Objective. To examine the landscape of research and graduate affairs nationally and within schools and colleges of pharmacy. This report, part 2 of a three-part series, focuses on characteristics of full-time PhD enrollees and graduates in schools and colleges of pharmacy, and career planning and preparation in graduate programs.

Findings. Despite a 41% increase in funding awarded by the National Institutes of Health (NIH) to schools and colleges of pharmacy over the last 10 years, NIH funding per principal investigator only increased 14% and graduate student enrollment increased just 6% during the period. However, there was a 15% increase in PhD degrees conferred in the 10-year period, which is evidence that degree completion time decreased. The number of female graduates from pharmacy schools consistently increased, and outpaced growth in the number of male graduates by more than 10%. Most graduate programs do not include training for industry-specific skills, abilities, and experiences to better prepare graduates for nonacademic careers, although national programs have been recognized as vital to graduate student career preparation.

Summary. Graduate biomedical science programs and faculty members must recognize that academia is an “alternative” career choice for their trainees, and provide job skills training to support the majority of nonacademic career choices, without compromising the rigorous training in basic biomedical disciplines.

Keywords: graduate, training, workforce, skills, career

INTRODUCTION

Graduate trainees are critical personnel that support the research programs of faculty mentors by producing and analyzing data that lead to manuscripts that, in turn, allow the development of new research grants or continuation of existing funding streams that support positions for future trainees. Research faculty members expect trainees to prioritize research and allow them limited time for other career development experiences. If graduate programs rounded out “traditional” experiences with development of critical skills such as grant writing, budget management, and hiring and firing laboratory personnel, trainees would be better prepared to enter academia or other careers. However, academic careers are not the predominant choice of those earning PhD degrees. Even 25 years ago, only 40% of those with a PhD in the biomedical sciences were tenure-track or tenured faculty members. The majority instead chose to enter the pharmaceutical and biotechnology industries.¹ The percentage of biomedical PhD graduates pursuing academic careers declined to less than 30% by 2008,² suggesting that academia is becoming merely an “alternative” career choice for this group. However, this is not broadly acknowledged by graduate biomedical science faculty members. The challenge for programs is to provide job skills training to graduate students to support the majority that will choose nonacademic career choices without compromising the rigorous training in basic biomedical disciplines needed by those who choose academic careers.

The 1998 American Association of Colleges of Pharmacy (AACP) Commission on the Future of Graduate Education in the Pharmaceutical Sciences was charged to examine two major questions: What are the numbers and abilities of PhD graduates needed in the pharmaceutical sciences, and what should be the nature of the education and training of PhD students in the pharmaceutical sciences? Two of the major recommendations made by the Commission were that all schools and colleges of pharmacy with graduate programs should provide “survival skills” training to their graduate students, including research ethics, written and oral communication skills
development, teaching skills development, computer skills enhancement, career counseling, and research team building opportunities; and that schools and colleges of pharmacy need to increase their recruitment efforts for US students from disciplines other than pharmacy.

As described in first paper of this series, additional information on the current issues facing graduate education in schools and colleges of pharmacy were gathered by AACP’s Research and Graduate Affairs Committee (RGAC) from focus group discussions and through a customized survey. Both the focus group questions and the survey instrument were designed to collect data from the academic pharmacy community on the gaps in current knowledge about the status of graduate education, including postdoctoral training, in the academic pharmacy community. Overall, the goal of this data collection effort was to provide the most current snapshot possible of graduate education in US schools and colleges of pharmacy to inform the work of the RGAC and the pharmacy schools engaged in training the next generation of researchers.For these three reports, AACP Institutional Research data (available online to members) were mined regarding extramural research funding, graduate student enrollees, PhDs conferred, and student composition, including gender and race/ethnicity. Data on graduate enrollment, PhDs conferred, and demographics are reported annually by pharmacy schools, and compiled, analyzed, and summarized by the AACP. The authors also examined biomedical research and graduate education reports published in the last 10 years.1 Many reviews of graduate science education focus on a number of changes that need to occur to ensure its sustainability, accountability, and success. These include better aligning the “graduate student research experience” and the current and future workforce needs for nontraditional biomedical careers. The National Institutes of Health (NIH), American Chemical Society,4 and National Science Foundation5 all recommended changes that included not only an infusion of “professional non-research skills” (also known as “soft skills”) into graduate education programs, but also the importance of a team science focus to address the “big issues” in science and public health.

OBJECTIVE

This article is the second part of a series of three articles describing the graduate research landscape in schools and colleges of pharmacy from various perspectives: programs and faculty members, students and graduates, and diversity. Objectives were to summarize changes in the demographics of full-time PhD enrollees and PhD graduates in pharmacy schools over a 10-year period from FY2008 to FY2017, and address issues with career preparation and training for a contemporary workforce of biomedical scientists.

FINDINGS

The full-time enrollment of PhD students in schools and colleges of pharmacy from FY2008 through FY2017 are presented in Table 1. The number of enrolled doctoral students increased by just 6% over 10 years (2,909 to 3,098), despite the fact that NIH dollars awarded to principal investigators (PIs) at increased 31% (from $263M to $343M), and total NIH awards increased by 41% (from $290M to $410M). During this same period, there was also a 36% increase in the number of full-time faculty members (4,631 to 6,319) and a 52% increase in pharmacy schools reporting research funding (from 63 to 96). By comparison, PharmD enrollments increased 20% (from 52,685 to 63,087) over the 10-year period.

Demographics of Enrollees and Graduates

The proportion of male and female full-time PhD enrollees in schools and colleges of pharmacy from FY2008 through FY2017 is shown in Table 1. Although the total number of enrollees increased by 189 students over 10 years, the gender distribution over this period remained essentially unchanged. Over this 10-year period, the percentage of female to male graduate students has ranged from 50% to 53% male and 47% to 50% female. Female enrollment over the last 10 years has been consistent, with relatively the same increases as those for male students.

The PhD degrees awarded from FY2008 through FY2017 in schools and colleges of pharmacy are shown in Table 2. During this 10-year period, the number of female graduates increased by 17% (from 206 to 241), and the

Table 1. Full-Time Student Enrollment in PhD Programs by Gender*

|          | FY2008 | FY2009 | FY2010 | FY2011 | FY2012 | FY2013 | FY2014 | FY2015 | FY2016 | FY2017 |
|----------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| Male     | 1497   | 1479   | 1535   | 1617   | 1705   | 1650   | 1635   | 1743   | 1738   | 1597   |
| Female   | 1412   | 1450   | 1516   | 1492   | 1561   | 1444   | 1451   | 1551   | 1612   | 1499   |
| Total    | 2909   | 2929   | 3051   | 3109   | 3266   | 3094   | 3086   | 3294   | 3350   | 3098   |
| Female, %| 48.5   | 49.5   | 49.7   | 48.0   | 47.8   | 46.7   | 47.0   | 47.1   | 48.1   | 48.4   |

* American Association of Colleges of Pharmacy reports by year noted, Enrollments - Profile of Pharmacy Students
number of male graduates increased by 13% (from 262 to 296). The gender distribution of graduates over this 10-year period remained essentially unchanged (~45% female), except in 2013 where the numbers of female and male graduates were approximately even. There have been consistent positive increases in the number of female PhD graduates, but more effort is needed.

According to the Survey of Earned Doctorates (SED), an annual assessment of all individuals completing a research doctorate in one of 331 fields of study from a US academic institution during the period from July 1, 2016, to June 30, 2017, nearly all (98%) of the research doctorate recipients surveyed in 2017 earned a PhD, and 91% completed the survey. There were 54,664 research doctorate degrees awarded in US institutions in 2017, of which 41,438 (76%) were in science and engineering fields (including life sciences, physical sciences and earth sciences, mathematics and computer sciences, psychology and social sciences, and engineering). Life sciences degrees comprise 30% (12,592) of the science and engineering doctorates earned in 2017. One of several subcategories within the life sciences group is biological and biomedical sciences, which comprises 67% (8,477) of the 2017 life sciences doctorates or 16% of all doctorate degrees earned in 2017. At the same time, there were 537 doctorate degree recipients from pharmacy schools, representing one percent of the SED total or 6% of the 2017 earned doctorates in the biological and biomedical sciences.

Over a 10-year period between 2008-2017, the number of earned doctorates in the biological and biomedical sciences increased by nearly 9% (from 7,797 to 8,477) according to the SED. Meanwhile the number of PhD degrees conferred by schools and colleges of pharmacy grew nearly twice as fast in the same 10-year period (15%), likely because of the increase in the number of new pharmacy schools, expanded or new graduate programs, and increases in overall institutional research funding.

In terms of gender, the SED data showed that, in 2017, female students earned 47% of all research doctorates and 53% of those in the SED subcategory of biological and biomedical sciences. Comparatively, 46% of PhD graduates from pharmacy schools in FY2017 were female, and trend data indicate this has remained largely unchanged for at least the last 10 years. The numbers of enrollees to and graduates from schools and colleges of pharmacy have continued to outpace national growth year after year. Although the pipeline of graduates continues to grow, targeted efforts are needed to achieve gender equity.

Career Training and Destinations
The NIH Biomedical Workforce Report provides insight on the primary careers for biomedical and life sciences graduates: in 1993, 34% of biomedical PhDs entered into either tenured or tenure-track faculty positions but by 2014 it declined to 26%. Furthermore, 25% of those with a PhD conduct research in industry or government settings and 20% work in science-related occupations but do not conduct research. The percentages of people with biomedical PhD degrees in industry and government have remained relatively constant as well. The following section provides a summary of the career placements for graduates from schools and colleges of pharmacy.

The AACP collects postgraduation data for PharmD graduates, but at this time AACP does not collect PhD program verified data regarding careers. Nonetheless, through its survey instrument, the RGAC collected non-verified data on career placements of graduates over a five-year period (2009-2014). The total number of graduates captured through the survey was 1,884, or 73% of the total PhD graduates based on AACP data from all graduate programs at schools and colleges of pharmacy for the time period.

As expected, the two major career destinations following completion of PhD degrees and postdoctoral fellowships were academia (42%) and the pharmaceutical industry (43%). The federal government was the third career destination, with 6%, and 9% other/unknown. These survey data were consistent with the 2014 SED report, which found the proportions entering academia, industry, and government were 41%, 38% and 1%, respectively. Also according to the RGAC survey, 504 PhD graduates entered postdoctoral training in academia from 2009-2014; an additional 249 trainees were postdoctoral

| Variable | FY2008 | FY2009 | FY2010 | FY2011 | FY2012 | FY2013 | FY2014 | FY2015 | FY2016 | FY2017 |
|----------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| Male     | 262    | 228    | 243    | 250    | 275    | 293    | 298    | 312    | 297    | 296    |
| Female   | 206    | 230    | 207    | 221    | 222    | 296    | 267    | 249    | 250    | 241    |
| Total    | 468    | 458    | 450    | 471    | 497    | 589    | 565    | 561    | 547    | 537    |
| Female, (%) | 44.0  | 50.2   | 46.0   | 46.9   | 44.7   | 50.3   | 47.3   | 44.4   | 45.7   | 44.9   |
fellows in nonacademic training programs during the same period. For postdoctoral fellows, from 2009-2014 the percentages entering academia, industry, and government were 42%, 38%, and 1%, respectively.

According to the SED report, in 2014, approximately 47% of doctoral graduates in the life sciences entered academia. However, from 2005-2014, the rate of academic employment in life sciences declined by more than five percentage points. In addition, according to the NIH Biomedical Workforce Report, the proportion of biomedical PhD graduates that entered into either tenured or tenure-track faculty positions declined to 26% as of 2014. Another 25% of PhD graduates conducted research in industry or government settings, and 20% were in science-related occupations but did not conduct research.

As part of data gathering for this report, the authors examined the findings of the RGAC focus group of deans and associate deans of research to gain their perspective on major issues and trends impacting graduate education in schools of pharmacy. The following question generated a discussion on the financial debt of graduate students. “What are some of the major ‘trends’ in the environment that are either positively or negatively impacting graduate and postgraduate fellowship programs?” The focus group discussed points around financing graduate education as it related to stipend levels and costs to students entering graduate school. The comments ranged from debt as an impediment for recruiting PharmD students into PhD pathways, low graduate student stipends, recruitment of URMs, and concerns regarding the emphasis on recruiting a higher percentage of domestic students to meet requirements of NIH training grants (specifically, NIH T32 grants).

In response to the RGAC graduate student survey, schools and colleges of pharmacy reported several funding mechanisms used to support graduate student stipends and tuition. These include funding from the department, school, or university (teaching or graduate assistantships), as well as external awards from the federal government and science-based foundations. These funding models are consistent with the SED survey report that states proportions of funding sources for Life Sciences graduate programs in the STEM disciplines: 12% teaching assistantships, 33% research assistants, 41% fellowships or grants, 9% students’ personal resources, and 5% other resources. Pharmacy schools use various funding sources to support graduate students, for both stipends and tuition, although prior student debt may be a deterrent for PharmD graduates entering graduate school. While the AACP survey results suggest that the career destination of PhD doctoral graduates over the last five years is approximately split between academia and industry, the RGAC focus group responses suggest that this does not reflect the current trend. When the focus groups were asked the following, “What are the major challenges and trends focused on student pipeline or pharmacy faculty?” one of the most repeated responses was, “Too many graduate students going into industry and not into academic careers.” National data supports this statement for biomedical/life sciences graduates. Less than half of US-trained biomedical PhDs go on to a career in academia. Further, research has shown a decreased interest in faculty careers over the time course of academic/research training.

According to the NIH Biomedical Workforce Report, longer residence time in PhD programs and postdoctoral fellowships is correlated with a decrease in the number of PhDs considering academia. From 2009-2014, in pharmacy, approximately 38% of postdoctoral fellows and 43% of graduate students entered careers in the industry. Although the number of graduates that have completed PhD programs in schools and colleges of pharmacy is reported to AACP, there was no verified data stating their first employment nor specific information providing insight on the drivers for certain career choices.

**DISCUSSION**

The issue concerning the optimal time required for PhD completion and subsequent training has been an ongoing debate among biomedical graduate programs. The NIH Biomedical Workforce Report addressed this issue as it relates to variability across programs and the use of NIH awards to support graduate student training. Upon examination, the workgroup recommended the following: that NIH cap the time for support of graduate students under various funding mechanisms, that the cap be an institutional average of five years, and that no one individual receive more than six years of NIH funding. In addition, the American Chemical Society’s (ACS) workgroup examining “advancing graduate education in the chemical sciences” recommended a four-year completion time for chemistry-focused PhD graduate programs. Both the NIH and ACS estimates for the time for completion of a PhD graduate program (four to seven years) are consistent with reported data from schools and colleges of pharmacy.

**The Culture Gap in Graduate Programs**

Next, we examined emerging issues regarding the structure of biomedical graduate programs, and the misalignment with the career destinations of current and prospective trainees. The curriculum, format, and experiences provided by biomedical graduate programs are not sufficient to prepare trainees for nonacademic
science-based positions. Why does an undeniable disconnect persist between the graduate training paradigm and career destination? Clearly, curricular changes are needed in graduate programs and these can be accomplished by using existing program models that have proven to be successful in contemporary career preparation. Existing norms, biases, and power structures may be challenging to overcome, but change is essential to remain competitive.

Graduate trainees are critical members of the research team that support the faculty mentor’s research program by producing data that lead to manuscripts and continued or new research grants. Research faculty members expect trainees to prioritize research; thus, they provide limited time for other career development experiences. While these “traditional” experiences provide a strong foundation in research and prepare them to enter academia after postdoctoral training, as noted, data suggest that the majority of graduates do not pursue an academic career path. To add to this disconnect, the nonacademic biomedical workforce is requiring prospective employees to have experiences that better align with the expectations and responsibilities of their workforce, such as communication skills, project management experience, cultural sensitivity, and teamwork skills.

Addressing this issue requires disruption of the traditional graduate education format to better focus on non-research skills without sacrificing rigorous scientific training. Unfortunately, the existing structure is firmly embedded in the culture of graduate programs in higher education. Academia is not the primary career destination of our graduates, and graduate students are very aware of its challenges including the rise in non-tenure track science faculty positions. Now more than ever PhD graduates are focused on pursuing employment in the nonacademic biomedical sector. Why is it that, while continuing to focus on training excellent scientists, graduate programs are not more responsive to preparing trainees for other career destinations (ie, workforce demands) and developing non-research skills that will best prepare graduate students for nonacademic careers? To that end, while continuing to focus on training excellent scientists, graduate programs must be responsive to the changing career destinations and address non-research skills that will best prepare graduate students for these nonacademic careers.

It is a fundamental obligation of faculty mentors to prepare their graduate trainees for a breadth of successful career paths. Therefore, it is no longer sufficient to simply acknowledge that nonacademic careers are where the majority of graduates enter the labor market, but take no action to address diverse workforce preparation. Graduate faculty members must proactively ensure the appropriate and well-rounded training of the scientists of the future, which may include locating and engaging “co-advisors” in different disciplines such as from the pharmaceutical industry to provide interprofessional training and guidance to PhD students with industry career interests.

The percentage of graduates entering the pharmaceutical and biotechnology industries increased from 2009-2014. However, most graduate programs have not incorporated course work, training opportunities, or internships to prepare graduates for industry careers. Graduate researchers who transition from academia-based research training to the industry face unanticipated challenges. In universities, schools, and departments, research decisions are ultimately the sole prerogative of the PI, and in some circumstances graduate students and postdocs have a level of autonomy. In contrast, in the pharmaceutical industry the structure is hierarchical and graduate students work in a large team where decisions are collaborative, involve senior executives, and are based on input from outside consultants, and sometimes built on criteria other than science.

Time management is another important cultural difference. In the pharmaceutical industry, there are annual objectives that are delineated and one’s performance is measured against those objectives; the emphasis is on short-term results that have direct commercial value. In academia, researchers, including graduate students and postdocs, have substantially more flexibility regarding deadlines, and the measurement of performance is often intangible or loosely defined. Although junior researchers who move to the private sector from academia are usually successful over time, these differences in culture can seriously impair their initial effectiveness and delay their career trajectory. The impact of this culture gap has not been quantified. Anecdotally, this topic is of significant interest among leaders in the biotechnology and pharmaceutical industry and major employers of the nonacademic biomedical workforce.

To adapt to a new and competitive environment, graduate programs should adjust their programs to better prepare students for these career destinations with training in industry-specific skills, abilities, and experiences. To this end, leadership and graduate faculty members in schools and colleges of pharmacy must take responsibility to change the curricula and the culture, and to shift to a student-centric focus to ensure that their trainees are both science ready and career ready.

Better Support for Graduate Students

Many factors impact graduate student career choices, and schools and colleges of pharmacy must...
address these in order to better align graduate training to emerging career destinations, including challenges such as length of the graduate/postdoctoral career and the structure of graduate biomedical education. This is a cultural, fundamental sea change that will be extremely difficult to address and implement because it requires additional skills and abilities for graduate students that are not a part of funded projects; hence, creating tension with the research mission and goals of graduate programs.

Faculty members are central to graduate education, providing training opportunities and preparing their trainees for the workforce. The NIH and NSF have created research programs specifically to determine best practices in graduate education to address the career destinations of trainees. These programs are the NIH Broadening Experiences in Scientific Training (BEST) program and the NSF Research Traineeship (NRT) program.

The BEST program is an effort by 17 institutions to explore ways of improving biomedical career development. A fraction of biomedical PhDs will take a tenure-track faculty position, so training programs are developing innovative approaches to prepare students and postdocs for a range of contemporary career options. The BEST consortium established fundamental philosophies that can serve as guides for transforming training to better reflect workforce needs. Those that resonate the strongest include: value the broad range of research-related careers open to early-career scientists; view these careers not only as legitimate, but also as essential to the scientific enterprise; and encourage active, time-efficient career development while maintaining high standards for research and not increasing the time it takes to receive a graduate degree or complete postdoctoral training. Just as important, the NIH BEST program will broadly share information, best practices, as well as unintended consequences learned through this initiative to support and enhance similar changes in graduate education programs.

The National Science Foundation Research Traineeship (NRT) Program is designed to encourage the development and implementation of bold, new, and potentially transformative models for STEM graduate education training. The NRT program includes two tracks: Traineeship Track and Innovations in Graduate Education (IGE) Track. The Traineeship Track is dedicated to effective training of STEM graduate students in high-priority interdisciplinary research areas, through the use of a comprehensive traineeship model that is innovative, evidence-based, and aligned with changing workforce and research need. The IGE Track focuses on test-bed projects aimed at piloting, testing, and validating innovative and potentially transformative approaches to graduate education. The BEST and NRT programs are the first federal efforts to systematically address transforming graduate education to ensure trainees are appropriately prepared for their careers. It will be important to track results and best practices outcomes from each of these programs as graduate education moves toward a new model of training.

Although national data indicates that academia is not a career destination for trainees, there is a consistent minority of our graduates interested in academia. Accordingly, graduate programs and these graduates are also interested in a more robust exposure to multidisciplinary research questions and this interest aligns well with NIH priorities. Concurrent with increasing contemporary experiences that prepare graduate students for nonacademic careers, programs must also embrace new paradigms to stimulate interest in the academic biomedical research mission. Multi-disciplinary experiences provide graduate students with a better understanding of the various facets of a research problem and can comprehensively address a research question. Through these experiences, graduate students are strategically exposed to the utility and importance of other disciplines so that they develop an understanding of “team science.” These approaches align well with national health care initiatives in interprofessional education and care.

The importance of team science has been a focus of the National Academies and NIH. The National Academies state that future progress in the biomedical sciences depends on the ability of researchers to engage more effectively in translational and interdisciplinary initiatives, involving teams of scientists from diverse disciplines and backgrounds. Further the NSF states that “the grand research challenges of today will not be solved by one discipline but a convergence of disciplines to stimulate innovation and diversity.”

As shown in Table 2 of part 1 of this series on graduate education, schools and colleges of pharmacy are involved in numerous interdisciplinary graduate programs. However, the extent of the interdisciplinary research interactions may vary depending on the principal investigator, their research team, and collaborators. The willingness for mentors to embrace “team science” is varied, limited, and informed by their research programs and its reliance on the traditional and overly discipline-focused approach of graduate research education. To that end, in the short term, there must be an incentive in terms of pharmacy schools adopting team science research approaches, led by successful and talented scientists, so that this approach begins to be implemented nationally. The transition from discipline-focused experience to a “team science” environment will be difficult as the decision maker in the current environment is the principal...
investigator. Incentives, both internal (university mandates and potential students) and external (funding agencies and potential investors) will be the motivator for the transition to take place. Taken together, team science experiences in graduate education have been advocated for by the NIH, NSF, and the National Academies of Science and Engineering. The leadership and faculty members at schools and colleges of pharmacy must take responsibility to ensure that biomedical science students train within a team science environment so that they remain competitive within the workforce.

Clearly, there needs to be a concerted effort by schools and colleges of pharmacy to provide additional education and professional training to support all career destinations for graduates, and to explore ways to build a diverse pipeline of future graduate students. Models that have proven to be successful already exist, and graduate programs must offer such opportunities for students to explore options relatively early in graduate school so that they are able to adjust their training to the kind of career they plan to pursue.

**CONCLUSION**

Two decades ago, various organizations and foundations recommended that graduate programs provide more curricular or experiential options to increase the breadth of skills of graduates. Despite significant progress in this area, this recommendation is still timely, perhaps even more so now because of continuously changing workforce needs. All schools and colleges of pharmacy with graduate programs should include industry-specific skills through a combination of didactic presentations and supervised experiences to better prepare graduates students for nonacademic careers, while continuing to focus on training excellent scientists. Training of PhD students cannot last longer than the average 5.5 years. Furthermore, the leadership within graduate programs should encourage and support changing the culture and faculty attitudes towards training graduate students for careers in a wide array of industrial and other research settings.

**REFERENCES**

1. National Science Foundation, National Center for Science and Engineering Statistics. 2019. Doctorate Recipients from U.S. Universities: 2018. Special Report NSF 20-301. Alexandria, VA. https://ncses.nsf.gov/pubs/nsf20301/. Accessed March 15, 2019.

2. Alberts B, Kirschner MW, Tilghman S, Varmus H. Rescuing US biomedical research from its systemic flaws. *Proc Natl Acad Sci USA*. 2014;111(16):5773-5777.

3. Tilghman S, Rockey S, Degen S, et al. *Biomedical Research Working Group Report*. 2012 Retrieved from NIH. Washington, DC: http://acd.od.nih.gov/biomedical_research_wgreport.pdf.

4. Advancing Graduate Education in the Chemical Sciences. *Summary Report of an ACS Presidential Commission*. Washington, DC: American Chemical Society; 2013.

5. National Science Foundation, National Center for Science and Engineering Statistics. 2018. Doctorate Recipients from U.S. Universities: 2017. Special Report NSF 19-301. Alexandria, VA. https://ncses.nsf.gov/pubs/nsf19301/. Accessed March 25, 2019.

6. National Academy of Sciences and Medicine. *The Next Generation of Biomedical and Behavioral Sciences Researchers: Breaking Through*. Washington, DC: The National Academies Press; 2018.

7. Roach M, Sauermann H. The declining interest in an academic career. *PLoS One*. 2017;12(9):e0184130.

8. Fuhrmann CN, Halme DG, O’Sullivan PS, Lindstaedt B. Improving graduate education to support a branching career pipeline: recommendations based on a survey of doctoral students in the basic biomedical sciences. *CBE Life Sci Educ*. 2011;10(3):239-249.

9. Sauermann H, Roach M. Science PhD career preferences: levels, changes, and advisor encouragement. *PLoS One*. 2012;7(5):e36307.

10. National Academy of Sciences and Medicine. *Graduate STEM Education for the 21st Century*. Washington, DC: The National Academies Press; 2018.

11. The Professional Society for Health Economics and Outcomes Research. https://www.ispor.org/strategic-initiatives/more/health-competencies-framework. Health Economics and Outcomes Research Competencies Framework 2019. Accessed March 15, 2019.

12. Mathur A, Meyers FJ, Chalkley R, O’Brien TC, Fuhrmann CN. Transforming training to reflect the workforce. *Sci Transl Med*. 2015;7(285):285ed4.

13. National Science Foundation Research Traineeship (NRT) Program. https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=505015. 2017. Accessed March 27, 2019.

14. National Science Foundation. *10 Big Ideas for Future NSF Investments*. https://www.nsf.gov/about/congress/reports/nsf_big_ideas.pdf. 2016. Accessed March 15, 2019.

15. The CTSA Program at NIH: Opportunities for Advancing Clinical and Translational Research. In: Committee to Review the Clinical and Translational Science Awards Program at the National Center for Advancing Translational Sciences; Board on Health Sciences Policy; Institute of Medicine; Liverman CT, Schultz AM, Terry SF, Leshner AI editors. Washington, DC: National Academies Press (US); 2013.

16. Gibbs KD, Jr., McGreedy J, Griffin K. Career development among American biomedical postdocs. *CBE Life Sci Educ*. 2015; 14(4):ar44.

17. Rubio DM, Robinson G, Galbrilove J, Meagher EA. Creating effective career development programs. *J Clin Transl Sci*. 2017; 1(2):83-87.

18. Beyond Academics: A Holistic Framework for Enhancing Education and Workplace Success. *ACT Research Report Series 2015*. Camara W, O’Connor R, Mattern K, Hanson MA, editors. ACT 2015.