2013
ACS Graduate Student Survey

ACS Chemistry for Life®

American Chemical Society

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Supported by the Alfred P. Sloan Foundation

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AMERICAN CHEMICAL SOCIETY

About this report

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Dr. Shannon Gilmartin was essential in developing, piloting, refining, and analyzing the survey instrument and its results. Her insights ensured that the survey questions were relevant and would solicit useful responses from the graduate students surveyed. Dr. Gilmartin was ably assisted by Dr. Tiffani Riggers-Piehl, who provided detailed analysis of the survey results. Dr. Chris Golde offered valuable guidance in developing the survey instrument.

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Dr. Mark Connolly, University of Wisconsin, Madison
Dr. Geoff Davis, Google
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This report was written by Drs. Corrie Kuniyoshi, Joe Sostaric, and Mary Kirchhoff of the American Chemical Society. We are grateful to our colleagues, Ms. Nancy Bakowski and Dr. Jodi Wesemann, for their feedback on this report.

Finally, we greatly appreciate the thoughtful responses provided by the graduate students who participated in this survey. We sincerely hope that this survey has provided you with a voice in helping create the future of graduate education in the chemical sciences.

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Executive Summary

The American Chemical Society (ACS) conducted a survey of its 16,307 graduate student members in August 2013. A total of 2,992 usable responses were received; of these, 2,753 (92 percent) were doctoral students and 239 (eight percent) were master's students. The survey consisted of 38 questions that focused on career plans and preparation, student-advisor relationships, and support mechanisms.

The key findings from the 2013 ACS Graduate Student Survey are

- Seventy-eight percent of doctoral students and 70 percent of master's students reported that they were "very" or "generally" satisfied with their overall graduate student experience.
- Students at both the master's and doctoral levels were most interested in research careers in industry, government, or national laboratories.
- Approximately 20 percent of doctoral students responded that their funding was inadequate to meet their cost of living. Inadequate funding was more frequently reported by students supported by teaching assistantships.
- Students identified professional conferences and meetings, search engines, and networking events as the most useful career resources.
- Men, more than women, reported that their advisors engaged in behaviors that help them advance professionally.
- More than 90 percent of respondents indicated that safety training, graduate student orientation, career counseling, a graduate student association, and teaching assistant training were available on their campus.

The findings contained within this report, coupled with the conclusions in *Advancing Graduate Education in the Chemical Sciences*, are complementary and present an inclusive picture, reflecting both student and faculty perspectives, of graduate education in chemistry and the related sciences. The major recommendations resulting from the 2013 ACS

Graduate Student Survey are

- Chemistry departments should partner with their campus career centers to develop a comprehensive suite of career resources targeted to the needs of graduate students at all levels in the chemical sciences.
- The American Chemical Society should consider developing more formal career-focused programming specifically for graduate students and their advisors at its national and regional meetings.
- The American Chemical Society, National Science Foundation, National Institutes of Health, and other funding agencies should expand their portfolio of proposal-writing workshops, webinars, and other opportunities to assist graduate students in developing the oral and written communication skills essential for success in a wide range of careers.

- Graduate programs in chemistry should formalize an annual review process to ensure that graduate students receive timely feedback on progress toward degree and appropriate guidance in preparing for their careers. Creating an Individual Development Plan (IDP) that is reviewed and updated on an annual basis would provide graduate students with such feedback and guidance.
- Chemistry departments should balance graduate student support between research and teaching assistantships to ensure that students have adequate time for research while gaining the valuable skills acquired through experience as a teaching assistant.
- Institutions should develop and implement programs that educate all faculty members and students on implicit bias.
- Graduate programs should provide all graduate students with detailed information about the benefits available to them.

Introduction

Graduate education has been the focus of numerous studies and reports over the years. The Council of Graduate Schools (CGS), which is "dedicated solely to the advancement of graduate education and research" (*1*), regularly publishes reports that provide data and analysis of trends in graduate education. A 2010 CGS report noted that "the competitiveness of the United States and our capacity for innovation hinges fundamentally on a strong system of graduate education." (*2*) Citing advances in graduate education in other countries, this report further notes that "The growing competition points to the need for changes in U.S. graduate education so that the U.S. does not continue to fall behind in its production of graduate degree recipients."

The National Academies addressed graduate education through the lens of research universities in its 2012 report, *Research Universities and the Future of America: Ten Breakthrough Actions Vital to Our Nation's Prosperity and Security* (*3*). One of the 10 recommendations emphasized the need to reform graduate education by improving "the capacity of graduate programs to attract talented students by addressing issues such as attrition rates, time-to-degree, funding, and alignment with both student career opportunities and national interests."

Although many of these reports address graduate education in general, others are discipline specific. Chemistry was one of six disciplines involved in the Carnegie Initiative on the Doctorate, an initiative conducted from 2001–2005, which was designed to improve the effectiveness of doctoral programs (*4*). A 2012 National Academies' workshop report on *Challenges in Chemistry Graduate Education* opened with the statement, "Chemistry graduate education is under considerable pressure." (*5*) The report cited a number of factors responsible for this pressure, including federal funding limitations, the shift in chemical R&D to overseas, and the downsizing of the pharmaceutical industry. This same report quoted George Whitesides on the current system of graduate education: "Most of the emphasis goes into, in my opinion, research productivity, as opposed to thinking about the students."

Also in 2012, the American Chemical Society (ACS) released *Advancing Graduate Education in the Chemical Sciences* (*6*), a report by a Presidential Commission convened by ACS President Bassam Shakhashiri. The Commission was charged with answering two overarching questions:

- What are the purposes of graduate education in the chemical sciences?
- What steps should be taken to ensure that they address important societal issues as well as the needs and aspirations of graduate students?

The Commission's report presented four main conclusions relevant to graduate education:

1. Current educational opportunities for graduate students, viewed on balance as a system, do not provide sufficient preparation for their careers after graduate school.
2. The system for the financial support of graduate students, as currently operated by private, institutional, state, and federal funds, is no longer optimal for national needs.
3. Academic chemical laboratories must adopt best safety practices. Such practices have led to a remarkably good record of safety in the chemical industry and should be leveraged.
4. Departments should give thoughtful attention to maintaining a sustainable relationship between the availability of new graduates at all degree levels and genuine opportunities for them. Replication in excess is wasteful of resources and does injustice to the investment made by students and society.

Each of these conclusions was accompanied by specific recommendations. Members of the Commission included prominent chemists from industry and academia. Graduate student viewpoints were solicited during focus groups held at ACS National Meetings, but the graduate student perspective is not prominently reflected in the Commission's report. The 2013 *ACS Graduate Student Survey* is designed to fill this gap.

With support from the Alfred P. Sloan Foundation, the *ACS Graduate Student Survey* allows us to assess the graduate experience from students' viewpoints. The responses are intended to highlight what is working well and identify opportunities for graduate programs, the ACS, funding agencies, and other entities with a vested interest in graduate education in the chemical sciences to enhance retention, socialization, and the career preparation of students. The long-term goal of this project is to catalyze changes in chemistry graduate education that are informed by the results of the survey, and which will lead to a more positive and productive graduate student experience.

Methodology

Survey Design and Administration

The ACS conducted a survey of its graduate student members from August 1–September 3, 2013. The survey consisted of 38 questions and focused on career plans and preparation, student–advisor relationships, and support mechanisms (the survey instrument is available in Appendix A; details about survey design are included in Appendix D). The survey was delivered online. An e-mail with a link to the survey was sent on August 1, 2013, to 16,307 ACS graduate student members drawn from the ACS database.

Three reminder e-mails were sent on August 9, 20, and 30. Advertisements in the *ACS Graduate & Postdoctoral Chemist* magazine and on www.acs.org/grad, promotions on Twitter and Facebook, and an e-mail to graduate coordinators were used in an effort to engage non-ACS graduate student members in the survey. As an incentive for participating in the survey, students were offered the chance to register to win one $1,000 award in travel support to an ACS meeting or one Apple iPad.

A total of 3746 individuals responded to the survey. At the start of the survey, 656 respondents self-identified as non–graduate students in the chemical sciences (presumably because their status had changed since the last time they had updated their ACS membership information), and were therefore excluded from analysis. An additional 98 individuals did not continue the survey after this first question. Thus, the final sample for analysis includes 2992 respondents, 239 (eight percent) of whom are current master's students and 2753 (92 percent) of whom are current doctoral students.[1] A total of 269 U.S. colleges and universities were represented among these respondents, or 88 percent of the total number of Ph.D. and master's chemistry degree–granting institutions in the United States (*7*). A complete listing of institutions represented in the *ACS Graduate Student Survey* can be found in Appendix B.

[1] Due to attrition throughout the survey, the data analysis for each item was performed using the valid N for that item or group of items. Throughout this report, where "N" is listed it represents the total population of an item (valid N), and "n" represents the sample size of a subgroup shown in the table.

Table 1 presents key demographic characteristics of the ACS sample compared with those among the national population of master's and doctoral degree–earners in chemistry in 2010.[2] As these data indicate, master's students are substantially underrepresented in the ACS sample. Women are overrepresented in the predominantly doctoral student survey sample relative to their percentage among all doctoral degree–earners. Looking at race/ethnicity among U.S. citizens and permanent residents only, the distribution of survey respondents is similar to that among the national population of doctoral degree–earners, although there are proportionately more survey respondents who are classified as "white" (based on self-reports), and fewer classified as "other/unknown". Additional demographic and background characteristics of survey respondents can be found in Appendix C.

Because the survey sample is composed primarily of doctoral students, the trends in this report are mainly reflective of individuals in Ph.D. programs in the chemical sciences. Differences between master's and doctoral student responses were tested for statistical significance on nearly all survey items (see Appendix D for further methodological details). Only those differences that reached statistical significance at $p<.05$ are discussed in text. Select tables in this report present data separately for master's and doctoral students; see Appendix E for additional disaggregation of survey data by degree program.

Moreover, data were disaggregated by gender on nearly all survey items in order to examine how women and men differed in the sample and to aid in making inferences about the total population of graduate students in the chemical sciences. Across all survey items, only those differences that reached statistical significance at $p<.05$ are discussed in text. Select tables present data for women and men separately. Appendix E provides additional disaggregation of survey data by gender.

Finally, throughout the report, select data are disaggregated by students' year in degree program, age, underrepresented racial/ethnic minority (URM) status[3] or citizenship status[4]. As with gender and degree program, between-group differences discussed in text reached statistical significance at $p<.05$. Tabular presentations of these data are available from the authors upon request.

[2] Demographic information (gender, race) for the ACS graduate student member mail-out population is available for approximately 50 percent or less of those included, thus rendering a comparison between the survey sample and the member mail-out unreliable. However, among those graduate student members for whom demographic data are available, the racial/ethnic distribution closely resembles that in the *ACS Graduate Student Survey* sample. Women are somewhat overrepresented in the survey sample (among both all respondents and Ph.D. respondents only), and master's students are greatly underrepresented. These trends track with comparisons to the national population.

[3] For the purposes of this report, "underrepresented minorities" (URM) consists of those students who identified as American Indian/Alaskan Native, Black/African American, and those identifying as Latino/a or being of Hispanic origin (n=284, 10.9%). The URM group was compared to respondents identifying as White and Asian/Pacific Islander/Native Hawaiian, and "other" (n=2328, 89.1%). These specific definitions were used to better draw parallels between this study and other higher education–focused STEM-research (*8*).

[4] In disaggregating students by citizenship, students who identified as U.S. Citizens, Naturalized Citizens, and Permanent Residents were considered "domestic" (n=2035, 76.7%), while those who identified as F-1 or other visa holders were categorized as "international" (n=620, 20.7%).

Table 1. Comparing the 2013 *ACS Graduate Student Survey* Sample with Characteristics of the National Population of Doctoral and Master's Degree–Earners in Chemistry, 2010

	ACS Graduate Student Survey sample (N=2992)	Master's degree-earners, national population[a] (n=2175)	Doctoral degree-earners, national population[a] (n=2564)
Current degree program			
Ph.D.	92.0	---	---
Master's	8.0	---	---
Sex			
Female	49.0	48.5	38.8
Male	51.0	51.5	61.2
Citizenship or visa status			
U.S. native	71.1	---	---
U.S. naturalized citizens	3.5	---	---
U.S. permanent resident	2.1	---	---
Foreign student (F-1) visa	21.5	---	---
Other visa	1.9	---	---
Racial background			
American Indian/Alaska Native	1.7	---	---
Asian American/Pacific Islander	23.7	---	---
Black/African American	3.9	---	---
Other	3.8	---	---
White	67.0	---	---
Of Hispanic/Latino/a descent[b]	5.8	---	---
Race/ethnicity among U.S. citizens/permanent residents only[c]			
American Indian/Alaskan Native	1.8	0.3	0.5
Asian American/Pacific Islander	8.0	12.7	9.8
Black/African American	3.5	6.1	3.8
Hispanic/Latino/a	5.7	6.6	4.7
Other/unknown	2.0	11.1	10.2
White	78.9	63.2	71.0

[a] Source: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations of U.S. Department of Education, National Center for Education Statistics, Integrated Postsecondary Education Data System, Completions Survey, 2001–10.

[b] On the *ACS Graduate Student Survey*, the Hispanic/Latino/a question was asked separately from the race/ethnicity question. Nearly 6% of all respondents marked that they were Hispanic/Latino/a. Ninety-two percent of those marking Hispanic/Latino/a marked an additional racial/ethnic category (the distribution was as follows: 59.3% white, 5.0% black/African American, 4.3% American Indian/Alaskan Native, 5.0% Asian/Pacific Islander, and 26.4% other).

[c] For the ACS sample and purposes of comparability with the NSF data, the Hispanic/Latino/a category was merged with existing racial categories in this calculation. If a respondent marked Hispanic/Latino/a, the respondent was placed into this category regardless of other racial categories that the individual may have marked.

Results

The *ACS Graduate Student Survey* solicited feedback from graduate students in three major areas: career goals and preparation; socialization, with a focus on the student–advisor relationship; and the availability and usefulness of resources and benefits. The following sections present the survey results in the context of these categories, along with data on funding and overall satisfaction.

Career Goals and Preparation

The 2001 report *At Cross Purposes: What the experiences of today's doctoral students reveal about doctoral education* observed that "Two common assumptions about purpose and process underlie most doctoral programs. First, the Ph.D. is assumed to be a research degree, and its primary purpose is teaching junior scholars to conduct sound, rigorous research. Second, the operating model is one of apprenticeship." (*9*) This model is reflected in the career interests of participants in this study, as reported in Table 2. Research careers in industry and government laboratories garnered the highest interest among both Ph.D. and master's students. More doctoral (24.8 percent) than master's (17.7 percent) students were "very interested" in becoming a professor with an emphasis on research. Master's students were significantly more likely than doctoral students to want to be a researcher at a university, or work in industry, government, or educational administration/management.

Taking gender into account at the doctoral level (Table E2a, Appendix E), men were significantly more likely to be "very interested" in being a research professor or in starting their own company. Women were more interested in becoming a teaching professor or an administrator or manager in the higher education, nonprofit, and K–12 sectors. Men at the master's level also were more likely than master's level women to be "very interested" in starting their own company or becoming a research professor, as well as becoming a teaching professor, taking a position as a researcher in a college or university, and pursuing research in industry (Table E2b, Appendix E).

The full survey question asked students to "Please tell us about your current interest in the careers listed, and how your interest has changed over the course of your graduate studies." The largest self-reported increase in interest among both doctoral and master's students (Table 2) was in the "Researcher at government agency or national lab" category (44.6 percent and 41.4 percent, respectively, reported that their interest in this position had increased), while the largest decrease was seen in the area of research professor (39.1 percent and 24.7 percent, respectively). These changes could reflect a better understanding of the job responsibilities associated with working at a government agency or national lab, perhaps acquired through a collaborative project with these entities, along with the tight academic job market.

Table 2. Current Career Interests and Change in Interests Since Entering Degree Program, by Degree Type (N=2844)

	Doctoral Students (n=2621)			Master's Students (n=223)		
	Percentage of respondents who are currently	Percentage change in interest for all respondents		Percentage of respondents who are currently	Percentage change in interest for all respondents	
Career	"very interested"	Increase	Decrease	"very interested"	Increase	Decrease
Professor (emphasis on research)	24.8	21.6	39.1	17.7	23.7	24.7
Professor (emphasis on teaching)	28.6	27.5	22.9	24.2	27.6	20.1
Researcher in industry	46.7	40.7	9.5	47.1	37.3	9.9
Researcher at government agency or national lab	45.5	44.6	7.7	51.8	41.4	5.6
Researcher (not professor) in college/university	14.1	18.1	17.7	23.8	20.0	17.7
Administrator/manager in industry	19.2	25.3	10.2	26.9	30.2	12.7
Administrator/manager in government	14.6	22.2	10.7	25.9	27.8	12.3
Administrator/manager in a college/university	9.1	14.5	16.7	15.9	16.6	18.0
Administrator/manager in a nonprofit organization	9.6	14.7	13.3	10.0	14.1	16.4
K-12 educator or administrator	4.7	10.5	19.9	9.2	13.2	23.1
Starting your own company	15.0	24.5	12.5	17.2	26.0	15.8

Overall, the career findings in this survey are consistent with those from a survey of doctoral students in the basic biomedical sciences at the University of California, San Francisco (UCSF). Results from the UCSF survey showed a large change in students' confidence in their choice of a single career path (as opposed to all career options they were considering) between the first and second years of graduate school (*10*). The authors of the study suggest that the drop in confidence may be due to the intense thesis–laboratory experience of second-year UCSF doctoral students, which immerses them in day-to-day academic research. This survey also indicated that doctoral students in the biomedical sciences were interested in a variety of careers, with a decreased interest over time in working as a principal investigator at a research-intensive institution.

In addition to career interest itself, the survey also explored internal and external factors that influence career choice (where "internal" refers to personal motivations and desires, and "external" refers to contextual circumstances). As seen in Table 3 (summarizing internal factors), a desire for job security was cited as "very" or "extremely" important by 83.0 percent of respondents. A job that provides time for family, friends, and hobbies also ranked highly for all students (80.8 percent), and was a more significant factor for women (84.3 percent) than for men (77.5 percent) (Table E3, Appendix E). A job that offers advancement opportunities was considered "very" or "extremely" important by over three-quarters of respondents. Finding a well-paying job was more important for men than for women (71.2 percent and 65.6 percent, respectively). Women (47.6 percent) were more likely than men (42.4 percent) to place importance on finding a job in a specific geographical location.

Table 3. "Internal" Factors Important to Students' Choice of Careers (N=2651)

Factors	Percentage marking "very" or "extremely" important
Having job security	83.0
Having a job that gives me time for family, friends, and hobbies	80.8
Finding a job that offers advancement opportunities	77.0
Finding a well-paying job	68.5
Changing intellectual interests	49.6
Desire to have a job in a certain geographical location	45.0

As shown in Table 4 (summarizing external factors), job prospects in the student's field were deemed "very" or "extremely" influential with respect to career choice by 74.2 percent of respondents. Almost half (46.7 percent) of the respondents indicated that encouragement by their advisor or mentor to pursue a specific career goal was "very" or "extremely" influential.

Students who reported having a partner tended to rank their partner's professional circumstances as a major influence in their career choice, and women (68.3 percent) were more likely than men (56.3 percent) to list their partner's situation as "very" or "extremely" influential (Table E4, Appendix E). These data are consistent with the findings from the 2008 report *Dual-Career Academic Couples: What Universities Need to Know* (*11*). This study found that "men privilege their careers over those of their partners at significantly higher rates than do women."

Table 4. "External" Factors Influencing Students' Choice of Careers (N=2649)

Factors	Percentage marking "very" or "extremely" influential
Job prospects in your field	74.2
Partner's professional circumstances[a]	61.9
Encouragement by an advisor or mentor to pursue a specific career goal	46.7

[a] Only includes responses from those who indicated that they had a partner (n=1032).

Given the time spent in graduate school preparing for a career in the chemical sciences, how useful are the career resources available to graduate students? Data in Table 5 show that professional conferences and meetings were deemed "extremely" or "very" useful by 46.7 percent of the respondents (though among the small proportion of students who found these meetings "not useful", men were more highly represented, as shown in Table E5b, Appendix E). Search engines, other networking events, career resources from a scientific or professional society, and LinkedIn also ranked relatively highly among graduate students. The importance of networking is evident when considering the top five "extremely/very useful" resources in Table 5: Professional meetings and conferences, other networking events, and LinkedIn all include a significant networking component.

Table 5. Usefulness of Career Resources (N=2632)

	Percentage marking:			
Resources	"Extremely/ very useful"	"Moderately/ slightly useful"	"Not useful"	"Not applicable"
Professional conferences/meetings	46.7	38.0	5.7	9.5
Search engine	39.4	48.2	6.5	5.8
Other networking events	37.3	38.7	6.5	17.3
Career resources from a scientific or professional society	27.1	52.1	10.3	10.2
LinkedIn	22.7	40.2	16.2	20.7
Career development/counseling center	17.2	39.0	23.9	19.7
Graduate studies office at your institution	12.7	39.0	30.5	17.8
Blogs	8.1	26.4	31.4	34.3
Other online community	6.9	25.5	23.4	44.6
Facebook	4.7	23.5	51.0	20.8
Twitter	2.3	15.1	44.5	37.3

With respect to social media, LinkedIn was viewed as useful to some degree ("extremely/very/moderately/slightly") by 62.9 percent of respondents; by contrast, Facebook was considered "not useful" by 51.0 percent of students. In the eyes of the graduate students responding to this survey, LinkedIn is seen as the professional network it was designed to be. Interestingly, men found Facebook, Twitter, blogs, and other online communities more useful

than did women (Table E5b, Appendix E). At the same time, men were more likely than women to report that several of these resources were "not useful"[5]. This is partially because women had higher "not applicable" responses to these items than did men; in other words, women may have been less likely than men to have used these social media resources at all.

There are some further interesting differences to note when comparing students by degree type and age (Table E5a, Appendix E). In examining differences by degree type, doctoral students found blogs more useful to any degree ("extremely/very/moderately/slightly") than their master's counterparts. Master's students indicated they found career resources from a professional society, search engines, LinkedIn, Facebook, and other online communities useful to any degree at higher rates than doctoral students. Master's students were also more likely to say that career counseling and attendance at professional conferences were "not useful" than doctoral students.

Considering the age of students (data available upon request), "older" respondents were more likely than "younger" respondents to say that attending professional conferences/meetings and other networking events was useful.[6] This result suggests that older students may be more actively engaged in career-related networking events because they are closer to completing their degrees than their younger counterparts. Older students also found career resources from a scientific or professional conference, LinkedIn, Facebook, and other online resources to be more useful than younger students.

On-campus resources, including career development and counseling centers and the graduate studies office, were considered useful ("extremely/very/moderately/slightly") by more than half of all students. Men were more likely than women (Table E5b, Appendix E) to report that the graduate studies office (53.7 percent vs. 49.1 percent) was useful ("extremely/very/moderately/slightly"). Finally, among the students who found "other networking events" not useful, men indicated this response at a higher rate than women.

The survey also explored confidence levels in career preparation (Table 6). Master's students expressed a greater degree of confidence with respect to career preparation than did doctoral students (Table E6, Appendix E). The higher confidence levels reported by master's degree students on all factors may indicate that students pursuing a master's degree do so with a specific career goal in mind. At both master's and doctoral levels, men expressed greater confidence in navigating the job market and building a career than did women. Doctoral men were more likely than doctoral women to feel prepared to make informed career decisions. Confidence varied by other student subgroups, as well. International graduate students reported lower confidence in career preparation than did domestic students, as did underrepresented minority students in comparison with white and Asian students (data available upon request).

[5] Specifically, men found LinkedIn, Blogs, Twitter, and "other online" sources "not useful" at higher rates than women.
[6] For this question, "older" students were 29 or older and "younger" students were 28 and younger.

Table 6. Confidence in Career Preparation, by Degree Type (N = 2806[a])

	Mean (SD)
Making informed career decisions[b]	
Doctoral Students	2.96 (1.01)
Master's Students	3.32 (1.05)
Navigating the job market	
Doctoral Students	3.11 (.98)
Master's Students	3.31 (1.03)
Building a career	
Doctoral Students	3.40 (.98)
Master's Students	3.64 (.97)

[a] Doctoral students n=2585, Master's students n=221.
[b] Each question measured on a 5 point scale, where 5=extremely prepared, and 1=not at all prepared.

Socialization

Socialization is the process through which an individual learns to adopt the values, skills, attitudes, norms, and knowledge needed for membership in a given society, group, or organization (*12*). Golde described the unique situation encountered by graduate students: "The socialization of graduate students is an unusual double socialization. New students are simultaneously directly socialized into the role of graduate student and are given preparatory socialization into graduate student life and the future career common to most doctoral students." (*13*)

Socialization has been connected in various studies to attrition in doctoral education (*14, 15*), with the Council of Graduate Schools reporting that unsuccessful socialization is a contributing factor to a student's decision to leave graduate school (*16*). In chemistry, 62 percent of doctoral students complete their degrees within 10 years, compared with an overall 10-year completion rate of 57 percent across all disciplines (*17*). The 38 percent attrition rate could be attributed, in part, to unsuccessful socialization.

As noted by Gardner (*18*), "In particular, faculty members play myriad roles in the socialization of doctoral students…" For many graduate students, the faculty member who is most influential is the research advisor. The student–advisor relationship can affect understanding of program requirements and expectations, sense of community and, ultimately, program outcomes. In light of this literature, a series of survey questions probed the relationship between graduate students and their advisors.

Students were asked to respond to the question, "To what extent does each of the following behaviors describe your primary research advisor?" As shown in Table 7, men, more so than women, reported that their advisor provided encouragement in pursuing challenging opportunities, presenting at conferences, and attaining their goals; helped them develop professional relationships; and was supportive of their chosen career path. Men also were more likely to say that their advisor gave regular feedback on their research and progress toward degree completion, provided opportunities for writing grant proposals, and offered information

on careers (both academic and non-academic) to a "considerable" or "very great" extent. In addition, 65.8 percent of men reported that their advisor created an environment where group members were treated fairly to a "considerable" or "very great" extent, whereas for women this percentage was significantly lower at 60.9 percent.

Doctoral students were more likely than master's students to report that, to a "considerable" or "very great" extent, their advisors engaged them in writing first drafts of manuscripts and grant proposals, gave an appropriate level of credit for research contributions, served as an advocate for them, and encouraged them to take on challenging opportunities (Table E7b, Appendix E). Master's students were more likely than doctoral students to indicate that their advisors to a "considerable" or "very great" extent provided regular feedback on progress toward degree completion, along with information on nonacademic career paths.

Table 7. Ratings of Behaviors of Primary Advisor (For Those Students with One Advisor[7]), by Gender (N=2299[a])

Behavior of advisor	Percentage indicating that each behavior is descriptive of advisor to a "considerable" or "very great" extent.		
	All Students	Men	Women
Gives the appropriate level of credit to me for my research contributions	77.6	78.9	76.3
Encourages me to take on challenging opportunities	73.6	77.0	70.1
Encourages me to attain my goals	72.3	74.6	69.9
Asks me to write the first drafts of scientific manuscripts	72.2	73.8	70.6
Gives regular feedback on my research	68.1	70.7	65.3
Models good professional relationships	67.0	67.9	66.1
Advocates for me	66.0	68.1	63.8
Encourages me to present our research at scientific conferences	65.8	68.4	62.9
Creates an environment where all group members are treated fairly	63.4	65.8	60.9
Supports my career path of choice	59.4	61.4	57.3
Takes time to learn about my background, interests, and/or personal relationships	47.9	49.0	46.7
Gives regular feedback on my progress towards degree completion	44.8	46.7	42.8
Helps me to develop professional relationships	43.3	45.7	40.8
Provides information about academic career paths	38.8	40.5	37.0
Engages me in writing grant proposals	33.0	35.6	30.3
Provides information about nonacademic career paths	25.8	26.9	24.7

Note: See Appendix Table E7a for significance notations.
[a] Men: n=1179; Women: n=1112

Fewer than 50 percent of graduate students reported that their advisor was giving them feedback on their progress toward degree completion to a "considerable" or "very great" extent (Table 7). In this study, feedback on degree progress appears to diminish as students get further along in their program, with two-thirds of first-year students indicating that their advisors gave them feedback to a "considerable" or "very great" extent. This number holds steady around 45 percent

[7] Respondents were asked to indicate whether they had one primary research advisor or two primary research advisors (co-advisors). These data were examined separately to determine whether responses from students with more than one advisor differed significantly from those with only one advisor. These two groups were not significantly different, thus the data for students with one advisor is included in the report and serves to describe both groups.

in the second and third year, and drops to 39 percent for those who have been in their program five years or longer (data available upon request). This trend makes sense when considering that students who are in the early years of their graduate work tend to have numerous requirements, such as cumulative exams and research proposals, which require monitoring on the part of their advisor and department. The decline in feedback on progress to degree after five years seems less than ideal, however, because students who have been in graduate school five years or more need to have clear expectations as to when they will complete their degrees.

Table 8. Ratings of Relationship with Primary Advisor (For Those Students with One Advisor) (N=2289)

	Percentage indicating they "strongly" or "somewhat" agree with each statement
I get along well with my primary advisor.	85.4
My primary advisor is satisfied with my research productivity.	81.2
My primary advisor is satisfied with my progress toward degree completion.	82.2
I am satisfied with the amount and quality of time spent with my primary advisor.	71.6
My primary advisor sees me as a top student.	62.4
My primary research advisor is out of touch with the career issues that graduate students face.	29.5

Students were asked to indicate their level of agreement with a series of statements regarding their relationship with their primary research advisor and their perceptions of their primary research advisor's viewpoints (Table 8). In response to the statement, "I get along well with my primary advisor," 85.4 percent of respondents stated that they "strongly" or "somewhat" agreed. More than three-fourths of respondents also agreed "strongly" or "somewhat" that their advisor was satisfied with their research productivity and progress towards their degree. The majority of students were satisfied with the amount and quality of time spent with their research advisor. Men were more likely than women to indicate that their advisor sees them as a top student; men also were more likely to report that their advisor is out of touch with the career issues that graduate students face (Table E8, Appendix E).

Notably, 7.4 percent of students "do not know" if their advisor is satisfied with their research productivity and 8.8 percent "do not know" if their advisor is satisfied with their progress toward degree (data available upon request). Nearly one in 10 students is uncertain of his or her advisor's assessments of their progress and productivity. These responses suggest that enhanced communication between advisors and students is warranted in some cases.

Graduate students were asked to consider how much support and advice they currently received and ideally desired for their professional development and career. The data in Table 9 show that research advisors and other graduate students are the primary sources of support for doctoral students. Overall, only a small proportion of students who reported that their current level of support was "none" or "moderate" across various sources indicated that they wanted a greater amount of support from these sources. For those students, their fellow graduate students were the group from whom they wanted additional support the most.

Table 9. Doctoral Students' Current and Ideal Amount of Support (N=2458)

Source of support	Percentage indicating they currently have [a]: "A lot of" support	Percentage indicating they currently have [a]: "None" or "moderate" support	Percentage marking "none" or "moderate" who want a greater amount of support
Primary research advisor	30.0	67.8	3.9
Other grad students (at current institution)	28.4	70.0	7.2
Postdocs (at current institution)	16.8	69.0	5.1
Professional colleagues (not at current institution)	11.3	80.1	5.5
Other sources of support [b]	10.5	20.8	2.4
Administrators or staff members (at current institution)	10.1	84.7	4.7
Other faculty (at current institution)	8.3	88.4	0.0

[a] Percentage of respondents who marked "N/A" are not reported.
[b] Respondents wrote in "partner/spouse", "family", "alumni", "friends", and "professional organizations", among other sources of support.

Doctoral students (Table 9) were more likely than master's students (Table E9c, Appendix E) to report getting "none" or "moderate" support from their primary research advisor and professional colleagues at other institutions. Master's students were more likely than doctoral students to indicate they were receiving "a lot" of support from other faculty at their institution and professional colleagues at other institutions, while doctoral students, more than master's students, reported getting "a lot" of support from postdoctoral researchers, administration and staff, and "other" sources (which included partner/spouse, family, and alumni, among others). At the same time, doctoral students were also more likely to respond that the support they received from postdocs and "other" was "none" or "moderate". One explanation for this apparent contradiction is that master's students responded "not applicable" to the question of postdoc and "other" support at a higher rate than did doctoral students (42 percent vs. 14 percent).

Interestingly, women were more likely than men to indicate that they received "a lot of support" from other graduate students, professional colleagues, and "other" sources of support, while men were more likely than women to indicate that they received "a lot of" support from their primary research advisor (compare data in Table E9a to Table E9b, Appendix E). There were no differences, however, in how much *additional* support men and women wanted from the various sources listed.

Campus Resources and Benefits

Academic departments, as well as the institutions in which they are housed, offer a variety of resources that support the training and professional development of graduate students. To assess the accessibility and efficacy of resources in enhancing the graduate student experience, those surveyed were asked about the availability and usefulness of campus-provided resources focused on training, workshops, and career counseling.[8] Responses (Table 10) showed high availability of most of the campus resources listed in the survey. According to student respondents, almost

[8] In examining data related to resources and benefits available on campus (Tables 10 and 11, respectively), the institution was treated as the unit of analysis (in addition to the student). In light of this, gender and degree differences were not analyzed for these particular items.

all institutions in this sample offered safety training (96.6 percent) and graduate student orientation (95.9 percent). Likewise, more than 90 percent of institutions offered career counseling, had a graduate student association, and provided training for teaching assistants. The resources that had the lowest percentage of availability were teaching/pedagogy workshops (83.1 percent) and job placement (74.8 percent).

Table 10. Availability and Usefulness of Campus Resources

Resources	Percentage of institutions where resource is available [a]	Among students who report that this resource is available, percentage responding to the question: "If you used the resource, was it useful?"			
		"Yes"	"No"	"N/A"	n
Safety training	96.6	80.1	17.1	2.8	2478
Graduate student orientation	95.9	70.1	23.8	6.1	2410
Career counseling	92.8	24.7	23.8	51.4	1905
Graduate student association	91.7	44.6	30.0	25.4	2295
Teacher assistant training	91.3	64.3	25.3	10.4	2239
Teaching/pedagogy workshops	83.1	44.9	20.5	34.5	1754
Job placement	74.8	18.2	23.4	58.3	1020

[a] Indicates the percentage of institutions (N=266) represented among student respondents where at least one student indicated that "yes" this resource was available. For example, 96.6% of institutions (n=257) had at least one student indicate that safety training was available.

Student utilization of these resources was mixed. Even at those institutions where career counseling and job placement services were available, more than half of the students chose "N/A" (not applicable) in response to the question of whether they had found them useful. Keeping in mind that the survey included students from all stages of their graduate career (Appendix C), this may simply suggest that many students do not access these services until late in their program. Other services, such as orientation and safety training, are generally given at the start of a graduate program, and most students would already have participated in these.

Safety training and orientation had the most positive perception, with the number of those agreeing these were useful greatly outweighing those who did not. Those services related to teaching (teaching assistant training and teaching/pedagogy workshops) yielded a greater percentage of "useful" ratings than "not useful" ratings. Graduate student associations had the highest "not useful" rating; specifically, of students who indicated that an association was available, nearly one-third reported that it was not useful.

Graduate student respondents were also asked about benefits offered by their institutions. As seen in Table 11, almost all institutions made health insurance available, and about two-thirds of institutions made vision and dental insurance available. Fewer than one percent of institutions offering these benefits had students who did not know about their availability. A primary factor that may contribute to this high awareness is that these are benefits that students are likely to have accessed. Alternatively, it may be that institutions do an effective job at explaining these particular benefits, or that the media emphasis on issues surrounding the Affordable Care Act in the past year has significantly raised the visibility of health insurance in students' eyes.

With respect to life and disability insurance, student responses suggest that only about half of institutions offer these. Further, among institutions offering such benefits, more than three-fourths have students who do not know about their availability—with an average "don't know" rate of over 50 percent. The relative lack of awareness could be because the institutions are less effective about advertising the availability of these benefits, or it may be that the majority of students do not consider them personally relevant, and therefore they pay less attention to them.

Table 11. Availability of Campus Benefits

		Among institutions offering this benefit:	
	Percentage of institutions offering this benefit[a]:	Percentage of institutions where at least one student reported "don't know [if this benefit is available]"[b]	Mean percentage of students reporting "don't know [if this benefit is available]" (of institutions where at least one student answered this way)[c]:
	%	%	Mean (SD)
Health insurance	93.6	0.6	3.6 (0.0)
Fitness subsidy	83.8	58.3	26.8 (13.9)
Public transportation subsidy	76.2	52.4	23.3 (13.6)
Dental insurance	69.2	0.6	22.0 (0.0)
Parking subsidy	67.7	69.9	30.4 (14.1)
Onsite child care	67.3	71.3	49.4 (15.5)
Housing subsidy	64.8	68.6	36.0 (13.0)
Vision insurance	63.9	0.6	39.6 (0.0)
Life insurance	52.6	78.6	51.9 (17.4)
Disability insurance	50.8	76.9	59.2 (16.8)

[a] Indicates the percentage of institutions (N=266) represented among student respondents where at least one student indicated that "yes" this resource was available.
[b] Indicates percentage of institutions where at least one student indicated they "don't know" if the benefit was available, among institutions offering the benefit.
[c] Indicates average percentage of students indicating they "don't know" if the benefit was available, across institutions offering the benefit and having at least one student respondent marking "don't know".

Onsite child care is offered by about two-thirds of institutions in the sample, but a great number of students may be unaware of this. Again, one possible explanation is that those students who are not parents are unaware of the existence of this benefit. There are other benefits, though, that presumably apply to almost all students, but for which awareness is low. Fitness, public transportation, parking, and housing are subsidized at over 60 percent of institutions, but at those institutions, more than half have students who are not aware of these subsidies, with an average "don't know" rate ranging from 23 to 36 percent.

In considering whether they are consistent with other students' experiences, we note that these results are comparable to those from the Sloan Foundation Sigma Xi PostDoc survey (*19*), which included responses from 7600 postdoctoral scholars. In the Sigma Xi study, health, dental and vision insurance benefits had relatively higher percentages of availability in comparison with the availability of disability insurance, child care, and other benefits. Among the postdocs reporting

dissatisfaction with their postdoctoral experience in the Sigma Xi survey, lack of employment benefits was cited as one source of this dissatisfaction.

Funding

Financial support is one of the key factors in completion of degree programs, and mathematics and the physical sciences have a strong track record in this regard (*20*). Two aspects of financial support for doctoral students were addressed in this survey. First, students were asked about the source of their funding. Second, students were asked about the adequacy of that funding in meeting their living expenses. It is instructive to examine both of these, and also the interplay between funding source and adequacy.

Table 12. Funding Sources for Doctoral Students who Agree or Disagree that Their "Graduate Funding is Adequate to Meet the Cost of Living Where [They] Live"

	Proportional distribution of funding sources for respondents who:		
Types of Funding	Agree that their funding is adequate (n=1699, 69.1%)	Disagree that their funding is adequate (n=519, 21.1%)	Types of funding among all respondents (N=2218[a])
Teaching assistantships	35.5	42.2	37.1
Research assistantships	37.3	30.4	35.7
Fellowship/scholarships	21.8	13.0	19.7
Loans and other support[b]	3.4	12.7	5.6
Do not wish to respond	1.9	1.9	1.9

Note. Percentages of different funding sources for each group may not sum to 100 due to rounding.
[a] Omits respondents who answered "neither agree/disagree" that their funding is adequate to meet the cost of living where they live (n=244).
[b] Other support includes: Other Paid Employment, Personal Savings, Income from a Spouse/Partner, Familial Support, and Other.

From the data in Table 12, the three major sources of funding among doctoral student respondents are teaching assistantships (37.1 percent), research assistantships (35.7 percent) and fellowships/scholarships (19.7 percent). These numbers are similar to those cited in the ACS Committee on Professional Training *Survey of Ph.D. Programs in Chemistry* (*21*), in which a survey of departments showed that 38 percent of students were supported by teaching assistantships and 40 percent by research assistantships. Another point of comparison is the 2012 NSF Survey of Doctorate Recipients (*22*). This report found that 47 percent of physical scientists[9] are supported by research assistantships or traineeships, 38 percent are supported by teaching assistantships, 19 percent are supported by fellowships, and six percent are supported by other means. One interpretation is that other physical science fields are more successful at supporting their students through research assistantships, while chemistry departments are more reliant on teaching assistantships. The higher percentage of funding by teaching assistantships in this study may also reflect greater teaching needs in chemistry, particularly in general and organic chemistry classes and laboratories.

The second aspect of financial support addressed in the present survey was the adequacy of graduate student funding. Students were asked if their "graduate funding is adequate to meet the

[9] The "physical sciences" category includes astronomy, chemistry, physics, and physical sciences.

cost of living where [they] live". Sixty-nine percent of respondents agreed that their funding is adequate, 21.1 percent disagreed with the statement, and the remaining 9.8 percent neither agreed nor disagreed.

Students' perceptions of the adequacy of their support can be considered in relation to specific funding sources. "Inadequately funded" students were more likely to be supported by teaching assistantships (42.2 percent of their funding vs. 35.5 percent for the "adequately funded" students) and less likely to be supported by research assistantships (30.4 percent vs. 37.3 percent) or fellowships/scholarships (13.0 percent vs. 21.8 percent).[10] Potential interpretations of this difference include actual differences in the level of support for those with research assistantships versus teaching assistantships and/or a greater level of dissatisfaction among those students who feel they have to both teach and do research, instead of focusing singularly on research. The *Advancing Graduate Education in the Chemical Sciences* (*6*) report advocated for a realignment of funding sources for Ph.D. students, with an increase in fellowships and graduate program grants and a decrease in reliance on both grant-funded research assistantships and teaching assistantships.

With respect to gender differences and adequacy of funding (Table E12b, Appendix E), men and women were equally likely to agree that their funding was adequate. However, for those who reported being adequately funded, men were more likely to be supported by research assistantships, while women were more likely to rely on teaching assistantships. Further, although both women and men in our sample who perceived that their funding was inadequate cited teaching assistantships as their largest source of funding, men in this group reported more funding from research assistantships than women did (35.4 percent and 25.4 percent, respectively). A gender disparity in funding sources also was observed in the 2012 NSF Survey of Doctorate Recipients data, which showed that in the physical sciences, men (47.3 percent) were more likely than women (44.6 percent) to have research assistantships (*22*). For both the present study and the NSF report, women were slightly more likely to receive funding from fellowships and grants, and in our inadequately-funded group, men were slightly more likely to take on more loans. Together these data provide evidence of gender disparities in sources of doctoral student funding.

Considering differences by degree, doctoral students were more likely than master's students to agree that their funding was adequate (Table E12a, Appendix E). Master's students who said their funding was adequate ranked teaching assistantships as their greatest source of funding (28.3 percent), with an additional 27.4 percent coming from "loans and other support". Master's students were significantly less likely to receive fellowships and scholarships than their doctoral counterparts, and were more likely to take loans or find other sources of support. Of those who said their funding was inadequate, master's students reported the majority of their funding being from "loans and other" support (48.6 percent), with only 28.4 percent of their funding coming from teaching assistantships. These students were significantly more likely to take on loans or other support, and less likely to have any other type of support, than inadequately-funded doctoral students.

[10] The analyses comparing funding sources for adequately and inadequately funded students were conducted in concert with other comparative analyses mentioned previously in the methods section of this report. Specifically, for the items described in Table 12, t-tests were conducted to examine between-group differences. All differences discussed in text are statistically significant at $p<.05$.

Overall Satisfaction

Several questions in the present study probed graduate students' overall satisfaction with graduate school. In response to the question, "How satisfied are you with your overall graduate student experience at your current institution?", 78.0 percent of doctoral students and 71.9 percent of master's students indicated that they were "very" or "generally" satisfied (Figure 1). This percentage is comparable with the level of overall satisfaction (70 percent) expressed by postdoctoral scholars in Sigma Xi's postdoc survey (*19*).

Likelihood of degree completion and intent to remain in the chemical sciences can also be used as indicators of satisfaction. As seen in Table 13, approximately three-fourths (76.7 percent) of doctoral students reported definite plans to complete their degrees. An almost identical percentage (76.1 percent) of doctoral students were "extremely" or "very" likely to stay in the chemical sciences after graduation. The overall percentages are higher than those reported in the Council of Graduate Schools' 2008 report *Ph.D. Completion and Attrition: Analysis of Baseline Demographic Data from Ph.D. Completion Project,* which noted a 10-year completion rate of 62 percent for chemistry (*17*). The higher percentage reporting intent to complete in this survey would not include those students who have already abandoned their graduate studies.

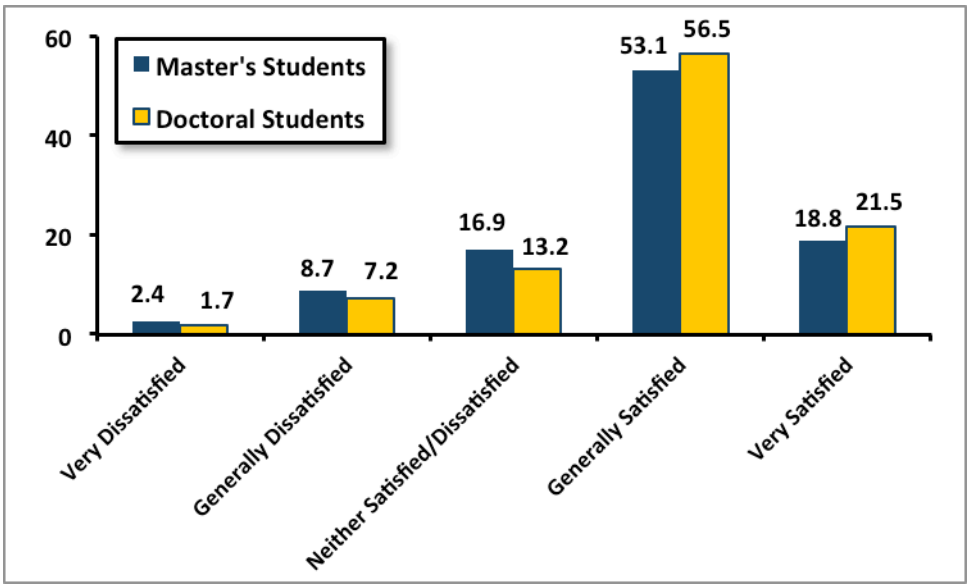

Figure 1. Student satisfaction with graduate experience at current institution, by degree type.

A higher percentage of master's students stated that they "definitely will" complete their degrees (doctoral students, as compared with their master's peers, were more likely to respond that they "probably will" complete their degrees). Both doctoral and master's students who stated that they "definitely will" complete their degree were more likely than their counterparts (i.e., all other doctoral/master's students) to indicate that they were "extremely" or "very" likely to stay in the chemical sciences.[11] Doctoral students planning to do a postdoc were more likely to report

[11] The analyses comparing doctoral and master's students' likelihood of degree completion and of remaining in chemistry were conducted in concert with other comparative analyses mentioned previously in the methods section of this report. Specifically, z-tests for proportions were conducted to examine the differences discussed here. All differences discussed are statistically significant at $p<.05$.

intentions to stay in the chemical sciences compared with doctoral students who were not planning to do a postdoc. There were no differences in the likelihood of staying in chemistry between master's students who planned to pursue a Ph.D. and those who did not.

Table 13. Likelihood of Graduate Degree Completion and Remaining in Chemical Sciences after Graduation, by Degree Type (N=2930)

	Percentage reporting they "definitely will" complete their degree	Percentage reporting they are "extremely" or "very" likely to stay in the chemical sciences after graduation
Doctoral students (n=2698)	76.7	76.1
Master's students (n=232)	88.9	72.3

Considering between-group differences, these data were examined by gender, URM status, and citizenship status. Although gender differences emerged in self-reported likelihood of degree completion, men and women doctoral students were equally likely to report that they would stay in the chemical sciences (Table E13, Appendix E). Male doctoral students were more likely than their female counterparts to report that they would definitely finish their degree. There were no statistically different responses between men and women master's students. Students who self-reported as underrepresented minorities stated that they "definitely will" complete their degree at a higher rate (84.5 percent) than did white and Asian students (76.9 percent). A higher percentage (86.6 percent) of international students, compared with domestic students (74.9 percent), indicated that they "definitely will" complete their degree. International students also reported at a higher rate (82.6 percent) than domestic students (76.4 percent) that they are "extremely" or "very likely" to stay in the chemical sciences after graduation (data available upon request).

Respondents were asked if, given the chance to start over in graduate school, they would change their current field of study, current institution, or primary research advisor. As seen in Table 14, approximately 12 to 16 percent of students would change one or more of these variables. These data are remarkably similar to those in the *At Cross Purposes* study, which reported that 9.9 percent, 15.4 percent, and 14.3 percent would change their field of study, institution, or research advisor, respectively (*9*).

Table 14. Factors Students Would Change if They Could Start Over (N=2656)

	Percentage Marking…	
Factors	"Yes, I would change"	"No, I would not change"
Current field of study	11.6	60.4
Current institution	15.8	47.3
Primary research advisor	14.8	55.7

Note: "maybe" and "n/a" options omitted.

Recommendations

The data gathered through the *ACS Graduate Student Survey* provide a snapshot of the graduate student experience from the student perspective, suggest opportunities for improving this experience, and highlight the need for additional research. It is encouraging to note that most graduate students reported overall satisfaction with their experience in graduate school. The interactions with and opportunities provided by their advisors are largely viewed positively, the financial support and benefits they receive are mostly deemed adequate, and the majority would not change their current field of study. The sections below highlight opportunities, identified through this survey, to enhance the graduate student experience.

Supporting Career Goals and Preparation

The preference for industrial careers over academic careers as reported in this survey is consistent with ACS membership, in which 54 percent of the members are employed in industry and 36 percent in academia (*23*). The significant decrease in interest in becoming a research professor over the course of a student's graduate education is borne out by other studies; a survey of doctoral students in the University of California system, for example, also revealed a decreased interest in becoming a research-focused professor (*24*). The main reason for this shift was attributed to work-life balance.

Our survey identified career information as a notable area of need; only 9.5 percent of students reported that their advisor "provides information about nonacademic career paths" to a "considerable extent", while 26.3 percent responded their advisor exhibits this behavior "not at all". Even for academic careers, 14.7 percent of respondents indicated that their advisor provides this information to a "considerable extent", with 15.2 percent responding "not at all". (These expanded data are available upon request.) As reported in Table 4, advisors can have a significant impact on graduate students as they are determining their career path. Almost half (46.7 percent) of respondents indicated that encouragement by an advisor or mentor to pursue a specific career goal was "very" or "extremely" influential.

Laursen *et al.* identified a mismatch between career decision-making needs and opportunities (*25*). Interviews with graduate students revealed that "…students often appeared to become stuck at the point of determining what career they wanted, while faculty expected students to make a career choice before they could or would assist. This resulted in a mismatch between where students needed help in career planning, and where faculty felt prepared to be of help." The authors suggest that "improved career socialization will depend on the actions of graduate students, faculty, and departments alike."

The mismatch between needs and opportunities could be addressed by developing more comprehensive and integrated career resources at the department, institution, and/or professional society level. In this study, conferences and meetings ranked as the most useful career resources, and these venues could offer more career-focused programming specifically targeted toward graduate students. Some programs already exist; for example, ACS currently offers the Postdoc to Faculty workshop and Academic Employment Initiative program in conjunction with its fall national meeting, as well as Preparing for Life After Graduate School and Career Pathways workshops throughout the year. The American Chemical Society might consider developing more formal career-focused programming specifically for graduate students and their advisors at

its national and regional meetings. The ACS can also play a role in better informing graduate students about job prospects in a particular field, because this was reported as the most influential external factor in students' career choice.

Some universities are already implementing career-focused resources such as these. A March 2014 article in *The Chronicle of Higher Education* (*26*) highlighted the need to integrate academic departments and career services to provide graduate students with the full array of career options. The article featured a program at Michigan State University, where campus career services introduces graduate students to "the many job markets" early and often throughout their graduate education. The PREP (Planning, Resilience, Engagement, and Professionalism) program helps students develop essential competencies, such as management and communication skills, which will help them succeed in a variety of career paths, not just academic pathways. Chemistry departments should partner with their campus career centers to develop a comprehensive suite of career resources targeted to the needs of graduate students in the chemical sciences.

Enhancing Socialization

Overall, graduate students viewed their relationship with their primary research advisor favorably, and they reported that their advisor engages them in activities, such as manuscript preparation and conference presentations, which will help them grow professionally. Advisors helped students develop professional relationships and engaged them in writing grant proposals to a lesser extent.

It is interesting to note that, for many behaviors described in Table 7, women reported less often than did men that their advisor demonstrated these behaviors. Women also reported lower confidence levels than men with respect to career preparation, and were less likely than men to respond that they would definitely finish their degree. Having an advisor who created an environment where group members were treated fairly received lower marks from women than from men. Taken together, these findings may reflect implicit bias, as noted in *Beyond Bias and Barriers: Fulfilling the Potential of Women in Academic Science and Engineering* (*27*). This 2007 National Academies' publication found that "…throughout their careers, women have not received the opportunities and encouragement provided to men to develop their interests and abilities to the fullest…" The report recommended that "Deans, department chairs, and their tenured faculty should develop and implement programs that educate all faculty members and students in their departments on unexamined bias and effective evaluation", and we support this recommendation.

The gaps in mentoring, such as proposal writing and developing professional relationships, identified through this survey could be filled by professional societies and funding agencies. For example, proposal-writing workshops and webinars offered by the American Chemical Society, National Science Foundation, National Institutes of Health, or other funding agencies would assist graduate students in developing the oral and written communication skills essential for careers in industry and academia. Structured networking events would foster the professional relationships essential for success in any career.

Less than half (44.8 percent) of the survey participants responded that their advisor gave them regular feedback on progress towards degree to a "considerable" or "very great" extent (Table 7).

Although this is higher than the 39.4 percent of chemistry students who reported having annual reviews in the 2001 report *At Cross Purposes: What the experiences of today's doctoral students reveal about doctoral education* (*9*), it is still considerably lower than the ideal of all students receiving at least annual feedback on progress towards degree. *At Cross Purposes* recommended that graduate faculty "Conduct a thorough annual evaluation of each advisee. Discuss students' timely progress through the program, and work to ensure that their experiences prepare them for the careers they plan to enter." We support the recommendations of *At Cross Purposes,* and suggest that graduate programs formalize an annual review process to ensure that graduate students receive timely feedback on progress toward degree and appropriate guidance in preparing for their careers. Creating an Individual Development Plan (IDP) for every graduate student is one approach that is being adopted on a number of campuses and across disciplines (*28*).

These conversations do not need to be limited to those between advisor and student; advisory or doctoral committees can also provide feedback on progress towards degree, as recommended in *Advancing Graduate Education in the Chemical Sciences* (*6*). This report noted that "Annual, or more frequent, meetings with advisory committees can help train students to stay on a productive track, aimed more at producing results than putting in time…More formal and explicit elaboration of plans, and monitoring of progress toward those plans by advisor and committee, would not only reduce time-to-degree, but also instill good professional habits in students."

Expanding Resources

With respect to funding, approximately one-fifth (21.1 percent) of doctoral respondents reported that their funding was inadequate, with 42.2 percent of these students being supported by teaching assistantships (Table 12). Teaching assistantships play an important role in the professional development of graduate students but, as noted in the *Advancing Graduate Education in the Chemical Sciences* (*6*) report, "…teaching assistantships should not be the major basis of support throughout one's graduate career, because such a situation shifts the student's balance of time commitment too far away from essential research activities." Chemistry departments should balance graduate student support between research and teaching assistantships to ensure that students have adequate time for research while gaining the valuable skills acquired through experience as a teaching assistant.

Though not specifically examined in this report, adequate funding is particularly important for students who are underrepresented minorities (URM). A 2013 issue brief by the Center for STEM Education & Innovation (*29*) noted that graduate students from URM groups who earn doctoral degrees in the Science, Technology, Engineering, and Mathematics (STEM) fields leave graduate school with more debt than their non-URM counterparts. In particular, African American graduate students in the STEM disciplines are more than twice as likely as non-URM students to accumulate debt in excess of $30,000. Future studies should consider examining the sources of funding for URM students to better understand the disparities in student loan burden described here.

In terms of on-campus benefits, survey respondents indicated a high degree of awareness of the availability of health-related benefits (medical, dental, and vision insurance), but were less aware of some of the other benefits available to them (Table 11). This finding suggests that graduate

programs could do a more thorough job of educating students about the benefits available to them.

Future Directions

The small number of master's degree students who responded to the survey suggests that additional research is needed on the state of master's degree students in the chemical sciences. In 2010, the National Science Foundation reported that 2175 master's degrees were awarded in chemistry, compared to 2564 doctoral degrees (*30*); 46 percent of all graduate degrees in chemistry in 2010 were awarded to master's students. Yet only eight percent of the survey respondents were master's students. One explanation for this difference may reside in the membership of the American Chemical Society, which consists predominantly of Ph.D. chemists. Given that the survey was sent to ACS graduate student members, it seems likely that most of these graduate students are pursuing doctoral degrees rather than master's degrees.

Approximately three-fourths of all graduate students responded that they were "very" or "generally" satisfied with their overall graduate school experience (Figure 1), and a high percentage reported their intent to complete their degrees and remain in the chemical sciences (Table 13). As shown in Figure 1, 11.1 percent of master's students and 8.9 percent of doctoral students reported that they were "very" or "generally" dissatisfied. Our survey data on this measure parallel the results of the Sigma Xi PostDoc survey (*19*), which reported that 11 percent of postdocs were dissatisfied with their positions. Although not probed in this survey, the reasons for this dissatisfaction are likely varied. The Sigma Xi survey noted that "Dissatisfaction among postdocs does not stem from any single dominant source." Further research could help identify the factors responsible for dissatisfaction among this segment of the graduate student population.

The data gathered through this survey should serve as a catalyst for conversations in chemistry departments, among funding agencies, and within professional societies, particularly the American Chemical Society. Listening to the voices of the graduate students is essential if we are to attract and retain talented colleagues in the chemical sciences.

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Appendix A. 2013 Survey of Graduate Students in the Chemical Sciences

The American Chemical Society (ACS), with support from the Alfred P. Sloan Foundation, is conducting a study of career plans and preparation among graduate students in the chemical sciences, including chemistry and chemical engineering, in the U.S. You are receiving this survey because you have been identified as a graduate student in the chemical sciences.

This survey is designed to gather information about your:

- Knowledge of career options
- Awareness and use of career resources
- Relationship with your advisor, and
- Access to support mechanisms for you in graduate school.

Your responses will help ACS and chemistry and chemical engineering departments develop programs and resources to benefit graduate students

2013 Survey of Graduate Students in the Chemical Sciences

To thank you for participating in this survey, ACS invites you to register for one chance to win $1,000 in travel support to an ACS meeting, and one chance to win a 32 GB Apple iPad. Please follow the link at the end of the survey to enter your name in this random drawing. Your registration for this prize incentive is independent of the main survey and your name cannot be linked to survey data.

Instructions:

Your participation in this survey is voluntary and strictly confidential. This survey is divided into five sections, and it will take you approximately 18 minutes to complete the survey. Only question 1 requires a response to progress through the survey; all other questions are voluntary. Please take this survey in one sitting.

I. Background Information

1. Are you currently a: (Mark one)

- ❍ Master's student in the chemical sciences, including chemistry and chemical engineering
- ❍ Doctoral student in the chemical sciences, including chemistry and chemical engineering
- ❍ None of the above

[If Question 1 was answered "Master's" or "Doctoral student" Question 2a would follow]

2a. When did you first enter your current degree program?

- ❍ 2002
- ❍ 2003
- ❍ 2004
- ❍ 2005
- ❍ 2006
- ❍ 2007
- ❍ 2008
- ❍ 2009
- ❍ 2010
- ❍ 2011
- ❍ 2012
- ❍ 2013
- ❍ Before 2002

[If Question 1 was answered "None of the above" Question 2b would follow]

2b. Since you are not a graduate student, please tell us your current position in the space provided below.

[*See Appendix A for complete list of respondents' institutions]
3. At which institution are you currently enrolled?

State

Name

If your institution is not listed, please enter its name here.

[If Question 1 was answered "Master's student" Question 4a would follow]
4a. How many additional years of graduate study do you estimate you will need in order to complete the requirements for your current master's degree program?

- ❍ 0
- ❍ 1
- ❍ 2
- ❍ 3
- ❍ 4
- ❍ 5
- ❍ 6
- ❍ 7
- ❍ 8
- ❍ 9
- ❍ 10 years or more

[If Question 1 was answered "Doctoral student" 4b would follow]
4b. How many additional years of graduate study do you estimate you will need in order to complete the requirements for your current Ph.D. degree program?

- ❍ 0
- ❍ 1
- ❍ 2
- ❍ 3
- ❍ 4
- ❍ 5
- ❍ 6
- ❍ 7
- ❍ 8
- ❍ 9
- ❍ 10 years or more

5. How likely are you to complete your current degree program?

- ❍ Definitely will
- ❍ Probably will
- ❍ Maybe will
- ❍ Probably will not
- ❍ Definitely will not

[If Question 1 was answered "Master's student" 6a would follow]

6a. Do you plan to continue in a Ph.D. program upon completion of your master's degree?

- ❍ Yes
- ❍ No
- ❍ Not sure

[If Question 1 was answered "Doctoral student" 6b would follow]

6b. Do you plan to do a postdoctoral position upon completion of your Ph.D.?

- ❍ Yes
- ❍ No
- ❍ Not sure

7. What is your primary field of study? (Mark one)

- ❍ Agricultural/food chemistry
- ❍ Analytical chemistry
- ❍ Biochemistry
- ❍ Chemical biology
- ❍ Chemical education
- ❍ Chemical engineering
- ❍ Chemical toxicology
- ❍ Colloid & surface chemistry
- ❍ Computational chemistry
- ❍ Electrochemistry
- ❍ Environmental chemistry
- ❍ General chemistry
- ❍ Geochemistry
- ❍ Inorganic chemistry
- ❍ Materials chemistry
- ❍ Medicinal/pharmaceutical chemistry
- ❍ Nuclear chemistry
- ❍ Organic chemistry
- ❍ Physical chemistry
- ❍ Polymer chemistry
- ❍ Theoretical chemistry
- ❍ Other Fill-in _____

II. Developing your career plans

The questions in Section II ask you about your career interests and plans, which career resources you have used, and the extent to which you have found these resources useful in your career planning.

8. In your opinion, how much time have you invested in career planning activities, as compared with the level of investment in career planning you perceive is needed to start a successful career?

- ❍ More than enough time
- ❍ About the right amount of time
- ❍ Less than enough time

9. Please tell us about your current interest in the careers listed, and how your interest has changed over the course of your graduate studies.

	My current level of interest in this career			My change in interest in this career, since starting graduate school		
	Very interested	Moderately interested	Not at all interested	More interested	Stayed the same	Less interested
Professor (emphasis on research)	❍	❍	❍	❍	❍	❍
Professor (emphasis on teaching)	❍	❍	❍	❍	❍	❍
Researcher in industry	❍	❍	❍	❍	❍	❍
Researcher at government agency or national lab	❍	❍	❍	❍	❍	❍
Researcher (not professor) in college / university	❍	❍	❍	❍	❍	❍
Administrator/manager in industry	❍	❍	❍	❍	❍	❍
Administrator/manager in government agency	❍	❍	❍	❍	❍	❍
Administrator/manager in a college / university	❍	❍	❍	❍	❍	❍
Administrator/manager in a non-profit organization	❍	❍	❍	❍	❍	❍
K-12 educator or administrator	❍	❍	❍	❍	❍	❍
Starting your own company	❍	❍	❍	❍	❍	❍

10. Are there other career options not displayed in the table in question 9 that you are considering at this time?

- ❍ No
- ❍ Yes - Fill in _____

11. Many factors may be important in the career planning process. How important is each of the following factors in your career planning?

	Extremely important	Very important	Moderately important	Slightly important	Not at all important	Not applicable
Finding a well-paying job	❍	❍	❍	❍	❍	❍
Having job security	❍	❍	❍	❍	❍	❍
Finding a job that offers advancement opportunities	❍	❍	❍	❍	❍	❍
Having a job that gives me time for family, friends, and hobbies	❍	❍	❍	❍	❍	❍
Desire to have a job in a certain geographical location	❍	❍	❍	❍	❍	❍
Changing intellectual interests	❍	❍	❍	❍	❍	❍

12. Certain factors may influence your career plans. How influential is each of the following factors on your career planning?

	Extremely influential	Very influential	Moderately influential	Slightly influential	Not at all influential	Not applicable
Encouragement by an advisor or mentor to pursue a specific career goal	❍	❍	❍	❍	❍	❍
Partner's professional circumstances	❍	❍	❍	❍	❍	❍
Job prospects in your field	❍	❍	❍	❍	❍	❍

13. To what extent have each of the following resources been useful to you in providing professional/career information?

	Extremely useful	Very useful	Moderately useful	Slightly useful	Not useful	Not applicable
Career development / counseling center at your institution	❍	❍	❍	❍	❍	❍
Graduate Studies Office at your institution	❍	❍	❍	❍	❍	❍
Career resources from a scientific or professional society / association	❍	❍	❍	❍	❍	❍
Professional conferences/meetings	❍	❍	❍	❍	❍	❍
Networking events outside of professional conferences / meetings	❍	❍	❍	❍	❍	❍
Search engine (e.g., Google, Bing, etc.)	❍	❍	❍	❍	❍	❍
LinkedIn	❍	❍	❍	❍	❍	❍
Facebook	❍	❍	❍	❍	❍	❍
Twitter	❍	❍	❍	❍	❍	❍
ACS Network	❍	❍	❍	❍	❍	❍
Blogs	❍	❍	❍	❍	❍	❍
Other online community	❍	❍	❍	❍	❍	❍

14. How prepared do you feel to make informed career decisions at this time?

❍ Extremely prepared
❍ Very prepared
❍ Moderately prepared
❍ Slightly prepared
❍ Not at all prepared

15. How confident are you in your ability to...

	Extremely confident	Very confident	Moderately confident	Slightly confident	Not at all confident
Successfully navigate the job market when you graduate?	❍	❍	❍	❍	❍
Build a successful career?	❍	❍	❍	❍	❍

16. Looking ahead, how likely is it that you will stay in the chemical sciences after you graduate?

❍ Extremely likely
❍ Very likely
❍ Moderately likely
❍ Slightly likely
❍ Not at all likely

17. Is there anything else you wish to share about your career preparation needs?

III. Building your professional network

Your primary research advisor and your research group can play a significant role in building your professional network, and contributing to your satisfaction during graduate school. The questions in this section explore your experience with your research group, and your relationship with your research advisor.

18. Are you currently in a research group?

- ❍ Yes
- ❍ No

[If Question 18 was answered "Yes" then Questions18a-18c would follow. If answered "No" then survey would skip to Question 19]

18a. Excluding rotations, have you switched research groups since beginning your current graduate program?

- ❍ No
- ❍ Yes - why? _____

18b. Why did you decide to join your current research group?

18c. Overall, how satisfied are you with your research group?

- ❍ Very satisfied
- ❍ Generally satisfied
- ❍ Neither satisfied/dissatisfied
- ❍ Generally dissatisfied
- ❍ Very dissatisfied

19. Do you currently have a primary research advisor?

- ❍ Yes, I have one primary research advisor
- ❍ No, I do not have a primary research advisor - why not? _____
- ❍ Yes, I have two primary research advisors (co-advisors)

[If Question 19 was answered "Yes, I have one primary research advisor" then Questions 19a-19c would follow. If answered "No" then survey would skip to Question 20]

19a. To what extent does each of the following behaviors describe your primary research advisor?

	To a very great extent	To a considerable extent	To a moderate extent	To a slight extent	Not at all
Asks me to write the first drafts of scientific manuscripts	❍	❍	❍	❍	❍
Engages me in writing grant proposals	❍	❍	❍	❍	❍
Encourages me to present our research at scientific conferences	❍	❍	❍	❍	❍
Gives regular feedback on my research	❍	❍	❍	❍	❍
Gives regular feedback on my progress towards degree completion	❍	❍	❍	❍	❍
Gives the appropriate level of credit to me for my research contributions	❍	❍	❍	❍	❍
Helps me to develop professional relationships	❍	❍	❍	❍	❍
Advocates for me	❍	❍	❍	❍	❍
Provides information about academic career paths	❍	❍	❍	❍	❍
Provides information about non-academic career paths	❍	❍	❍	❍	❍
Supports my career path of choice	❍	❍	❍	❍	❍
Models good professional relationships	❍	❍	❍	❍	❍
Encourages me to take on challenging opportunities	❍	❍	❍	❍	❍
Encourages me to attain my goals	❍	❍	❍	❍	❍
Takes time to learn about my background, interests, and/or personal relationships	❍	❍	❍	❍	❍
Creates an environment where all group members are treated fairly	❍	❍	❍	❍	❍

19b. The following statements ask about your relationship with your primary research advisor and your perceptions of your primary research advisor's viewpoints. Please indicate the extent to which you agree or disagree with each statement (you may also mark "I don't know").

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree	I don't know
I am satisfied with the amount and quality of time spent with my primary advisor.	❍	❍	❍	❍	❍	❍
My primary advisor is satisfied with my research productivity.	❍	❍	❍	❍	❍	❍
My primary advisor is satisfied with my progress towards degree completion.	❍	❍	❍	❍	❍	❍
I get along well with my primary advisor.	❍	❍	❍	❍	❍	❍
My primary research advisor is out of touch with the career issues that graduate students face.	❍	❍	❍	❍	❍	❍
My primary research advisor sees me as a top student.	❍	❍	❍	❍	❍	❍

19c. Is there anything you'd like to add regarding your relationship with your primary research advisor?

[If Question 19 was answered "Yes, I have two primary research advisors (co-advisors)" then the below text would appear, followed by Questions 19a-1 through 19a-3]

The following three questions focus on your relationship with your primary research advisors. Because you have indicated that you have 2 primary research advisors (i.e., co-advisors), you will be asked to respond to all three questions for both of your research advisors.

Now click "next" to respond to questions for primary research advisor A.

19a-1. To what extent does each of the following behaviors describe primary research advisor A?

	To a very great extent	To a considerable extent	To a moderate extent	To a slight extent	Not at all
Asks me to write the first drafts of scientific manuscripts	❍	❍	❍	❍	❍
Engages me in writing grant proposals	❍	❍	❍	❍	❍
Encourages me to present our research at scientific conferences	❍	❍	❍	❍	❍
Gives regular feedback on my research	❍	❍	❍	❍	❍
Gives regular feedback on my progress towards degree completion	❍	❍	❍	❍	❍
Gives the appropriate level of credit to me for my research contributions	❍	❍	❍	❍	❍
Helps me to develop professional relationships	❍	❍	❍	❍	❍
Advocates for me	❍	❍	❍	❍	❍
Provides information about academic career paths	❍	❍	❍	❍	❍
Provides information about non-academic career paths	❍	❍	❍	❍	❍
Supports my career path of choice	❍	❍	❍	❍	❍
Models good professional relationships	❍	❍	❍	❍	❍
Encourages me to take on challenging opportunities	❍	❍	❍	❍	❍
Encourages me to attain my goals	❍	❍	❍	❍	❍
Takes time to learn about my background, interests, and/or personal relationships	❍	❍	❍	❍	❍
Creates an environment where all group members are treated fairly	❍	❍	❍	❍	❍

19a-2. The following statements ask about your relationship with primary research advisor A and your perceptions of primary research advisor A's viewpoints. Please indicate the extent to which you agree or disagree with each statement (you may also mark "I don't know").

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree	I don't know
I am satisfied with the amount and quality of time spent with my primary advisor.	❍	❍	❍	❍	❍	❍
My primary advisor is satisfied with my research productivity.	❍	❍	❍	❍	❍	❍
My primary advisor is satisfied with my progress towards degree completion.	❍	❍	❍	❍	❍	❍
I get along well with my primary advisor.	❍	❍	❍	❍	❍	❍
My primary research advisor is out of touch with the career issues that graduate students face.	❍	❍	❍	❍	❍	❍
My primary research advisor sees me as a top student.	❍	❍	❍	❍	❍	❍

19a-3. Is there anything you'd like to add regarding your relationship with primary research advisor A?

[If Question 19 was answered "Yes, I have two primary research advisors (co-advisors)" then the below text would appear followed by Questions 19b-1 through 19b-3]

Now please respond to the same three questions for primary research advisor B.

Next >>

19b-1. To what extent does each of the following behaviors describe primary research advisor B?

	To a very great extent	To a considerable extent	To a moderate extent	To a slight extent	Not at all
Asks me to write the first drafts of scientific manuscripts	❍	❍	❍	❍	❍
Engages me in writing grant proposals	❍	❍	❍	❍	❍
Encourages me to present our research at scientific conferences	❍	❍	❍	❍	❍
Gives regular feedback on my research	❍	❍	❍	❍	❍
Gives regular feedback on my progress towards degree completion	❍	❍	❍	❍	❍
Gives the appropriate level of credit to me for my research contributions	❍	❍	❍	❍	❍
Helps me to develop professional relationships	❍	❍	❍	❍	❍
Advocates for me	❍	❍	❍	❍	❍
Provides information about academic career paths	❍	❍	❍	❍	❍
Provides information about non-academic career paths	❍	❍	❍	❍	❍
Supports my career path of choice	❍	❍	❍	❍	❍
Models good professional relationships	❍	❍	❍	❍	❍
Encourages me to take on challenging opportunities	❍	❍	❍	❍	❍
Encourages me to attain my goals	❍	❍	❍	❍	❍
Takes time to learn about my background, interests, and/or personal relationships	❍	❍	❍	❍	❍
Creates an environment where all group members are treated fairly	❍	❍	❍	❍	❍

19b-2. The following statements ask about your relationship with primary research advisor B and your perceptions of your primary research advisor B's viewpoints. Please indicate the extent to which you agree or disagree with each statement (you may also mark "I don't know").

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree	I don't know
I am satisfied with the amount and quality of time spent with my primary advisor.	❍	❍	❍	❍	❍	❍
My primary advisor is satisfied with my research productivity.	❍	❍	❍	❍	❍	❍
My primary advisor is satisfied with my progress towards degree completion.	❍	❍	❍	❍	❍	❍
I get along well with my primary advisor.	❍	❍	❍	❍	❍	❍
My primary research advisor is out of touch with the career issues that graduate students face.	❍	❍	❍	❍	❍	❍
My primary research advisor sees me as a top student.	❍	❍	❍	❍	❍	❍

19b-3. Is there anything you'd like to add regarding your relationship with primary research advisor B?

20. For each of the following individuals (or group of individuals), please indicate how much support and advice you are currently receiving for your professional development and career, and how much support and advice you ideally desire.

	Amount of support/advice you are currently receiving				Amount of support/advice you ideally desire			
	A lot	A moderate amount	None	N/A	A lot	A moderate amount	None	N/A
Primary research advisor	❍	❍	❍	❍	❍	❍	❍	❍
Other faculty (besides your primary research advisor) at your current institution	❍	❍	❍	❍	❍	❍	❍	❍
Other graduate students at your current institution	❍	❍	❍	❍	❍	❍	❍	❍
Postdocs at your current institution	❍	❍	❍	❍	❍	❍	❍	❍
Administrators and staff members at your current institution	❍	❍	❍	❍	❍	❍	❍	❍
Professional colleagues outside of your current institution	❍	❍	❍	❍	❍	❍	❍	❍
Other - Fill in	❍	❍	❍	❍	❍	❍	❍	❍

IV. Resources, Support, and Satisfaction

The questions in Section IV ask about the types of opportunities and benefits available to you as a graduate student, as well as your overall satisfaction with graduate school.

21. Please indicate if the following opportunities are available on your campus. If you have used the resource, please indicate if you found it to be useful.

	Is this resource available on your campus?			If you have used this resource, was it useful?		
	Yes	No	Don't know	Yes	No	N/A
Graduate student orientation	❍	❍	❍	❍	❍	❍
Graduate student association	❍	❍	❍	❍	❍	❍
Safety training	❍	❍	❍	❍	❍	❍
TA training	❍	❍	❍	❍	❍	❍
Teaching / pedagogy workshops	❍	❍	❍	❍	❍	❍
Career counseling	❍	❍	❍	❍	❍	❍
Job placement	❍	❍	❍	❍	❍	❍

22. Benefits offered to graduate students often vary from one institution to another. For each of the following benefits, please indicate if it is available at your current institution.

	Is this benefit available on your campus?		
	Yes	No	Don't know
Health insurance	❍	❍	❍
Dental insurance	❍	❍	❍
Vision insurance	❍	❍	❍
Life Insurance	❍	❍	❍
Disability Insurance	❍	❍	❍
Maternity / paternity leave	❍	❍	❍
Onsite child care	❍	❍	❍
Parking subsidy	❍	❍	❍
Public transportation subsidy	❍	❍	❍
Fitness subsidy	❍	❍	❍
Housing subsidy	❍	❍	❍

23. Are there any changes in benefits, including the addition of new benefits, that you would like to see for graduate students?

❍ No

❍ Yes - Please explain _____

24. Since starting your current degree program, how have your graduate studies been funded? Please slide the bars from the left to the right in the table below to indicate the approximate proportion of funding received from each source. Your responses must total 100%, as shown at the bottom right-hand corner of the table.

_____ Teaching assistantship(s)
_____ Research assistantship(s)
_____ Fellowship(s)/ scholarship(s)
_____ Loan(s)
_____ Other paid employment
_____ Personal savings
_____ Income from a spouse or partner
_____ Familial support
_____ Other - fill in
_____ *Do not wish to respond (Please slide bar to 100%)

25. Please indicate the extent to which you agree or disagree with the following statement: "The funding for my graduate studies is adequate to meet the cost of living where I live".

❍ Strongly agree
❍ Agree
❍ Neither agree nor disagree
❍ Disagree
❍ Strongly disagree

26. Since entering graduate school, have you experienced any problems directly related to your graduate program?

❍ No
❍ Yes - please describe _____

[If Question 26 was answered "Yes" then Question 26a would follow. If answered "No" then survey would skip to Question 27.]

26a. To whom did you turn for help and advice? Mark all that apply.

❑ Primary research advisor
❑ Other departmental faculty/staff member
❑ Family member
❑ Other graduate student or postdoc
❑ Campus counseling center
❑ Other individual/group – fill in _____
❑ No one

27. If you could go back in time and start your graduate studies over, knowing what you know now, would you change your choice of the following?

	Yes, I would change this	Maybe - I might change this but I might not	No, I would not change this	N/A
Your current field of study	❍	❍	❍	❍
Your current institution	❍	❍	❍	❍
Your primary research advisor	❍	❍	❍	❍

28. Is there anything else that you would change? Please describe in the space provided below.

29. How satisfied are you with your overall graduate school experience at your current institution?

❍ Very satisfied
❍ Generally satisfied
❍ Neither satisfied/dissatisfied
❍ Generally dissatisfied
❍ Very dissatisfied

30. Is there anything else that your department can do to improve the quality of your experience at graduate school?

V. Additional Background Information

The questions in Section V ask you to provide demographic information.

31. What is your sex?
- ❍ Male
- ❍ Female

32. What is your citizenship or visa status? (Mark one)
- ❍ U.S. native
- ❍ U.S. naturalized
- ❍ U.S. permanent resident
- ❍ J-1 visa
- ❍ F-1 visa
- ❍ H1-B visa
- ❍ Other visa: fill-in _____

[If Question 32 was answered "U.S. Permanent resident", "J-1 visa", "F-1 visa", "H1-B visa", or "Other visa: fill-in" then Question 32a would follow. If answered "U.S. native" or "U.S. naturalized" then Question 33 would follow.]

32a. What is your country of citizenship? (List two countries if you are a dual citizen).

33. Are you of Hispanic or Latino/a origin or descent?
- ❍ Yes
- ❍ No

34. What is your racial background? Mark all that apply.
- ❑ White
- ❑ Black or African American
- ❑ American Indian or Alaskan Native
- ❑ Native Hawaiian or other Pacific Islander
- ❑ Other race, please specify: _____
- ❑ Asian

35. What year were you born?

- ❍ 1992 or later
- ❍ 1991
- ❍ 1990
- ❍ 1989
- ❍ 1988
- ❍ 1987
- ❍ 1986
- ❍ 1985
- ❍ 1984
- ❍ 1983
- ❍ 1982
- ❍ 1981
- ❍ 1980
- ❍ 1979
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- ❍ 1975
- ❍ 1974
- ❍ 1973
- ❍ 1972
- ❍ 1971
- ❍ 1970
- ❍ 1969
- ❍ 1968
- ❍ 1967
- ❍ 1966
- ❍ 1965
- ❍ 1964
- ❍ 1963
- ❍ 1962
- ❍ 1961
- ❍ 1960 or earlier

36. Are you single, partnered, or married?

- ❍ Single
- ❍ Partnered/married

[If Question 36 was answered “partnered/married” then Question 36a and Question 36b would follow. If answered “single” then Question 37 would follow.]

36a. Is your spouse/partner: (Mark one)

❍ A scientist or graduate student/postdoc in a science field
❍ A non-scientist

[If Question 36a was answered "A scientist or graduate student/postdoc in a science field" then Question 36b would follow. If answered "a non-scientist" then Question 37 would follow.]

36b. Which field?

❍ Behavioral sciences
❍ Chemical sciences
❍ Computer sciences
❍ Earth / Environmental sciences
❍ Engineering
❍ Life sciences
❍ Mathematics & Statistics
❍ Physics
❍ Other - Fill in _____

37. Not including yourself or your spouse/partner, do you have one or more dependent child (or adult) who receives one half or more of their financial support from you?

❍ Yes
❍ No

[If Question 37 was answered "Yes" then Question 37a would follow. If answered "No" then Question 38 would follow.]

37a. Please write in the number of dependents.

5 years of age or younger ☐

6-18 years ☐

19 years or older ☐

38. What is the highest degree earned by your...

	Less than high / secondary school graduate	High / secondary school graduate	Some college	Bachelor's degree	Master's degree (e.g. MA, MS, MBA, MSW, etc.)	Professional degree (e.g. MD, DDS, JD, D.Min, Psy.D., etc.)	Research doctoral degree	Not applicable/unknown
Father	❍	❍	❍	❍	❍	❍	❍	❍
Mother	❍	❍	❍	❍	❍	❍	❍	❍

39. Thank you very much for your participation in this survey. If there is anything else that you wish to add or comment on relating to your graduate school experience, please do so in the box below. Otherwise, click the "next" button below to submit the survey. You will then be given the opportunity to provide your personal information if you wish to be entered into the drawing for the incentive prizes.

Appendix B. List of Represented U.S. Institutions by State. (N=269[a])

Alabama
- Auburn University
- Tuskegee University
- University of Alabama[b]
- University of Alabama, Birmingham

Alaska
- University of Alaska, Fairbanks

Arizona
- Arizona State University
- University of Arizona

Arkansas
- University of Arkansas

California
- California Institute of Technology
- California Polytechnic University
- California State University, Fresno
- California State University, Fullerton
- California State University, Long Beach
- California State University, Los Angeles
- California State University, Northridge
- California State University, San Diego
- California State University, San Jose
- California State University, Sonoma State
- Irell and Manella Graduate School of Bio Science
- Mount Saint Mary's College
- San Francisco State University
- Scripps Research Institute
- Stanford University
- University of California, Berkeley
- University of California, Davis
- University of California, Irvine
- University of California, Los Angeles
- University of California, Riverside
- University of California, Santa Barbara
- University of California, Santa Cruz
- University of California, San Diego
- University of California, San Francisco
- University of the Pacific
- University of San Francisco
- University of Southern California

Colorado
- Colorado School of Mines
- Colorado State University
- University of Denver
- University of Colorado, Boulder
- University of Colorado, Denver
- University of Northern Colorado

[a] Does not include institutions in US territories. Students at the University of Puerto Rico campuses including San Juan, Piedras, Mayaguez, and the Medical Sciences Campus, as well as those at the International American University of Puerto Rico were excluded from data analyses examining benefits and resources offered on campus (represented in tables 10 and 11).

[b] Institutions are listed as they appeared on the ACS Survey, with the exception of write-in responses, which were standardized as needed (e.g. if a respondent wrote in " CSU Northridge" the institution was noted here as "California State University, Northridge."

Appendix B (continued). List of Represented American Institutions by State.

Connecticut
- Sacred Heart University
- University of Connecticut
- University of St. Joseph
- Wesleyan University
- Yale University

Delaware
- Delaware State University
- University of Delaware

District of Columbia
- Catholic University of America
- George Washington University
- Georgetown University
- Howard University

Florida
- Florida Atlantic University
- Florida International University
- Florida State University
- Scripps Florida
- University of Central Florida
- University of Florida
- University of Miami
- University of South Florida

Georgia
- Emory University
- Georgia Institute of Technology
- Georgia Southern University
- Georgia State University
- University of Georgia

Hawaii
- University of Hawaii at Manoa

Idaho
- University of Idaho

Illinois
- Bradley University
- Governors State University
- Illinois Institute of Technology
- Illinois State University
- Loyola University Chicago
- Northern Illinois University
- Northwestern University
- Southern Illinois University, Edwardsville
- University of Chicago
- University of Illinois at Chicago
- University of Illinois at Urbana-Champaign
- Western Governors University

Indiana
- Ball State University
- Indiana University, Bloomington
- Indiana University - Purdue University Indianapolis
- Purdue University
- University of Notre Dame

Appendix B (continued). List of Represented American Institutions by State.

Iowa
- Iowa State University
- University of Iowa

Kansas
- Kansas State University
- University of Kansas

Kentucky
- Eastern Kentucky University
- University of Kentucky
- University of Louisville
- Western Kentucky University

Louisiana
- Louisiana State University, Baton Rouge
- Louisiana Tech University
- McNeese State University
- Tulane University
- University of New Orleans

Maine
- University of Maine

Maryland
- Johns Hopkins University
- Morgan State University
- Towson University
- University of Maryland
- University of Maryland, Baltimore Count

Massachusetts
- Boston College
- Boston University
- Brandeis University
- Harvard University
- Massachusetts Institute of Technology
- Northeastern University
- Tufts University
- University of Massachusetts, Amherst
- University of Massachusetts, Boston
- University of Massachusetts, Lowell
- University of Massachusetts, Medical School
- Worcester Polytechnic Institute

Michigan
- Central Michigan University
- Eastern Michigan University
- Michigan State University
- Michigan Technological University
- Oakland University
- University of Michigan
- Van Andel Institute Graduate School
- Wayne State University
- Western Michigan University

Appendix B (continued). List of Represented American Institutions by State.

Minnesota
- Jackson State University
- University of Minnesota, Duluth
- University of Minnesota, Twin Cities

Mississippi
- Mississippi State University
- University of Mississippi
- University of Southern Mississippi

Missouri
- Missouri State University
- University of Missouri
- University of Missouri, Kansas City
- University of Missouri, Saint Louis
- University of Missouri, Science Campus
- Missouri Western State University
- Saint Louis University
- Washington University in St. Louis
- Webster University

Montana
- Montana State University
- University of Montana

Nebraska
- Nebraska Wesleyan University
- University of Nebraska

Nevada
- University of Nevada
- University of Nevada, Las Vegas

New Hampshire
- Dartmouth College
- University of New Hampshire

New Jersey
- Kean University
- Montclair State University
- New Jersey Institute of Technology
- Princeton University
- Rutgers the State University of New Jersey, Camden
- Rutgers the State University of New Jersey, Newark
- Rutgers the State University of New Jersey, New Brunswick
- Seton Hall University
- Stevens Institute of Technology

New Mexico
- New Mexico State University
- University of New Mexico

New York
- City University of New York, Graduate Center
- Clarkson University
- Columbia University
- Cornell University
- Long Island University
- New York State University, College of Environmental Science and Forestry
- New York University
- Polytechnic Institute of New York University
- Rensselaer Polytechnic Institute

Appendix B (continued). List of Represented American Institutions by State.

New York (continued)
- University of Rochester
- Sloan-Kettering Institute
- St. Johns University
- State University of New York, Albany
- State University of New York, Binghamton
- State University of New York, Buffalo
- State University of New York, Oswego
- State University of New York, Stony Brook
- Syracuse University

North Carolina
- Duke University
- East Carolina University
- North Carolina State University
- University of North Carolina
- University of North Carolina, Charlotte
- University of North Carolina, Greensboro
- Wake Forest University

North Dakota
- North Dakota State University
- University of North Dakota

Ohio
- Bowling Green State University
- Case Western Reserve University
- Cleveland State University
- Kent State University
- Miami University
- Ohio State University, The
- Ohio University
- University of Akron, The
- University of Cincinnati
- University of Dayton
- University of Toledo
- Wright State University
- Youngstown State University

Oklahoma
- Oklahoma State University
- University of Oklahoma
- University of Tulsa

Oregon
- Oregon Health and Sciences University
- Oregon State University
- Portland State University
- University of Oregon

Pennsylvania
- Bryn Mawr College
- Bucknell University
- Carnegie Mellon University
- Drexel University
- Duquesne University
- Indiana University of Pennsylvania
- Lehigh University

Appendix B (continued). List of Represented American Institutions by State.

Pennsylvania (continued)
- Pennsylvania State University
- University of Pennsylvania
- University of Pittsburgh
- University of Sciences in Philadelphia
- Temple University
- Thomas Jefferson University
- Villanova University

Rhode Island
- Brown University
- University of Rhode Island

South Carolina
- Clemson University
- Medical University of South Carolina
- University of South Carolina

South Dakota
- South Dakota State University
- University of South Dakota

Tennessee
- East Tennessee State University
- Middle Tennessee State University
- Tennessee Technological University
- Tennessee State University
- University of Memphis, The
- University of Tennessee Health Science Center
- Vanderbilt University

Texas
- Baylor University
- Lamar University
- Rice University
- Tarleton State
- Texas A&M University
- Texas Christian University
- Texas Southern University
- Texas State University
- Texas Tech University
- University of Houston
- University of North Texas
- University of Texas
- University of Texas, Arlington
- University of Texas, Dallas
- University of Texas, El Paso
- University of Texas, San Antonio
- University of Texas Medical Center/Branch

Utah
- Brigham Young University
- Utah State University
- University of Utah

Vermont
- University of Vermont

Virginia
- George Mason University
- Norfolk State University
- Old Dominion University

Appendix B (continued). List of Represented American Institutions by State.

Virgina (continued)
- Virginia Commonwealth University
- Virginia Polytechnic Institute & State University
- University of Virginia

Washington
- Washington State University, Tri Cities
- Western Washington University
- University of Washington

West Virginia
- West Virginia University

Wisconsin
- Marquette University
- Medical College of Wisconsin
- University of Wisconsin, Madison
- University of Wisconsin, Milwaukee

Wyoming
- University of Wyoming

Appendix C. Disaggregated Characteristics of Survey Sample.

Table C1. Demographic Description of the Sample

Survey Item	Percentage marking each response
Are you a Master's or Ph.D. student? (N=2992)	
Master's	8.0
Ph.D.	92.0
What is your sex? (N=2656)	
Male	51.0
Female	49.0
What is your citizenship or visa status? (N=2655)	
U.S. native	71.1
U.S. naturalized citizen	3.5
U.S. permanent resident	2.1
Foreign student (F-1) visa	21.5
Other visa[a]	1.9
Are you of Hispanic or Latino/a origin or descent? (N=2640)	
Yes	5.8
No	94.2
What is your racial background?[b] (N=2600)	
African American/Black	3.9
American Indian/Alaskan Native	1.7
Asian/Pacific Islander	23.7
White	67.0
Other	3.8
What is the education level of your father? (N=2639)	
HS diploma or less	22.2
Any undergraduate experience	42.7
Master's	17.9
Professional degree (M.D., J.D.)	8.2
Ph.D.	7.6
Not applicable / unknown	1.4

Note. While 2992 doctoral and master's students began the survey, there was evidence of gradual attrition throughout the survey, resulting in a loss of 355 respondents from the very first question to the last. The data in this table represent the valid percent of respondents for each question. Percentages may not sum to 100 due to rounding.

[a] The "Other visa" category includes those who are in the U.S. with a J-1 or H1-B visa, as well as those who marked "other visa".

[b] Individuals who marked more than one racial category on the survey were placed into the least prevalent racial category for the purpose of analysis. Students who identified as Native Hawaiian are includes with Asian/Pacific Islanders.

Table C1. (continued) Demographic Description of the Sample

Survey Item	Percentage marking each response
What is the education level of your mother? (N=2637)	
HS diploma or less	23.5
Any undergraduate experience	49.4
Master's	19.3
Professional degree (M.D., J.D.)	3.7
Ph.D.	3.1
Not applicable / unknown	1.0
What is your partnership status? (n=2639)	
Single	60.8
Married/partnered	39.2
Is your partner in a science field?[c] *(N=1032)*	
Yes	41.5
No	58.5
Do you have one or more dependent children? (N=2644)	
At least one dependent	9.6
No dependents	90.4
If you have any dependents, how many do you have?[d]	
0-5 years old (n=182)	
1 child	76.9
2 children	19.8
3 or more children	3.3
6-18 years old (n=62)	
1 child	60.0
2 children	33.3
3 or more children	6.7
19 years or older (n=35)	
1 child	68.6
2 children	17.1
3 or more children	14.3
Age of respondent at time of survey (N=2599)	
23 or under	21.1
24	14.3
25	14.4
26	13.3
27	10.7
28	6.3
29	4.7
30	3.3
31-35	8.6
36 or older	3.3

[c] Includes only those who indicated that they were partnered or married.
[d] Respondents were able to mark multiple categories of dependents' ages, and thus these values do not sum to the total number of respondents who had at least one dependent (n=254).

Table C2. Enrollment Characteristics of the Sample

Survey Item	Percentage marking each response
What is your primary field of study? (N=2924)	
Agricultural/food chemistry	1.1
Analytical chemistry	9.1
Biochemistry	7.7
Chemical biology	4.8
Chemical education	1.8
Chemical engineering	5.6
Chemical toxicology	0.7
Colloid & surface chemistry	2.1
Computational chemistry	3.6
Electrochemistry	1.8
Environmental chemistry	4.8
General chemistry	0.4
Geochemistry	0.8
Inorganic chemistry	11.3
Materials chemistry	9.0
Medicinal/pharmaceutical chemistry	4.1
Nuclear chemistry	1.2
Organic chemistry	15.6
Physical chemistry	6.8
Polymer chemistry	5.5
Theoretical chemistry	1.6
Other[a]	0.8
Number of years enrolled in your current degree program (N=2975)	
Doctoral students (n=2736)	
Less than one year	3.7
One year	17.2
Two years	18.4
Three years	19.9
Four years	21.5
Five years	12.2
Six years	4.3
Seven or more years	2.6
Master's students (n=239)	
Less than one year	10.9
One year	44.4
Two years	25.1

Note. The data in this table represent the valid percent of respondents for each question. Percentages may not sum to 100 due to rounding.

[a] "Other" fields of study (asked as an open-ended response option in this survey question) include: atmospheric, catalytic, and cosmetic chemistry; biophysics; and non-chemistry-related fields.

Table C2. (continued) Enrollment Characteristics of the Sample

Survey Item	Percentage marking each response
Master's students (continued)	
Three years	10.5
Four years	6.3
Five or more years	2.9
Years of graduate study needed to complete your… (N= 2932)	
Doctoral students: Doctoral degree (n=2698)	
Less than one year	13.4
One year	27.2
Two years	21.2
Three years	17.0
Four years	14.3
Five years	5.7
Six or more years	1.0
Master's students: Master's degree (n= 234)	
Less than one year	32.5
One year	51.7
Two years	11.5
Three years	2.6
Four or more years	1.7
Asked of doctoral students only: Do you plan to do a postdoctoral position upon completion of your degree? (N=2697)	
Yes	40.0
No	19.2
Unsure	40.8
Asked of Master's students only: Do you plan to continue in a Ph.D. program upon completion of your master's degree? (N=232)	
Yes	33.2
No	30.6
Unsure	36.2
Are you currently in a research group? (N=2788)	
Yes	94.6
No	5.4
Do you currently have a primary research advisor? (N=2774)	
Yes, one advisor	87.0
Yes, two advisors	9.7
No (no advisor)	3.4

Appendix D: Additional Methodological Details.

Pilot Survey

Prior to the present study, ACS conducted a pilot survey of its graduate student members from Nebraska and Oregon in January 2013, in order to test survey functionality and clarity. The pilot consisted of 37 questions developed with input from the advisory committee and two focus groups of graduate students. The survey was sent electronically to ACS members listed as current graduate students in the ACS database in these two states. A total of 63 out of 231 responded to the pilot survey, and the survey respondents represented 12 institutions. Three out of 63 identified themselves as no longer enrolled in graduate school and four dropped out of the survey within the first few questions, resulting in a total of 56 respondents (16 women, 40 men) who completed the pilot survey. As an incentive for participating in the survey, students were offered the chance to win a $100 gift card. These students were not excluded from the invitation to complete the main survey.

In addition to responding to the survey questions, students taking the pilot were asked to evaluate survey functionality, language ambiguity, and their satisfaction with the length of time required to complete the survey. Based on analysis of the responses, the survey was modified to improve usability and question clarity. The survey design was changed to include branching questions and open-ended options, while eliminating some write-in responses.

Final Survey Data Validation and Cleaning

Following administration of the main survey in August/September 2013, a series of data validation and "cleaning" steps were conducted in order to prepare the data for analyses. First, to specify the institutions included in the sample, students' responses to the question "At which institution are you currently enrolled?" were examined. Respondents could mark their institution from an extensive drop-down menu of institutional names, or enter their institution's name in an open-ended comment box if their institution was not represented on the menu. A total of 188 students wrote in their institution's name. Fifty-one responses (representing 33 institutions) were recoded to match institutions already on the list; an additional 57 U.S. institutions were new to the list. The final institutional count included 269 U.S. institutions.

This process was repeated with respondents who wrote in their field of study (n=137) in response to the question "What is your primary field of study?" Write-in responses for the most part were recoded to match existing fields on the accompanying drop-down survey menu. The final list included 26 unique fields of study plus an "other" category (which included primarily non-chemistry disciplines). (See Appendix C).

Prior to data analysis, missing values were examined to determine if there was a pattern to the missing data. Over the course of the survey—from the first item to the last—355 individuals dropped out, which represents approximately 12 percent of the total sample. After examining the responses, it was determined that attrition happened throughout the survey and did not represent

a consistent pattern related to individual characteristics or certain survey items. As the data analysis was limited to descriptive statistics, missing values were not imputed. Thus, all data reported represent the valid responses for a given question.

Further data cleaning included small modifications such as recoding calendar years into "years of study" or "age." Finally, in order to examine how many institutions offered resources such as TA training and safety training, and benefits such as health insurance, the survey data were aggregated to the level of the institution based upon each respondent's institutional affiliation. The percentage of institutions where at least one student indicated that "yes, this benefit/resource is offered at my campus" was then tabulated. While a single institution may have had two students indicating "yes, this benefit/resource is offered" and "no, this benefit/resource is not offered", respectively, the "yes" response indicated evidence that the institution offered the resource/benefit for the purpose of these analyses.

Analyses of Sub-Group Differences

The goal of this investigation was to better understand the relationships that graduate students in the chemical sciences have with their research advisors, examine their sources of financial and emotional support, and learn about their career preparation and planning. These research objectives lent themselves to descriptive analysis of the respondents as a whole. However, comparative analysis between groups was performed where appropriate. Specifically, these between-group differences focused on differences by degree (master's and doctoral) and differences by gender (men and women), in order to facilitate comparisons to the national population. Where master's and doctoral student responses differed in notable ways, we also examined gender differences within groups (e.g. male and female master's students). In these cases, differences were tested within the degree type, but not across gender (e.g. female master's and doctoral students were not compared). Additional comparative analyses, including examinations by year in program, age, citizenship status, and underrepresented racial/ethnic minority (URM) status, were conducted as deemed relevant.

In order to determine if between-group differences were statistically significant, a number of statistical tests were utilized. Depending on the survey item, these included independent sample t-tests, z-tests for proportions, and/or Pearson's chi-squared test for independence. For these tests, a p-value of less than .05 denoted statistical significance (the size of a given difference also was considered to guide understanding of variation—however, effect sizes were not formally computed for the purpose of this report). Chi-squared tests were used primarily to determine if responses across ordinal or nominal response categories were distributed differently between groups. In a case where there were more than two response options and the overall distribution was significantly different, z-tests were used to determine if the proportions for specific response options (e.g. "extremely important") differed between groups[1]. Finally, when comparing means between groups, independent sample t-tests were used. Statistical tests were robust in the face of differing sample sizes. In the body of the report, all noted differences between groups are significant at $p<.05$.

[1] Sheskin, D. J. *Handbook of Parametric and Nonparametric Statistical Procedures,* 3rd ed.; Chapman & Hall/CRC: Boca Raton, FL, 2004.

Appendix E. Additional Disaggregation by Gender and/or Degree.

Tables in this appendix serve to supplement the tables in the main report document. Where statistically significant differences between degree type or gender were noted in the main report, tables are included in this appendix. Where no significant differences were found, tables are not included. Z-tests for differences in proportions, chi-square, and t-tests of the means were used to determine if results were statistically significant. These tests are explained in detail in Appendix D. In the tables below, asterisks are used to indicate significant differences ($p<.05$). Where space did not allow for an additional column, the significance notation (*) is located near the higher of the two results being compared.

The tables below are numbered to correspond to their respective table in the main report document. Where more than one table is related the main document, they are titled alphabetically (e.g. Table E2a, E2b, etc.).

Table E2a. Doctoral Students' Current Career Interests and Change in Interests Since Entering Degree Program, by Gender (N=2424[a])

	Women			Men		
Career	Percentage of respondents who are currently "very interested"	Percentage change in interest for all respondents: Increase	Percentage change in interest for all respondents: Decrease	Percentage of respondents who are currently "very interested"	Percentage change in interest for all respondents: Increase	Percentage change in interest for all respondents: Decrease
Professor (emphasis on research)	15.5	17.8	43.3	32.9*	25.2	36.0
Professor (emphasis on teaching)	31.1*	31.1	23.0	26.3	24.2	22.8
Researcher in industry	45.6	41.0	10.3	47.3	41.2	8.6
Researcher at government agency or national lab	45.4	47.0	8.5	45.6	43.9	7.0
Researcher (not professor) in college / university	14.3	19.1	16.6	14.1	17.8	18.3
Administrator/manager in industry	19.1	27.3	8.4	19.1	25.2	11.3
Administrator/manager in government	15.3	25.2	8.5	14.1	20.8	12.3
Administrator/manager in a college / university	10.0*	16.9	13.1	8.8	13.5	19.4
Administrator/manager in a non-profit organization	12.5*	18.4	9.1	7.2	12.0	16.5
K-12 educator or administrator	6.5*	14.9	16.3	3.2	6.5	22.7
Starting your own company	8.8	19.8	13.1	20.9*	29.8	11.6

[a] Women n=1171, Men n=1253

* $p<.05$; Comparing percentage of women vs. men who are currently "very interested" in a certain career.

Table E2b. Masters Students' Current Career Interests and Change in Interests Since Entering Degree Program, by Gender (N=204[a])

	Women			Men		
	Percentage of respondents who are currently "very	Percentage change in interest for all respondents		Percentage of respondents who are currently "very	Percentage change in interest for all respondents	
Career	interested"	Increase	Decrease	interested"	Increase	Decrease
Professor (Emphasis on research)	10.3	20.2	26.3	28.2*	27.7	22.9
Professor (Emphasis on teaching)	20.7	25.4	16.7	28.6*	31.7	23.2
Researcher in industry	40.2	29.2	8.8	58.1*	46.3	12.2
Researcher at government agency or national lab	51.3	38.6	5.3	58.1	48.2	6.0
Researcher (not professor) in college / university	19.5	17.5	15.8	27.9*	22.9	19.3
Administrator/Manager in industry	28.4	28.6	10.7	25.0	31.7	14.6
Administrator/Manager in government	25.9	25.0	9.8	27.1	32.9	15.9
Administrator/Manager in a college / university	15.5	16.1	15.2	15.3	16.0	22.2
Administrator/Manager in a non-profit organization	10.4	15.9	13.3	11.8	13.4	20.7
K-12 educator or administrator	8.8	14.3	20.5	10.6	13.4	26.8
Starting your own company	8.6	20.2	19.3	26.7*	36.1	10.8

[a] Women n=118, Men n=86

* p<.05; Comparing percentage of women vs. men who are currently "very interested" in a certain career.

Table E3. "Internal" Factors Important to Students' Choice of Careers, by Gender (N=2651[a]).

	Percentage marking "very or extremely important"			
Factors	All respondents	Women	Men	Sig.
Having job security	83.0	83.2	82.7	
Having a job that gives me time for family, friends, and hobbies	80.8	84.3	77.5	*
Finding a job that offers advancement opportunities	77.0	75.3	78.7	
Finding a well-paying job	68.5	65.6	71.2	*
Changing intellectual interests	49.6	47.9	51.3	
Desire to have a job in a certain geographical location	45.0	47.6	42.4	*

[a] Women n=1301, Men n=1350

* p<.05

Table E4. "External" Factors Influencing Students' Choice of Careers, by Gender (N=2656[b]).

Factors	Percentage marking "very or extremely important"			
	All respondents	Women	Men	Sig.
Job prospects in your field	74.2	76.4	71.2	
Partner's professional circumstances[a]	61.9	68.3	56.3	*
Encouragement by an advisor or mentor to pursue a specific career goal	46.7	45.7	47.7	

[a] Women n=1302, Men n=1354
[b] Only includes responses from those who indicated that they had a partner (All N=1032, women n=483 men n=545).
* p<.05

Table E5a. Usefulness of Career Resources, by Degree Type (N=2779[a]).

Resources	Percentage marking "Useful"[b]				Percentage marking "Not Useful"			
	All	Ph.D.	Master's	Sig	All	Ph.D.	Master's	Sig
Professional Conferences/Meetings	84.7	85.3	77.2		5.7	5.4	9.6	*
Search Engine	87.6	87.2	92.2		6.5	6.8	3.2	*
Other Networking Events	76.2	75.9	77.4		6.5	6.6	5.5	*
Career Resources for a Scientific or Professional Conference	79.2	79.1	80.9		10.3	10.4	10	
LinkedIn	62.9	62.7	65.3		16.2	16.5	12.8	*
Career Development / Counseling Center	56.2	56.3	55.5		23.9	23.5	27.7	*
Graduate Studies Office at Your Institution	51.7	51.8	49.5		30.5	30.3	33.2	
Blogs	34.5	62.7	28.4	*	31.4	31.5	29.8	
Other Online	32.4	28.0	33		23.4	23.7	20.6	*
Facebook	28.2	28.0	31.5	*	51.0	51.7	42.5	*
Twitter	17.4	18.5	17.6		44.5	44.7	43.1	

[a] PhD Students: n = 2559; Master's students: n = 220
[b] Useful" includes "extremely useful," "very useful," "moderately useful," and "slightly useful" response options. Table omits students who responded "na."
* p<.05

Table E5b. Usefulness of Career Resources, by Gender (N=2632[a]).

Resources	Percentage marking "Useful"[b] All	Women	Men	Sig.	Percentage marking "Not Useful" All	Women	Men	Sig.
Professional Conferences/Meetings	84.7	85.9	84.1		5.7	4.0	7.1	*
Search Engine	87.6	87.3	88.5		6.5	6.5	6.2	
Other Networking Events	76.2	74.4	77.9		6.5	4.9	8.2	*
Career Resources for a Scientific or Professional Conference	79.2	80.0	79.0		10.3	8.8	11.9	*
LinkedIn	62.9	63.3	63.1		16.2	13.4	18.6	*
Career Development / Counseling Center	56.2	54.9	58.1		23.9	23.3	24.2	
Graduate Studies Office at Your Institution	51.7	49.1	53.7	*	30.5	30.9	30.6	
Blogs	34.5	32.3	36.7	*	31.4	28.1	34.0	*
Other Online	32.4	28.0	36.1	*	23.4	20.4	25.8	*
Facebook	28.2	26.6	29.5	*	51.0	51.2	51.1	
Twitter	17.4	16.0	20.3	*	44.5	42.0	47.0	*

[a] "Women: n = 1290; Men: n = 1343

[b] Useful" includes "extremely useful," "very useful," "moderately useful," and "slightly useful" response options. Table omits students who responded "na ."

* p<.05

Table E6. Confidence in Career Preparation, by Degree Type and Gender (N=2806[a]).

	All	Women	Men	Sig.
Making informed career decisions [b]				
Doctoral students (n=2585)	2.96 (1.01)	2.77 (0.98)	3.12 (1.01)	*
Masters students (n=221)	3.32 (1.05)	3.32 (1.08)	3.33 (1.02)	
Navigating the job market [b]				
Doctoral students (n=2447)	3.11 (0.98)	2.93 (0.97)	3.25 (0.97)	*
Masters students (n=207)	3.31 (1.03)	3.18 (0.97)	3.54 (1.05)	*
Building a career [b]				
Doctoral students (n=2445)	3.40 (0.98)	3.24 (0.98)	3.54 (0.96)	*
Masters students (n=207)	3.64 (0.97)	3.51 (0.97)	3.85 (.95)	*

[a] Women: n = 1300; Men: n = 1354

[b] 5 point scale: 5 = extremely prepared, 1 = not at all prepared

* p<.05

Table E7a. Ratings of Behaviors of Primary Advisor (For Those Students with One Advisor[1]), by Gender (N=2299[a])

Behavior of advisor	Percentage indicating that each behavior is descriptive of advisor to a "considerable" or "very great" extent.		
	All Students	Men	Women
Gives the appropriate level of credit to me for my research contributions	77.6	78.9	76.3
Encourages me to take on challenging opportunities	73.6	77.0*	70.1
Encourages me to attain my goals	72.3	74.6*	69.9
Asks me to write the first drafts of scientific manuscripts	72.2	73.8	70.6
Gives regular feedback on my research	68.1	70.7*	65.3
Models good professional relationships	67.0	67.9	66.1
Advocates for me	66.0	68.1	63.8
Encourages me to present our research at scientific conferences	65.8	68.4*	62.9
Creates an environment where all group members are treated fairly	63.4	65.8*	60.9
Supports my career path of choice	59.4	61.4*	57.3
Takes time to learn about my background, interests, and/or personal relationships	47.9	49.0	46.7
Gives regular feedback on my progress towards degree completion	44.8	46.7*	42.8
Helps me to develop professional relationships	43.3	45.7*	40.8
Provides information about academic career paths	38.8	40.5*	37.0
Engages me in writing grant proposals	33.0	35.6*	30.3
Provides information about non-academic career paths	25.8	26.9*	24.7

[a] Men: n = 1179; Women: n = 1112

* $p<.05$

[1] This table is reproduced in Appendix E to allow for statistical differences to be noted on the table itself.

Table E7b. Ratings of Behaviors of Primary Advisor (For Those Students with One Advisor) (N=2362[a])

Behavior of advisor	Percentage indicating that each behavior is descriptive of advisor to a "considerable" or "very great" extent.		
	All Students	Ph.D. students	Master's students
Gives the appropriate level of credit to me for my research contributions	77.6	77.8*	71.2
Encourages me to take on challenging opportunities	73.6	74.2*	67.3
Encourages me to attain my goals	72.3	72.6	68.0
Asks me to write the first drafts of scientific manuscripts	72.2	73.8*	46.6
Gives regular feedback on my research	68.1	67.7	70.1
Models good professional relationships	67.0	67.0	68.3
Advocates for me	66.0	66.7*	55.9
Encourages me to present our research at scientific conferences	65.8	65.9	63.0
Creates an environment where all group members are treated fairly	63.4	63.5	68.0
Supports my career path of choice	59.4	59.2	63.2
Takes time to learn about my background, interests, and/or personal relationships	47.9	47.7	51.0
Gives regular feedback on my progress towards degree completion	44.8	44.1	55.8*
Helps me to develop professional relationships	43.3	43.5	39.0
Provides information about academic career paths	38.8	38.4	44.8
Engages me in writing grant proposals	33.0	33.4*	22.4
Provides information about non-academic career paths	25.8	25.3	34.7*

[a] Ph.D. students: n = 2215; Master's students: n = 147
p<..05

Table E8. Ratings of Relationship with Primary Advisor, by Gender (N=2291[a])

	Percentage marking "to a considerable/very great extent"			
	All respondents	Women	Men	Sig
I am satisfied with the amount and quality of time spent with my primary advisor.	71.6	69.5	73.6	
My primary advisor is satisfied with my research productivity.	81.2	81.6	80.8	
My primary advisor is satisfied with my progress toward degree completion.	82.2	82.3	82.1	
I get along well with my primary advisor.	85.4	84.4	86.4	
My primary research advisor is out of touch with the career issues that graduate students face.	29.5	27.9	31.0	*
My primary advisor sees me as a top student.	61.5	57.9	64.8	*

[a] Women n=1112, Men n=1179
* p<.05

Table E9a. Male Doctoral Students' Current and Ideal Amount of Support (N=1256)

Source of support	Percentage indicating they currently have [a]: "A lot of" support	Percentage indicating they currently have [a]: "None" or "moderate" support	Percentage marking "none" or "moderate" who want a greater amount of support
Primary research advisor	32.0	65.7	4.3
Other grad students (at current institution)	26.8	71.5	7.1
Postdocs (at current institution)	18.1	68.6	5.4
Professional colleagues (not at current institution)	9.9	82.3	4.8
Other sources of support [b]	7.8	22.1	2.8
Administrators or staff members (at current institution)	10.5	85.0	4.6
Other faculty (at current institution)	8.6	88.3	0.0

Note: Significant differences between genders for this item are located in the main body of the report.
[a] Percentage of respondents who marked "N/A" are not reported.
[b] Respondents wrote in "partner/spouse", "family", "alumni", "friends", and "professional organizations", among other sources; n= 269.

Table E9b. Female Doctoral Students' Current and Ideal Amount of Support (N=1172)

Source of support	Percentage indicating they currently have [a]: "A lot of" support	Percentage indicating they currently have [a]: "None" or "moderate" support	Percentage marking "none" or "moderate" who want a greater amount of support
Primary research advisor	28.0	70.2	3.5
Other grad students (at current institution)	30.3	68.4	7.3
Postdocs (at current institution)	15.5	69.1	4.8
Professional colleagues (not at current institution)	12.7	78.0	6.1
Other sources of support [b]	12.7	20.2	2.1
Administrators or staff members (at current institution)	9.7	84.3	4.6
Other faculty (at current institution)	7.9	88.9	0.0

Note: Significant differences between genders for this item are located in the main body of the report.
[a] Percentage of respondents who marked "N/A" are not reported.
[b] Respondents wrote in "partner/spouse", "family", "alumni", "friends", and "professional organizations", among other sources; n=250.

Table E9c. Master's Students' Current and Ideal Amount of Support (N=209)

Source of support	Percentage indicating they currently have [a]: "A lot of" support	Percentage indicating they currently have [a]: "None" or "moderate" support	Percentage marking "none" or "moderate" who want a greater amount of support
Primary research advisor	29.3	55.8	7.0
Other grad students (at current institution)	27.8	65.1	14.4
Postdocs (at current institution)	8.1	50.2	5.5
Professional colleagues (not at current institution)	14.1	67.8	8.2
Other sources of support [b]	7.8	9.4	0.0
Administrators or staff members (at current institution)	8.6	81.3	10.6
Other faculty (at current institution)	12.5	80.3	0.0

Note: Significant differences between degree types for this item are located in the main body of the report.
[a] Percentage of respondents who marked "N/A" are not reported.
[b] Respondents wrote in "partner/spouse", "family", "alumni", "friends", and "professional organizations", among other sources; n=64.

Table E12a. Funding Sources for Students who Agree or Disagree that Their "Graduate Funding is Adequate to Meet the Cost of Living where [They] Live", by Degree Type (N=2383)

	Proportion of funding for students who say their funding is adequate[a]			Proportion of funding for students who say their funding is inadequate[b]		
	Ph.D.	Master's	Sig.	Ph.D.	Master's	Sig.
Teaching Assistantships	35.5	28.3		42.2	28.4	*
Research Assistantships	37.3	26.9		30.4	12.9	*
Fellowship/Scholarships	21.8	13.5	*	13.0	3.9	*
Loans and Other Support[c]	3.4	27.4	*	12.7	48.6	*
Do not Wish to Respond	1.9	4.0	*	1.9	6.3	*

Note: Omits "neither agree/disagree" responses
[a] Students who indicate funding is adequate, n=1779,Ph.D students. n=1699, Master's students n=80
[b] Students who indicate funding is inadequate n=604, Ph.D. students n=519, Master's students n=85
[c] Other support includes: Loans, Other Paid Employment, Personal Savings, Income from a Spouse/Partner, Familial Support, and Other.

Table E12b. Funding Sources for Doctoral Students who Agree or Disagree that Their "Graduate Funding is Adequate to Meet the Cost of Living where [They] Live", by Gender (N=2205)

	Proportion of funding for students who say their funding is adequate[a]			Proportion of funding for students who say their funding is inadequate[b]		
	Women	Men	Sig.	Women	Men	Sig.
Teaching Assistantships	36.7	34.6	*	44.8	39.3	
Research Assistantships	34.3	40.4	*	25.4	35.4	*
Fellowship/Scholarships	23.8	19.8	*	14.7	13.3	
Loans and Other Support[c]	3.3	3.3		12.0	17.0	*
Do not Wish to Respond	1.9	1.9		3.1	0.6	

Note: Omits "neither agree/disagree" responses
[a] Doctoral students who indicate funding is adequate, n=1687,Women n=832, Men n=855
[b] Doctoral students who indicate funding is inadequate n=518, Women n=259, Men n=259
[c] Other support includes: Loans, Other Paid Employment, Personal Savings, Income from a Spouse/Partner, Familial Support, and Other.

Table E13. Likelihood of Graduate Degree Completion and Remaining in Chemical Sciences after Graduation, by Degree Type and Gender (N=2656)

	Percentage reporting they "definitely will" complete their degree		Percentage reporting they are "extremely" or "very" likely to stay in the chemical sciences after graduation	
	Women	Men	Women	Men
Doctoral students (n=2449[a])	73.4	79.8*	76.6	79.6
Master's students (n=207[b])	87.5	90.8	72.5	75.9

[a] women n=1182, men n=1267
[b] women n = 120, men n=87
* p<.05; Comparing women to men, within each item using z-test for proportions.