsample size constituted a large proportion of the target population (i.e., 300 awardees represented 50 percent of the awardees meeting both criteria), a finite population correction factor was required for the power analysis. To determine the MDE associated with this subsample size, we applied the following correction to the sample sizes and associated MDEs derived above in Exhibit B.1:

\[
  n'_{\text{Awardee}} = \frac{n_{\text{Awardee}}}{1 + \frac{n_{\text{Awardee}}}{N_{\text{Awardee}}}}
\]

where

- \( n'_{\text{Awardee}} \) = the corrected sample size of awardees needed;
- \( n_{\text{Awardee}} \) = the analytic sample size of awardees in Exhibit B.1; and
- \( N_{\text{Awardee}} \) = the size of our target population of awardees.

A corresponding formula is used to calculate \( n'_{\text{Nonawardee}} \) = the corrected sample size of non-awardees needed for the bibliometric analysis.

Exhibit B.2 shows the corrected sample sizes required to detect associated MDEs for different subsample sizes for the bibliometric analysis.

Budgetary constraints limited the bibliometric subsample to 300 awardees and 300 non-awardees. From an examination of Exhibit B.2, a sample size of 300 awardees and 300 non-awardees can be expected to yield bibliometric analyses with 80 percent power to detect MDE of approximately .2 standardized effect sizes at an alpha level of .05. Our ultimate response rates for the bibliometric analyses (\( n = 223 \) awardees; \( n = 219 \) non-awardees). As a result the analyses had 80 percent power to detect MDEs between .2 and .3.
### Exhibit B.2

Corrected sample sizes needed for minimum detectable effect sizes (MDEs) associated with variations in power, alpha based on underlying target population for bibliometric analyses

<table>
<thead>
<tr>
<th>Alpha</th>
<th>Power</th>
<th>MDE</th>
<th>Population Ns (from Exhibit B.1)</th>
<th>Original sample sizes</th>
<th>Corrected sample sizes&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
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<td>.05</td>
<td>.80</td>
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<td>589 730</td>
<td>393 393</td>
<td>236 255</td>
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<td>3</td>
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<td>175 175</td>
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</tr>
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<td>.85</td>
<td>2</td>
<td>589 730</td>
<td>449 449</td>
<td>255 278</td>
</tr>
<tr>
<td>.05</td>
<td>.85</td>
<td>3</td>
<td>589 730</td>
<td>200 200</td>
<td>149 157</td>
</tr>
</tbody>
</table>

Exhibit reads: For the bibliometric analyses, the corrected number of awardees needed to detect an MDE of .2 with 80 percent power at an alpha level of .05 is 236; the number of non-awardees is 255.

Notes

<sup>a</sup> The corrected sample size is based on the finite population correction factor shown in the text.
Appendix C: Bibliometric Data

Abt Associates provided the names and institutional affiliations of 600 PIs to ipIQ, subcontractor responsible for the collecting and compiling bibliometric data. Using PI names, ipIQ requested information on all papers published in any of the peer-reviewed journals included in Thomson Scientific's Science Citation Index and Social Science Citation Index. To ensure that publications by a particular PI were not missed, variants of each PI's name were used in the search process. For example, if a PI's name was “Douglas M. Creighton,” then variants such as “DM Creighton,” and “DCreighton” were included as search terms. The resulting dataset from Thomson included 186,125 papers published between 1981 and 2006. Only those papers published between 1990 and 2006 were retained.

For the retained papers, ipIQ conducted an additional round of manual accuracy checks to ensure that the PI listed on each candidate paper was, in fact, the same individual as the PI included in the study subsample. These additional checks were especially useful for individuals with common last names (e.g., Smith, Miller, etc.). For example, extensive internet research was used to examine the institutional affiliations of PI in the subsample and that of the author of the candidate paper.

To identify patents held by one of the 600 PIs, ipIQ searched the USPTO and EPO records. Searches were limited to U.S. patents only, issued between 1990 and 2006. Furthermore, the address of the inventor whose name matched one of the 600 PIs had to be a U.S. address. This last criteria was used to eliminate the potentially high number of false positive identifications of an inventor whose last name matched that of one of the 600 PIs but who was actually a different individual, a particularly common occurrence for those with last names of Asian origin.

ipIQ returned an Access database to Abt with the corresponding paper and patent information on each of the 600 PIs.
## Size and Durations Requirements by Solicitation

<table>
<thead>
<tr>
<th>Deadline(s)</th>
<th>Solicitation #</th>
<th>FAQ #</th>
<th>Award Size</th>
<th>Min. Award Size</th>
<th>Directorate Specific Award Sizes &amp; Supplement Info.</th>
<th>Award Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deadlines are 7/18-20/06 (depending on Directorate or Office)</td>
<td>NSF 05-579</td>
<td>NSF05-027</td>
<td>$400K</td>
<td>none</td>
<td>BIO - $500K min. (approx. $100K/year)</td>
<td>5 years (set)</td>
</tr>
<tr>
<td>Deadlines are 7/19-22/05 (depending on Directorate or Office)</td>
<td>NSF 05-579</td>
<td>NSF05-027</td>
<td>$400K</td>
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<td>BIO - $500K min. (approx. $100K/year)</td>
<td>5 years (set)</td>
</tr>
<tr>
<td>Deadlines are 7/20-22/04 (depending on Directorate or Office)</td>
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<td>NSF 03-031</td>
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<td>BIO - $500K min. (approx. $100K/year)</td>
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<td>Deadlines are 7/22-24/03 (depending on Directorate or Office)</td>
<td>NSF 02-111</td>
<td>NSF 03-031</td>
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<td>none</td>
<td>BIO - $500K min. (approx. $100K/year)</td>
<td>5 years (set)</td>
</tr>
<tr>
<td>Deadlines are 7/23-25/02 (depending on Directorate or Office)</td>
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<td>NSF 02-113</td>
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<td>BIO - $500K min. (approx. $100K/year)</td>
<td>5 years (set)</td>
</tr>
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<td>NSF 01-97</td>
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<td>none</td>
<td>BIO - $500K minimum (approx. $100K/year); ENG std. $375K ($75K/year)</td>
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</tr>
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<td>Deadlines are 07/-25-27/2000 (depending on Directorate or Office)</td>
<td>NSF 00-89</td>
<td>NSF 00-90</td>
<td>$250K</td>
<td>None</td>
<td>ENG: std. $375K ($75K/yr) 5 years (set)</td>
<td>5 years (set)</td>
</tr>
<tr>
<td>One NSF-wide deadline: 07/22/1999</td>
<td>07/22/1999</td>
<td>faq99-110</td>
<td>$200K</td>
<td>$500K</td>
<td>ENG: std. $200K ($50K/year for 4 yrs) plus one-time equipment supplement of up to $10K if matched by univ. All awards have optional industrial matching supplement, up to 25K/year</td>
<td>4 or 5 years</td>
</tr>
<tr>
<td>One NSF-wide deadline: 07/22/1998</td>
<td>NSF 98-103</td>
<td>faq98103</td>
<td>$200K</td>
<td>$500K</td>
<td>ENG: std. $200K ($50K/year for 4 yrs) plus one-time equipment supplement of up to $10K if matched by univ. All awards have optional industrial matching supplement, up to 25K/year</td>
<td>4 or 5 years</td>
</tr>
<tr>
<td>One NSF-wide deadline: 07/22/1997</td>
<td>NSF 97-87</td>
<td>faq97-87</td>
<td>$200K</td>
<td>$500K</td>
<td>ENG: std. $200K ($50K/year for 4 yrs) plus one-time equipment supplement of up to $10K if matched by univ. All awards have optional industrial matching supplement, up to 25K/year</td>
<td>4 or 5 years</td>
</tr>
</tbody>
</table>
### Size and Durations Requirements by Solicitation

<table>
<thead>
<tr>
<th>Deadline(s)</th>
<th>Solicitation #</th>
<th>FAQ #</th>
<th>Award Size</th>
<th>Min. Award Size</th>
<th>Directorate Specific Award Sizes &amp; Supplement Info.</th>
<th>Award Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>One NSF-wide deadline: 10/17/1996</td>
<td>NSF 95-115</td>
<td>faq95-115</td>
<td>$200K</td>
<td>$500K</td>
<td>ENG: std. $200K ($50K/year for 4 yrs) plus one-time equipment supplement of up to $10K if matched by univ. All awards have optional industrial matching supplement, up to 25K/year</td>
<td>4 or 5 years</td>
</tr>
<tr>
<td>Two deadlines: 10/17/95; CISE, EHR, ENG, MPS 12/15/95; BIO, GEO, OPP and SBE</td>
<td>NSF 95-118</td>
<td>none</td>
<td>$200K min. for 4 yrs. and $250K min for 5 yrs including a 20% admin. allowance in lieu of indirect costs. Funding level will be consistent with the scope of the project and NSF directorate and disciplinary practices.</td>
<td>none</td>
<td>ENG: std. $200K ($50K/year for 4 yrs) plus one-time equipment supplement of up to $10K if matched by univ. All awards have optional industrial matching supplement, up to 25K/year</td>
<td>4 or 5 years</td>
</tr>
<tr>
<td>ENG, CISE, EHR, &amp; MPS deadline: 10/17/94; all other deadlines (or target dates) vary by Directorate or Office</td>
<td>NSF 94-101 and supplemental Brochures (84-135 A-G)</td>
<td>None</td>
<td>No minimum. Funding level will be consistent with the scope of the project and NSF directorate and disciplinary practices. 10% administrative allowance in lieu of indirect costs</td>
<td>None</td>
<td>BIO, EHR, GEO, and OPP same as NSF (3-5 years w/ no minimum or maximum award size); ENG: std. $200K ($50K/yr for 4 years) with optional $10K one-time equip. supplement; SBE: $30K-$110K/yr; CISE up to $45K/year for 3 years; MPS: $25K to $100K/year for 3-5 years; All awards have optional industrial matching supplement, up to $25K/year</td>
<td>3 to 5 years</td>
</tr>
</tbody>
</table>
Eligibility Criteria by Solicitation

Fiscal Years 2006, 2007, and 2008 (NSF 05-579)

Proposers for the FY 2006-2008 competitions must meet all of the following eligibility requirements:

- By the Directorate's July deadline for submission of CAREER proposals:
  - Hold a doctoral degree in a field of science or engineering supported by NSF;
  - Be untenured;
  - Have not previously received an NSF PECASE or CAREER award (prior or concurrent Federal support for other types of awards or for non-duplicative research does not preclude eligibility);

  **AND**

- By October 1st following the July deadline for submission of CAREER proposals:
  - Be employed in a tenure-track position (or tenure-track-equivalent position) as an assistant professor (or equivalent title) at an institution in the U.S., its territories, or possessions, or the Commonwealth of Puerto Rico, that awards degrees in a field supported by NSF;

  **OR**

  - Be employed in a tenure-track position (or tenure-track-equivalent position) as an assistant professor (or equivalent title) at an organization in the U.S., its territories, or possessions, or the Commonwealth of Puerto Rico, that is a non-profit, non-degree-granting organization such as a museum, observatory, or research lab.

* Proposers may submit only one CAREER proposal per annual competition, and may not participate in more than three CAREER competitions. Proposals that are not reviewed (i.e., are withdrawn or are returned without review) do not count toward the three-competition limit.

Note: For a position to be considered a tenure-track-equivalent position, it must meet all of the following requirements:

1. the employing department or organization does not offer tenure;
2. the employee is engaged in research in an area of science or engineering supported by NSF;
3. the appointment is a continuing appointment;
4. the appointment has substantial educational responsibilities; and
5. the proposed project relates to the employee's career goals and job responsibilities as well as to the goals of the department/organization.

NO EXEMPTIONS FROM THESE ELIGIBILITY CRITERIA WILL BE GRANTED.
FY 2005, FY2004 and FY2003 (NSF 02-111):
Applicants must meet all of the following requirements:

By the appropriate Directorate’s July submission deadline:
- hold doctoral degree in field of science or engineering supported by NSF
- be untenured
- have not previously received an NSF PECASE or CAREER award
- have not competed more than 2 times previously in the NSF CAREER Program

By October 1st following the July deadline:
- be employed in a tenure-track (or tenure-track-equivalent position) as an Asst. Prof. (or equivalent title) at an institution in the U.S., its territories, or possessions, or the Commonwealth of Puerto Rico, that awards degrees in a field supported by NSF or at a non-profit, non-degree-granting organization in the U.S., its territories or possessions or the Commonwealth of Puerto Rico

Or

- be employed in a tenure-track (or tenure-track-equivalent position) as an Assistant Prof. (or equivalent title) at an organization in the U.S., its territories, or possessions, or the Commonwealth of Puerto Rico, that is a non-profit, non-degree-granting organization such as a museum, observatory, or research lab

NO exemptions to eligibility requirements

FY2002 (NSF 01-84):

Unless granted an exemption (see below) applicants must meet all of the following requirements:

By July 23, 2001:
- be untenured

As of October 1, 2001:
- have received first doctorate within the last 8 years (after 10/1/1993)
- be employed in a tenure-track position at an institution in the U.S., its territories or possessions, or the Commonwealth of Puerto Rico, that awards degrees in a field supported by NSF, or in a tenure-track-equivalent position
- have entered their first tenure-track or equivalent position within the last 4 years (after October 1, 1997.) (Those who started their first tenure-track or equivalent appointment prior to receiving their first doctoral degree should substitute their degree date for the tenure-track appointment date.)
- have not previously received an NSF PECASE or CAREER award

These individuals are eligible to apply only if an NSF CAREER Directorate contact approves tenure-track equivalency in advance:

- individuals in continuing faculty appointments having substantial educational responsibilities at institutions or departments that do not offer tenure
- individuals who are engaged in significant education and research activities at non-profit, non-degree-granting institutions such as museums, observatories, and research labs. The educational component of the proposal must be integrally related to education dimensions of the PI's appointment

Abt Associates Inc. Appendix D: History of the CAREER Solicitation D-5
### FY2002 (NSF 01-84):

These are the only exceptions to the eligibility criteria above. Individuals in these categories can only apply if an NSF CAREER Directorate contact approves an exemption request before a proposal is submitted:

- non-tenured faculty members who entered their first tenure-track or equivalent position before October 1, 1997 or who received their first earned doctorate before October 1, 1993 but who have interrupted their careers for military service, family leave, or serious health problems. After deducting the duration of the career interruption(s), the time since receiving the doctorate must be no more than 8 years and the period of active work in tenure-track or equivalent positions must be no more than 4 years.

### FY2001 (NSF 00-89):

Applicants must meet all of the following criteria:

**By July 24, 2000:**
- be untenured

**As of October 1, 2000:**
- be employed in a tenure-track position at an institution in the U.S., its territories or possessions, or the Commonwealth of Puerto Rico, that awards baccalaureate or advanced degrees in a field supported by NSF

and

- have entered their first tenure-track (or tenure-track equivalent) academic position within the last 4 years (after October 1, 1996) - have earned their first doctorate within the last 8 years (after October 1, 1993)

**Other:**
- have not previously received an NSF PECASE or CAREER award

The following are the only exceptions to the eligibility criteria above. Individuals in these categories may also be eligible to apply if an NSF CAREER Directorate contact approves an exemption request before a proposal is submitted:

- individuals in "tenure-track-equivalent" positions whose appointments are continuing faculty appointments having substantial educational responsibilities at institutions or departments that do not offer tenure
- non-tenured faculty who entered their first full-time tenure-track appointment before October 1, 1996 or who received their first earned doctorate degree before October 1, 1992, but who have interrupted their careers for family leave or serious health problems.
### FY2000 (NSF 99-110)

To be eligible for a CAREER award, applicants must meet all of the following requirements:

- be employed at an institution in the U.S., its territories or possessions, or the Commonwealth of Puerto Rico, that awards a baccalaureate or advanced degree in a field supported by NSF
- be in their first or second full-time tenure-track academic appointment and have begun the first tenure-track or tenure-track-equivalent appointment (at any institution) on or after July 1, 1995 and before July 22, 1999
- not be tenured or have held tenure on or before July 22, 1999
- not be a current or former recipient of an NSF PECASE, Presidential or NSF Young Investigator, Presidential Faculty Fellow, or NSF CAREER award.

The following are exceptions to the eligibility criteria listed above. Individuals in the following categories may also be eligible to apply if they obtain a written approval for exemption from the appropriate CAREER contact person prior to submitting the proposal:

- individuals in "tenure-track-equivalent" positions whose appointments are continuing faculty appointments having substantial educational responsibilities at institutions or departments that do not offer tenure
- individuals who are engaged in significant education and research activities at two-year colleges or non-profit or non-academic institutions such as museums, observatories, and research laboratories
- non-tenured faculty whose initial full-time tenure-track appointment preceded July 1, 1995, and who have interrupted their careers for substantive reasons such as family leave or serious health problems

### FY1999 (NSF 98-103)

To be eligible for a CAREER award, applicants must meet all of the following requirements:

- be employed at an institution in the U.S., its territories or possessions, or the Commonwealth of Puerto Rico, that awards a baccalaureate or advanced degree in a field supported by NSF
- be in their first or second full-time tenure-track academic appointment and have begun the first tenure-track or tenure-track-equivalent appointment (at any institution) on or after July 1, 1994 and before July 22, 1998
- not be tenured or have held tenure on or before July 22, 1998 and
- not be a current or former recipient of an NSF PECASE, Presidential or NSF Young Investigator, Presidential Faculty Fellow, or CAREER award

The following are exceptions to the eligibility criteria listed above. Individuals in the following categories may also be eligible to apply if they obtain a written approval for exemption from the appropriate NSF Program director in advance:

- individuals in "tenure-track-equivalent" positions whose appointments are continuing faculty appointments having substantial educational responsibilities at institutions or departments that do not offer tenure
- individuals who are engaged in significant education and research activities at two-year colleges or non-profit or non-academic institutions such as museums, observatories, and research laboratories
- non-tenured faculty whose initial full-time tenure-track appointment preceded July 1, 1994, and who have interrupted their careers for substantive reasons such as family leave or serious health problems.
FY1998 (NSF 97-87):

To be eligible for a CAREER award, applicants must meet all of the following requirements, except as noted below:
- be employed at an institution in the U.S., its territories or possessions, or the Commonwealth of Puerto Rico, which awards a baccalaureate or advanced degree in a field supported by NSF
- be in their first or second full-time tenure-track or equivalent academic appointment at any institution and have begun the first appointment on or after July 1, 1993 and before July 22, 1997
- not hold or have held tenure on or before July 22, 1997
- not be a current or former recipient of a Presidential or NSF Young Investigator, Presidential Faculty Fellow, PECASE, or CAREER award.

Individuals in the following categories may also be eligible to apply, but must obtain written approval for exemption from the cognizant NSF Program Director prior to proposal submission:
- individuals who are engaged in significant education and research activities at two-year colleges or non-profit, non-academic institutions such as museums, observatories, and research laboratories
- non-tenured faculty whose initial full-time tenure-track appointment preceded July 1, 1993, and who have interrupted their careers for substantive reasons such as family leave or serious health problems

FY1997 (NSF 96-115):

To be eligible for a CAREER award, applicants must meet all of the following requirements, except as noted below:
- be employed at an institution in the U.S., its territories or possessions, or the Commonwealth of Puerto Rico, which awards a baccalaureate or advanced degree in a field supported by NSF
- be in their first or second full-time tenure-track or equivalent academic appointment at any institution and have begun the first appointment on or after July 1, 1992 and before October 17, 1996
- not hold or have held tenure on or before October 17, 1996
- not be a current or former recipient of a Presidential or NSF Young Investigator, Presidential Faculty Fellow, or CAREER award

Individuals in the following categories may also be eligible to apply if they receive an exemption from the cognizant NSF PD prior to proposal submission:
- individuals engaged in significant education and research activities at two-year colleges or non-profit, non-academic institutions such as museums, observatories, and research laboratories
- non-tenured faculty whose initial full-time tenure-track appointment preceded July 1, 1992 and who have interrupted their careers for substantive reasons such as family leave or serious health problems
**FY1996 (NSF 95-118):**

To be eligible for a CAREER award, applicants must meet all of the following requirements, unless written approval is given for the exemptions noted below and submitted with the proposal:

- be employed at an institution in the U.S., its territories or possessions, or the Commonwealth of Puerto Rico, which awards a baccalaureate or advanced degree in a field supported by NSF
- be in their first or second full-time tenure-track or equivalent academic appointment at any institution and have begun the first appointment on or after July 1, 1991 and before the CAREER application deadline
- not hold or have held tenure on or before the program application deadline
- not be a current or former recipient of a Presidential or NSF Young Investigator, Presidential Faculty Fellow, or CAREER award

In the following cases, written approval for exception to the requirements listed above must be obtained from the cognizant NSF PD prior to proposal submission and submitted with the proposal:

- individuals who are engaged in significant education and research activities at two-year colleges or non-profit, non-academic institutions such as museums, observatories, and research laboratories
- non-tenured faculty whose initial full-time tenure-track appointment preceded July 1, 1991, but whose careers have been interrupted for substantive reasons such as family leave or serious health problems


To be eligible for a CAREER award, applicants must meet of the following requirements, unless written approval is given for the exceptions noted below:

- be employed at an institution in the U.S., its territories or possessions, or the Commonwealth of Puerto Rico, which awards a baccalaureate or advanced degree in a field supported by NSF
- be in their initial full-time tenure-track or equivalent academic appointment and within the first four years of that appointment at the program application deadline
- not hold or have held tenure on or before the program application deadline
- not be a current or former recipient of a Presidential or NSF Young Investigator, Presidential Faculty Fellow, or CAREER award

In the following cases, written approval for exception to the above requirements must be obtained from the cognizant NSF PD prior to proposal submission and submitted with the proposal:

- individuals who are engaged in significant education and research activities at two-year colleges or non-profit, non-academic institutions such as museums, observatories, and research labs
- non-tenured faculty more than four years beyond their initial full-time tenure-track appointment who have interrupted their careers for substantive reasons such as family leave or serious health problems