NAVIGATING THE PATH TO A BIOMEDICAL SCIENCE CAREER

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Andrea McNeely Zimmerman

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Abstract

The number of biomedical PhD scientists being trained and graduated far exceeds the number of academic faculty positions and academic research jobs. If this trend is compelling biomedical PhD scientists to increasingly seek career paths outside of academia, then more should be known about their intentions, desires, training experiences, and career path navigation. Therefore, the purpose of this study was to understand the process through which biomedical PhD scientists are trained and supported for navigating future career paths. In addition, the study sought to determine whether career development support efforts and opportunities should be redesigned to account for the proportion of PhD scientists following non-academic career pathways. Guided by the social cognitive career theory (SCCT) framework this study sought to answer the following central research question: How does a southeastern tier 1 research university train and support its biomedical PhD scientists for navigating their career paths? Key findings are: Many factors influence PhD scientists’ career sector preference and job search process, but the most influential were relationships with faculty, particularly the mentor advisor; Planned activities are a significant aspect of the training process and provide skills for career success; and Planned activities provided skills necessary for a career, but influential factors directed the career path navigated. Implications for practice and future research are discussed.

Keywords: biomedical science, career path, academia, alternative careers, social cognitive career theory
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Chapter One

Within two days of posting a tenure-track junior faculty position vacancy, a department of biophysics had 204 applications from extremely qualified candidates. Candidates had strong experience, honors, and publication records from impressive programs and institutions. Most of these applicants had applied to many similar positions over the course of several years, often without even receiving an interview. A large number of these highly qualified scientists continued in postdoctoral or adjunct positions while applying for full-time, tenure-track positions or eventually they gave up and found work in industry or government.

Academia has long been the encouraged path for PhD scientists, but there are few academic faculty positions available, particularly for junior faculty. If the purported sole purpose of biomedical science graduate education is to train future academics for research and faculty appointments, the outlook for graduate students, academic institutions, and even K-12 education and private industries and corporations is grim (Fuhrmann, Halme, O’Sullivan, & Lindstaedt, 2011).

Many researchers agree that the number of science PhD students being trained and graduated far exceeds the number of available academic faculty positions (Benderly, 2005; Goldman, 2002; Levitt, 2010). The academic pipeline is clogged, with graduate schools pumping more potential candidates into the workforce while the number of potential academic research jobs shrinks. A question arises regarding the career paths of this group of highly qualified professionals. If biomedical PhD scientists increasingly seek career paths outside of academia, then more needs to be known about their intentions, desires, training experiences, and career path navigation. Therefore, the purpose of this study was to understand the process through which biomedical PhD scientists are trained and supported for navigating a future career
path. In addition, the study sought to determine how and to what extent career development support efforts and opportunities might be redesigned to integrate and account for the proportion of PhD scientists following non-academic career pathways.

If the current system of training biomedical scientists is inadequate to adapt to the career opportunities available post-training, a useful analysis would examine tensions between the academic and non-academic sectors. Research has revealed that many PhD scientists decide on careers in more stable, financially rewarding fields (Altschuld, 2003); documentation exists to support the thesis that individuals may be less likely to go into biomedical research science unless there is a reasonable chance of finding a good job in their field after graduation (Altschuld, 2003; Levitt, 2010). The challenge, which is a focus of this study, is to evaluate, understand, and reconstruct a career structure that can provide young scientists the hope that their intensive preparation and their investment in years of education can prepare them to secure employment and become leaders in science-grounded careers (Benderly, 2010).

Quantitative studies have reported on trends and outcomes of biomedical PhD scientists pursuing employment in their areas of study within the academic arena. These studies have used the traditional academic pathway as the definition of success. Research, however, has not focused on the job search experience of biomedical PhD scientists who pursue careers outside of that employment framework – beyond academia, per se. Scholars have only infrequently examined in particular the skills and training that would have aided these professionals in preparing for careers outside of academia.

The findings of this study could benefit graduate students, postdoctoral fellows, faculty members, industries, federal agencies, primary and secondary school systems, and the general public. The issues explored in this research are not U.S. specific; countries around the world
might also benefit from this study. This exploratory research provides an understanding of the job search process experiences of biomedical PhD scientists; proposes a redesign of the career development series, which may assist in better preparing graduate students and postdoctoral fellows at the research site, a large southeastern research institution, and beyond to follow broader biomedical science career paths.

**Significance of Research Problem**

Biomedical scientists do important work supporting public health worldwide. Many conduct basic research to understand biological processes, to develop technologies and medicines, to try to understand risks to health, including how diseases exist and persist. Biomedical scientists also study research diagnosis and treatment of disease, and the work they conduct in the lab setting is crucial to extending the length of life for the general population and to increasing its quality. This problem of practice is significant because it examines how individuals may be less likely to go into biomedical research science unless there is a reasonable chance of finding a respectable job in their field after graduation (Altschuld, 2003; Levitt, 2010). Many PhD scientists decide on careers in more stable, financially rewarding fields (Altschuld, 2003).

Prospective career opportunities within academic research are grim, and trainees are beginning to look elsewhere for career options. Most PhD scientists entered graduate school to conduct research and teach in academic institutions after training; however, there are too few jobs in academia to fulfill these intentions. When fewer trainees stay in academic research, this changes the composition of laboratories; it simultaneously and negatively affects principal investigators’ grant funding and papers published. This causes federal and state funding support of graduate programs to dry up.
Economic recessions which also compromise funding are of particular concern because job prospects are even more limited within periods of economic downturn. These broader dynamics affect positions in this field; those positions have increasingly been cut or simply not filled when they become vacant, and because demand rises. This increases the intensity of competition. Taking a job one is overqualified for has a concrete and longstanding impact on future career prospects. Also, during recessions, when budgets are tight, grant funding is limited. Academic laboratories compete for funding and resources and edge one another out of science.

As technology advances and the need for more biomedical research increases, restricting the number of individuals who go into science would be detrimental. Researchers have advocated for an evaluation and restructuring of the current training mechanisms to provide positive changes to the system that could allow for appropriate growth and opportunities for PhD scientists. For example, Matthews, Calhoun, Lo, and Ho (2011) called for PhD programs to pay more attention to how they are managed and monitor the number of students they admit annually to effectively match the supply with the job demand. This perspective was confirmed in the media: The Economist, for example reported in an article titled “The disposable academic” (2010) that institutions have stopped admitting graduate students as an effort to restrict the number of PhDs being produced; however, some media experts and researchers have pointed out that if top universities cut back on enrollment, other universities will step in to offer programs to those applicants.

The current system of training biomedical scientists is inadequate for the encouraged career opportunities available to these individuals post-training; an unnecessary tension exists between academic versus non-academic sectors. Many PhD scientists decide on careers in more stable, financially rewarding fields than academia (Altschuld, 2003). Instead of becoming
tenure-track professors as intended, many scientists will work outside of academia; indeed, those who completed PhDs in 1985-1986 were twice as likely to work in industry as those who completed PhDs in 1963-1964 (Austin, 2002). While few scholars entered tenure-track positions in 2006 after completion of the PhD 5-6 years before, 43% of PhDs enter nonacademic settings, 17% are in non-tenure track academic positions, 10% work part-time or are out of the labor force, and 17% are still in postdoctoral positions (Fuhrmann et al., 2011, pp. 239-240). The need to evaluate and reconstruct a career structure that can provide young scientists a reasonable hope that spending years preparing to do science will provide a satisfactory career has become increasingly apparent (Benderly, 2010).

Conducting a case study to understand the career search process of biomedical PhD scientists benefits both research and practice and assist graduate students, postdoctoral fellows, faculty members, industry, federal agencies, primary and secondary school systems, and other constituents, including the general public. Furthermore, this study is not U.S. specific; it is relevant to and of interest to other countries. One major goal of this study was to determine whether the career development workshop series might better prepare graduate students and postdoctoral fellows for broader biomedical science career paths. A nontraditional program informed by the insights of this study could provide PhD scientists with the necessary skills to successfully pursue broader career opportunities, ensuring that individuals interested in biomedical research continue to work in this important area and that they contribute to improving the quality of healthcare in the United States. This study has the potential to contribute to initiatives, such as the National Institute of Health (NIH) Training Grant programs. Other biomedical science graduate and postdoctoral fellows’ programs could also integrate the results of this study into their programs.
Research Questions

**Central question.** How does a southeastern tier 1 research university train and support its biomedical PhD scientists for navigating their career paths?

**Sub-question 1.** What was the process and outcome of the job search of biomedical scientists?

**Sub-question 2.** What factors of personality, environment, experiences, perceptions, etc. influenced the job search process for these scientists?

**Sub-question 3.** What skills (outside of laboratory/bench research) should biomedical PhD scientists be exposed to, and encouraged to develop, to prepare them for employment after graduation?

Positionality Statement

I see my experience in education administration through a sociological lens, which has opened my eyes to a number of problems of practice. Because of my training (undergraduate and graduate degrees in sociology), I seek to unearth unrealized biases and how those may inform my work and perceptions. My background in sociology will be beneficial to the way I approach the study and participants. Ethical research, with sensitivity to participants and a commitment to reporting findings with integrity and accuracy, has been instilled in me throughout my former work. I still recognize that I am subject to positionality and that my research will not be value neutral (Banks, 2006).

Bronfenbrenner’s (1979) ecological systems theory provides a helpful conceptual model to frame my thoughts and to discover the layers of my positionality. The microsystem is based around my personal bias and experience within the system. The mesosystem includes the
interaction and interdependence of faculty mentors, and the students and postdoctoral fellows, while the exosystem comprises NIH’s structure at an institutional level.

Structural issues exist in the exosystem that create problems in the diversity of training NIH training programs, which can enhance career paths. NIH training programs submit annual reports on the previous year’s progress to NIH that include reports of the past decade of trainees. NIH reviews the reports and places emphasis on career progression and job placement of trainees. If a proportion of the trainees do not go into research-intensive academia, these training programs are penalized by decreases in the number of grant slots (one slot per graduate student or postdoctoral fellow) and/or level of funding.

At the mesosystem level of interaction and interdependence between faculty mentors and the trainees, a value-system exists that consistently ranks research above teaching. This devalues teaching positions and creates a bottleneck through which we are educating a number of highly qualified candidates for few academic research positions, overeducating candidates in research for available positions, and under-educating scientists in teaching and pedagogy, overall making it difficult for these individuals to obtain employment in available positions (non-academic) in need of skilled scientists.

As the former program administrator of an NIH training program responsible for helping graduate students and postdoctoral scholars navigate their programs and training, I come with personal biases within the microsystem. I provided career development and counseling and act as an advocate for trainees encountering institutional and mentorship problems creating a personal and emotional stake in increasing the trainees’ professional potential, career opportunities, and overall success. My biased view of their situations is intensified because I was also responsible for reporting career positions and student progress to NIH, which impacted
our total grant funding or number of trainees we are able to support. The training program supported a large portion of my salary, which gives me a personal interest in its success and continuation.

Another bias I have stems from the amount of support these trainees receive. Occasionally trainees apply to this program with no intention of going into academia or interest in the strong training and career development offered; they treat the opportunity solely as a funding source. However, because of the funding relationship, those who are only interested in financial support or are the most qualified for the program but uninterested in an academic career often take available slots from other trainees who actually are interested in careers in research academia. This NIH training program supplies tuition, a stipend, health insurance, and funding for other trainee-related expenses, such as travel for conferences and workshops, memberships to professional organizations, and a journal subscription. The rich opportunities offered are given to support the scholars so they may progress and achieve academic success. All biomedical science graduate programs offer funds at the research site to cover tuition, a stipend, and health insurance; some, especially private institutions, are able to offer a larger amount of financial support. The funding provided to graduate students and postdoctoral fellows averages $61,000 per trainee per year, even at a public institution like the university where the training program is located. Because trainees receive generous funding for graduate school, many feel entitled to these benefits. The entitlement permeates their attitude while in training and their indirect opposition to the career path their training and the training program support.

In part, for the purposes of this study, I interviewed PhD scientists who had completed their training programs and had found employment. Because I am no longer managing the training program, I did not anticipate any issues with being in a position of power over
interviewees. However, because I was the researcher forming questions and reporting findings, there is always an informal position of power. Handling all interviewees with respect and discretion was essential to minimizing bias and also to protecting participants if sensitive information was revealed.

Pros and cons existed to interviewing scientists who were trained in my program or institution; another set of benefits and challenges arose in interviewing individuals trained at other institutions. I had to carefully weigh these to purposively define and select a sample. I had the opportunity to access a database of former trainees from one training program, which was used to select participants. Because I personally knew many, if not all former trainees, deleting identifying information in the sample selection process meant hiding practically all information. To minimize risks to individuals and their organizations, I hid names and identifying information in my reported findings.

I also care about the findings and want to see this study benefit current and future biomedical PhD scientists. Trying to report findings and shape a new program could potentially backfire and result in either slots cut for our program or a low score, which ultimately results in the grant not being renewed and funded. The NIH training program’s funding cycle is five years with two chances to have the grant renewed. Paylines, at the time this study was conducted, were getting tighter at NIH, and even highly successful programs were experiencing cuts. Two funding cycles ago (2006-2007), three slots were cut from the program. In the last cycle (2011), the program administrators had to resubmit a new program plan. The rest of the application was accepted, but the program plan was not, and radical changes needed to be made to the composition of the slots and the program direction. The challenge to find a solution within
acceptable changes to still be approved for funding has been difficult; however, I have seriously assessed this problem to prevent this difficulty from shaping my findings.

Knowing my personal bias and the factors that affect my position as a researcher helped me gather multi-dimensional perspectives in an effort to maintain neutrality. I am certain that I am influenced by other systems, individuals, institutions, and cultural positions, and constantly discovering and re-discovering my positionality has supported the validity and objectivity of this research project.

**Theoretical Framework**

Social Cognitive Career Theory (SCCT) has provided a framework for this problem of practice (Lent, Brown, & Hackett, 1994). The theory and model assisted in explaining and predicting the processes through which students develop vocational and academic interests, make choices regarding academic and professional pursuits, and attain specific levels of work and academic performance. Through the lens of SCCT, Lent et al. (1994) examined how various factors influence career choices (see Figure 1).

Major components of this theory include identifying occupation options, analyzing actual and perceived barriers, and modifying self-efficacy beliefs. The theory postulates that students believe they are able to succeed and obtain a position in a desired career path based on their personal performance and accomplishments, beliefs about the outcomes and opportunities, and their personal goals and determination.

**Historical trajectory of SCCT.** The chosen theory bridges and is more comprehensive than previous concepts and theories, identifying additional and related variables. Earlier similar frameworks and models focused on interest development, attitudes and values, choice and agency, performance, gender and race/ethnicity. SCCT offers a more comprehensive framework
that considers contextual influences.

Bandura (1986) developed a framework that served as the basis for SCCT -- a general social cognitive theory of reflexive thought and social processes in guiding behavior. Lent et al. (1994) extended aspects of Bandura’s (1986) theory to include relevant processes of interest formation, career selection, and performance and took liberty in suggesting certain paths and connections that do not directly come from general social cognitive theory (see Figure 2).

Stemming from Bandura’s work, two major streams of theories evolved. On one side, Krumboltz, Sherba, Hamel, and Kinnier (1979) developed a social learning theory of career decision making. On the other end of the spectrum, Hackett (who also contributed later to the formulation of SCCT) and Betz (1981) applied a self-efficacy construct to career development, specifically of women.

Mitchell and Krumboltz (1996) posited that opportunity structures affect career entry behaviors and interests. These structures, they claimed, are a function of societal reinforcement histories, but they did not specify cognitive mechanisms of individuals’ past experiences that lead to vocational interests. Social learning theory and SCCT both emphasize learning experience, interests and values, choices, and they simultaneously acknowledge genetic factor influence, special abilities, environmental conditions, and reinforcement history. SCCT shares these variables of interest. They do, however, more directly relate to Bandura’s work of social cognition, self-regulation, motivational processes, etc. and move beyond learning and conditioning on career decisions. SCCT is also more specific than social learning theory, using cognitive mediators through which learning experience guides career behavior; it incorporates personal and behavioral variables (interests, abilities, values), contextual factors influencing career outcomes, and the exercise of personal agency in career development.
Hackett and Betz (1981) analyzed self-efficacy and self-construction as they relate to career development. Their framework analyzed the extent to which our own ability to reach goals or complete tasks successfully exists. This line of research is less complicated in terms of the number of variables involved, but in many ways it is as developed – if not more – than Krumboltz’s approach. One reason may be because it is easier to ask and study fewer variables than to consider context and complex interactions. Another reason could be because this line of research has been used in career development and counseling to discuss individual personality, behavior, and performance to alter personal agency. Personal agency is central to career behavior and career counseling (Borgen 1991). The self-efficacy stream of theories has also been used heavily to help understand racial and gender differences in the career process (Hackett & Lent, 1992), career behavior on the job (Barak, 1981; Schunk, 1989), and the people-environment interaction and transaction (Dawis, 1996; Holland, 1997).

**Justification for SCCT.** Career development and choice can be analyzed through multiple lenses. Most theories in this area are based on psychological, sociological, or biological factors influencing career development. Some of the theories in this category do integrate traits of the individual; others look at structural factors and influences of external forces; and, still others look at efficacy and behavior. SCCT, however, is the theory that most comprehensively integrates all possible factors affecting the career process and pathways to success.

SCCT uses individual variables of gender, race and ethnicity, disability and overall health, and any predispositions related to individual characteristics. To round out the contextual view of the framework and to explain career choice behavior, Lent et al. (1994) included self-efficacy, performance and learning experiences, goals and motivation, actions, interests, background, personality, genetics, and expectations of outcomes. SCCT is also robust because
it is comprehensive and provides a framework for causal influences while also determining the outcome of a person-environment interaction. SCCT brings together concepts of related theories and models to more fully explain career process outcomes and to account for differences in how these constructs and models relate. The variables of the SCCT were used to shape the interview schedule for this study.

Though this theory seems to include all factors influencing career paths, there is less emphasis on the impact others have on individuals’ choices and the feasibility of those choices. The impact of others can fall under external and environmental factors and influences, but the interaction between the individual and other people is different than just the influence of others on the individual. Also, feasibility shapes the individual’s choices. Gaining education and experience often have upfront costs that may be prohibitive. Once a person is in an educational field and career path, this may not be as influential, but it is still a consideration that must be taken into account in the analysis.

**How SCCT shapes the study.** This study was influenced strongly by the theoretical framework. The methodology, analysis, and discussion of findings informed the chosen framework, which was selected because of its direct alignment with the problem of practice and with many contextual factors that were taken into consideration. That the SCCT is not single-variable focused and does not view variables as fixed or de-contextualized, but as dynamic to career decisions, adds to the robustness of the framework. This case study included a survey, document review, and qualitative interviews. Qualitative interviews were semi-structured to address research questions but were simultaneously open to being shaped by the participants.

Questions spanned a multitude of factors. The first set of factors included the individual’s characteristics, experience, background, and interests upon entering graduate school.
The second set involved learning and performance in graduate school; skills acquired; the career search; and interactions with mentors, faculty, and other students and researchers. The final set addressed the career path and necessary skills and abilities that should have been acquired in graduate school and postdoctoral training to aid in career development and the transition to work in or out of academia.
Chapter Two: Literature Review

Institutions, funding organizations, and faculty have supported academia as the intended career path for PhD scientists, but there are few positions available for graduates in the academic workplace. A goal of the government in industrialized nations is to provide highly skilled labor to meet society’s needs, including scientists and educated specialists; thus, our universities must see to it that we create these skilled scientists (Jaspers 1953; Kemp, Newnham, & Chapman, 2012). PhD scientists face considerable tensions regarding the career opportunities they desire; those recommended and encouraged by their advisors, institutions, and funding sources; and the opportunities available after training. Radetsky (1994) claimed the anti-industry bias among academics had disappeared, though this study is not substantiated by other research summarized in this literature review. An overemphasis on the academic track, and stigmatization and devaluation of career paths outside of academic research remain (Fiske, 2011) as many PhD scientists intend to, or are forced to, enter these career paths.

The issue is not new. Indeed, Hakala (2009b) recalled Max Weber’s concern about the reliability of the academic profession and its poor career prospects in 1918. There has been a shift over time to consider academia as a secondary employment type (Lee, Miozzo, & Laredo, 2010; Stephan, Sumell, Black, & Adams, 2004). Wendler et al. (2012) noted that the number of trainees outpacing the availability of academic positions causes an increasing number of graduate students to pursue paths outside of academia – a trend he called a leakage from the pipeline. The NIH is the main U.S. federal organization funding graduate students and academic research in biomedical science, with the goal of ensuring the existence of a sufficient biomedical workforce to sustain the future of scientific research (Wendler et al., 2012). One of the NIH’s objectives is
to develop a sustainable and diverse biomedical research workforce, which is being impeded by the variables affecting the balance of viable academic positions.

This dissertation aimed to determine how graduate students and postdoctoral fellows decide their career paths. Self-selection, perceptions about careers and opportunities, personal values, and structural dynamics affect the type of career and environment PhD scientists desire and choose. The purpose of biomedical graduate education is to train graduate students to conduct sophisticated research that makes an original contribution, enabling scientists to become independent scholars who exhibit the intellectual rigor, technical skills, personal discipline, and the appetite for enquiry and curiosity necessary to make significant strides in research (Kemp et al., 2012; Lee et al., 2010). Ideally, graduate students would continue academic pursuits within academic positions. But if the goal is to solely produce future academic research faculty, the outlook for graduate students and academic institutions is grim (Fuhrmann et al., 2011).

As technology and the need for more biomedical research increases, restricting the number of individuals who go into science would be detrimental. Scholars and practitioners alike have called for an evaluation and restructuring of the current training mechanisms with the goal of implementing positive changes to the system that would facilitate appropriate growth and opportunities for PhD scientists. Matthews et al. (2011) recommended that PhD programs pay more attention to how they are managed and monitor the number of students they admit annually to effectively match the supply with the job demand. An investigator observed in “The disposable academic” (2010) that some institutions have stopped admitting graduate students in their efforts to restrict the number of PhDs being produced; however, the article’s authors make the point that if top universities cut back on enrollment, other universities will step in to offer applicants programs.
Faculty mentors, institutions, and funding sources encourage biomedical PhD graduates and postdoctoral fellows to enter academic research; however, the number of positions available cannot sustain the number of graduates. Wendler et al. (2010) suggested career prospects follow a pathway more than a linear approach. Much of the current research on this issue has focused on single factors affecting career choice: oversupply and insufficient demand for PhD scientists in academia, the rising median age of professional achievements, prolonged training periods, and internationalization of tax the system. Many developed countries are facing similar pressures, with the number of trained scientists exceeding the number of positions they intend to apply for or will be able to obtain.

This literature review focuses on factors affecting the career paths of biomedical PhD scientists, including: recent trends in biomedical science academia over the past 50 years, the economic market, structural factors contributing to prolonged training periods, and individual perceptions and hurdles of working in academic and non-academic science.

**The Availability of Academic Faculty Positions**

The number of academic positions available is far less than the number of trained PhD scientists who graduate annually. Supply and demand of academic positions is an integral concern in analyses of oversupply. Academia is no longer the primary career path for biomedical scientists; however, it is still encouraged as the primary and most sought after goal. The first section of this literature review focuses on the recent trends in biomedical science academia over the period from approximately 1965 to 2017.

U.S. politicians talk of a PhD shortage, but the production of PhDs is increasing (Cyranoski, Gilbert, Ledford, Nayar, & Yahia, 2011). The proportion of people with science PhDs who obtain tenured academic positions has dropped steadily; however, the industry has not
fully absorbed the slack. Many researchers have documented that the number of science PhDs graduated and being trained, typically for long periods of time, exceeds the number of academic faculty positions available (Benderly, 2005; Goldman, 2002; Levitt, 2010; Taylor, 2011). Between 2005 and 2009, 100,000 doctoral degrees were awarded, but only 16,000 new professorships were created (“The disposable academic,” 2010, pp. 143). The graduate school pipeline pumps more people into the workforce while the number of potential academic jobs shrinks. Between 1995 and 2005, the number of doctoral degrees increased by 26% (Wendler et al., 2010, pp. 14). The large number of degrees granted leads to concern over the employment opportunities available (Hakala, 2009b).

A boom of faculty hires in the 1960s means job openings should have surged in recent years as senior professors retire or die (Goldman, 2002). Fiske (2011) noted an erroneous prediction in the 1980s that many faculty members were about to retire and open up a large number of positions. People are living longer and waiting later to retire, and since those who find a job in academia tend to stay in academia (Mangematin, 2000), fewer positions open to new junior faculty members. Taylor (2011) called PhD trainees “clones” of mentors and stated that they vastly outnumber their mentors, as the replacement number is far greater than the number of faculty training the replacements.

Coppola (2009) observed that only six percent of colleges and universities grant doctoral degrees. This ratio implies that the place a student earns a PhD is likely not the type of school where they will get a faculty position; simultaneously, universities have reduced the number of tenure-track positions, employing a greater number of adjunct faculty (Stephan, 2008). Austin (2002, pp. 99-100) found that while 61% of PhD graduates from 1963-1964 are in tenure-track appointments ten years post-graduation, only 38% of PhD graduates from 1985-1986 entered
tenure-track positions. Approximately two decades later, only 14% of PhDs entered into tenure-track academic positions (Fuhrmann et al., 2011, pp. 239). Similarly, Matthews et al. (2011, pp. 4) noted the drop in tenure track positions within six years of completing the PhD went from 55% in 1973 to 15% in 2006. The drop in tenure-track academic positions is significant and startling. In forty years, academic positions have become a secondary type of career for PhDs. This trend is not just prevalent in the United States, but also in the United Kingdom and other countries (Lee et al., 2010).

Austin (2002) observed that those faculty members holding tenure or tenure-track positions are outnumbered by those in term, contract, and part-time positions. Lee et al. (2010) found that even after seven to 10 years in the labor market, a high number of PhDs are employed on fixed-term contracts. Some of these positions are instructor-level, research scientist, and adjunct faculty positions. The number of postdoctoral positions and non-tenured positions increased two and a half times from 1981 to 2006, while the faculty positions only increased 1.6 times over this same time period (Matthews et al., 2011). This means individuals are staying in training in contingent positions longer, without having access to limited full-time academic positions. Filling other professional roles, graduate students and postdoctoral fellows hold half of the positions in biomedical research (Fuhrmann et al., 2011). Nearly one-half of all postdoctoral positions nationwide are in the biological sciences (Matthews et al., 2011). Tenured faculty positions have been traditionally assumed to be the motivating factor for gaining a graduate degree; however, attaining this goal has become more and more difficult as universities replace tenured faculty with non-tenured staff, increasingly leading students to other viable career paths (Wendler et al., 2012).
Instead of becoming professors as intended, many scientists will work outside of academia; indeed, those who completed PhDs in 1985-1986 were twice as likely to work in industry as those who completed PhDs in 1963-1964 (Austin, 2002). While few enter tenure-track positions, 43% of PhDs enter nonacademic settings (Fuhrmann et al., 2011, pp. 239). Many are turning to industry, though the number of positions available in this sector is not adequate to compensate for lack of tenure track positions; graduate schools have not limited enrollment accordingly or offered training needed for alternative careers (Matthews et al., 2011). Data reported by DTZ Pieda Consulting (as cited in Lee et al., 2010, pp. 870) showed just 15% of students who received U.S. federal funding for graduate studies and training ended up in permanent university or government public sector research positions, six to eight years after their sponsorship. Indeed, it has been argued that one of the most significant benefits to the economy from public-funded basic science is highly trained manpower for industry and government through science and engineering doctoral education (Lee et al. 2010). However, supply has overwhelmed demand, and though few PhD holders end up unemployed, it is not clear that the years spent gaining this level of training is justified for the jobs they actually acquire (Cyranoski et al., 2011).

In the brief context of the past 50 years of employment trends in biomedical science, it is clear there are fewer academic faculty positions are available than the number of graduate students and postdoctoral fellows training for them. Some projections concluded incorrectly that a greater number of positions would be available to future trainees; these prognostics, however, did not take into consideration postponed retirement or the shift to contingent faculty to absorb less governmental, state, and institutional funds provided for faculty positions. Biomedical academic faculty positions are less vacant and in high demand. The shift toward independent
research funds for faculty has created career-track complications for junior scientists who have a comparatively low track record in obtaining grants and publications. Students have continued pursuing biomedical science graduate school and training even though the positions they are encouraged to enter after their training are very limited. One might expect the supply of positions to result in adjustments in the demand for degrees or the supply of degree-granting opportunities, but this trend is not in line with what basic supply and demand economics would dictate. The next section will provide an overview of the influence of the economic market and federal funding fluctuations on academia.

**The Economic Market**

The economy affects grant funding agencies, departments and institutions, and individuals’ perceptions of the likelihood of gaining employment in a given sector. One might expect fewer people to go into graduate school for biomedical science or to pursue a postdoctoral fellowship in hopes of gaining a tenure-track academic position one day if grant funding goes down, fewer grants are awarded, or the average age of grant recipients increases. However, this does not seem to act as a typical supply-demand equilibrium issue in the area of biomedical academics. There must be other mitigating factors that alter expected supply and demand. How the economic market influences academia is the focus of the second section of this chapter.

A number of variables influence why academia does not follow a typical supply-demand curve. The number of positions open in graduate school annually has not fluctuated significantly; students, postdoctoral fellows, and laboratory staff are needed to keep science laboratories running. Additional schools and training programs have opened. There have been fluctuations in the national economy of the United States in the past several decades, which have influenced the amount of money available to the NIH and thus the money that can be accessed
by institutions for training programs that support graduate students and postdoctoral fellows. The fluctuations also influence the amount of money available for research grants and may give those in training a dismal picture of the funding opportunities available in the future, changing their perception of academic careers as viable options.

There are different academic labor markets operating globally, though trends are similar in Europe (Gaughan & Robin, 2004). In the United States, as with general economic trends, the NIH budget has “boom and bust” fluctuations, which contribute to the lack of U.S. science trainees (Altschuld, 2003). Government funding was tight in the late 1980s to mid-1990s, forcing labs to cut research program budgets or the programs altogether (Altschuld, 2003), but the budget doubled between 1998 and 2003, flattened through 2008 (Teitelbaum, 2008), surged with a $10 billion stimulus package in 2009, and has stayed flat since (Lane, 2011). Alberts, Kirschner, Tilghman, and Varmus (2014) noted that the demands for research dollars grew much faster than the supply after the rapid doubling of the NIH budget in 1998-2003 ended. Teitelbaum (2008, pp. 644) emphasized that after adjusting for inflation, the value of the NIH budget has declined by 13% from a peak in 2003.

When the NIH budget doubled in 2003, universities simply could not sustain all of the jobs that had been created during the previous budget spike (Benderly, 2009). Indeed, “biomedical research funding is both erratic and subject to positive-feedback loops that together drive system ineluctably toward damaging instability” (Teitelbaum, 2008). The infrastructure cannot change as rapidly as the funding levels. Markets experience expansions and contractions, but biomedical science does not respond, or responds sluggishly, to classic market forces. The funding system currently has no built-in regulator, so budget increases are always absorbed and create a need for more and larger increases (Alberts et al., 2014). Researchers call for systems of
predictability and stability of growth to avoid spiraling issues. Productivity is reduced, and promising careers are threatened in this hypercompetitive environment. Laboratories become unsustainable for research programs, or students late in their graduate programs find it difficult to leave. They may be urged to go or want to leave, but there is often nowhere to go because funding losses are pervasive. The increasing supply of scientists clamoring for limited resources and faculty employment opportunities yields a perpetual disequilibrium.

At least 60% of academic training costs are covered by the U.S. federal government through institutional and faculty grants; in contrast, France, for example, is more likely to support the individual graduate student (Gaughan & Robin, 2004, pp. 572). NIH, the National Science Foundation, the Department of Defense, NASA, and the United States Department of Agriculture supply a staggering 91% of all research and development support; Benderly (2005, pp. 717) blamed the pipeline clog on NIH funding. Bender and Heywood (2011) also related government subsidies for higher education to the oversupply and over-education of PhD scientists. Large surges and cuts to federal funding make the system not act like typical economic markets. Though the science PhD is designed as training for an academic job, the number of people trained is so unrelated to the number of job openings that some have called the situation a Ponzi or pyramid scheme (“The disposable academic,” 2010).

PhD scientists entering the labor market during a recession face even more severe competition from the number of other highly educated PhD scientists; many of these PhDs accept first jobs they had not anticipated and for which they are largely overeducated (Verhaest & Van der Velden, 2012). Job prospects are limited during recessions because positions are often cut or simply not filled when vacant, causing demand to rise and the intensity of the competition to increase. Taking a job for which one is overqualified has an impact on future
career prospects as well; this does not just impact the initial position one takes. Also, during recessions, when budgets are tight, grant funding is limited. Laboratories compete and edge one another out for funding and resources.

One would expect the market and supply of faculty positions to lead to fewer students pursuing science PhDs and careers, but this is not the case. One reason is that the growth depends largely on the availability of federal funding for research and research training (Coggeshall, Norvell, Bogorad, & Bock, 1978). The boom and bust of the economy leads to a boom and bust of federal money for institutions. In 2014, Francis Collins, the Director of the National Institutes of Health, which is the largest U.S. federal granting agency, said the rapid growth in the number of biomedical science graduate students and postdoctoral fellows is due to a doubling of the budget that ended over a decade ago (Alberts et al., 2014). Due to the lengthening of training periods for graduate students and postdoctoral fellows, the budget fluctuation has not trickled down to mean lowered enrollment or fewer applications to graduate school. In fact, graduate school applications have remained stable or increased, particularly with the influx of applications from foreign students seeking the appealing opportunities in the United States that are not as robust in their own countries.

It may seem that reduced government funding in some years would decrease funding in certain program or focus areas and also institutions, which would lower the number of students enrolled. However, the number of degrees conferred in the biomedical sciences did not start to decline in the 1970s as they did in physics, chemistry, and engineering (Coggeshall et al., 1978). In fact, between 1998 and 2008, the number of science doctorates earned grew each year by 40% (Cyranoski et al., 2011, pp. 276). In its 1976 and 1977 reports, one NIH committee called for a one-third reduction in NIH support for pre-doctoral students over a four year period, but it is not
evident that there was any change made (Coggeshall et al., 1978). The U.S. federal government is still the chief funder of higher education, but in the biomedical sciences, much of the funding is funneled through research grants to individual faculty members rather than through institutional grants to support the training of graduate students and postdoctoral fellows.

Universities cut back on hiring during recessions, faculty retirement slows down, state and federal budgets are slashed, and endowments and other investments suffer losses (Benderly, 2009). These factors contribute to a decline in the number of available entry-level faculty positions. Though federal funding has gone from boom to bust between surpluses and deficits, Altschuld (2003) called for educating more U.S scientists rather than fewer. However, Alberts et al. (2014) encouraged helping young scientists transition into a broader range of careers that would benefit from the specialized education and abilities; the authors also argued that the goal of institutions should be to gradually reduce the number of entrants into PhD training to better align graduates with available future opportunities. Universities exist in part to reproduce themselves, but also to participate in efforts toward innovation, and the solution is not to cause a slowing down of scientific production based on the reduction of job opportunities in science (Mangematin, 2000). Alberts et al. (2014) attributed these dynamics largely to the enormous growth in soft money and the perverse incentives for institutions to grow without making sufficient investments in their own faculty and facilities. Encouragement and incentives to recover revenue from external sources allowed for the expansion of academic medical centers with expectations of receiving overhead payments and borrowed capital (Teitelbaum, 2008).

As reported by the NIH in 2012, the percentage of recent PhDs in academic positions fell to 20% (as cited in Alberts et al., 2014, pp. 5775). The research community has received warning signs for years of the oversupply of PhD scientists, which it cannot ignore any longer.
The problem threatens to worsen because structural issues in the system cause more stress and risk. More PhD holders are taking jobs that do not require a PhD, wasting the many years of resources, time, and money spent training these individuals who accept jobs for which they are not well suited, matched, or trained (Cyranoski et al., 2011).

The principles of economics postulate that fluctuations in supply and demand in a market interact to achieve equilibrium. It seems that in biomedical science academia, the usual market stimuli do not have the desired or expected effects. The shift in funding not only shifts the revenue streams but also the constraints for the money incorporated and the culture of institutions. Soft money drives competition up and creates the potential for dissension between should-be collaborators. The difficulty in getting publications accepted and grants awarded, combined with the length of time in graduate school and postdoctoral training, has contributed to delayed scientific independence. Prolonged training periods and delayed scientific independence are contributing factors to scientists seeking career paths outside of academia, which is the focus of the following section.

Delayed Scientific Independence

A PhD is necessary for most academic faculty employment. It takes years of hard work and dedication to become a competent scientist. Individuals may be less likely to go into research science unless there is a reasonable chance of finding a good job in their field after graduation. (Altschuld, 2003; Levitt, 2010). Scientists are beginning their careers later due to longer training periods, and increased standards and criteria for publishing papers and receiving grants have contributed to the amount of time biomedical scientists must remain in training. Delayed scientific independence is covered in this section, which addresses two main factors: the
difficulty gaining accepted publications and awarded grants, and the length of time spent in
graduate and postdoctoral training.

A respectable 55% of PhD scientists were in tenure track positions within six years of
graduating with a PhD in 1973, but this number dropped drastically to 15% in 2006 (Cyranoski
et al., 2011, pp. 277). The average age of attaining tenure was 36 in 1985 and 39 in 1999; the
average age of graduating with a doctoral degree rose from 31 to 33 during the same period
(Mason, Goulden, & Frasch, 2009). Nearly 75% of teaching staff at colleges and universities,
including research institutions granting biomedical doctorates, are non-tenured faculty (Kemp et
al., 2012, pp. 638). Changing the ratio of tenured versus non-tenured faculty has far-reaching
implications. The best science faculty members train far more scientists than are needed to
replace themselves, generating a supply much greater than the relevant positions in academia can
absorb (Alberts et al., 2014). As Alberts et al. (2014) stated, little has been done to reform the
system primarily because it continues to benefit the more established and influential scientists
and undoubtedly produces great science.

Scientific independence now happens at a later stage in the life of professionals. The
median age for obtaining a first independent faculty appointment is 36 (Benderly, 2005), an
estimated 14 or 15 years after beginning a PhD program. Trainees must generally obtain a PhD
and complete at least one or two postdoctoral fellowships before receiving a faculty position.
Yewdell (2008) posited that a decent student should finish a PhD within four or five years,
certainly within 6 years; students not reaching this status within this time frame should determine
whether or not they are suited for science or if, perhaps, they are being exploited by their
advisors. Scientists are sometimes “scooped,” where another laboratory or scientist publishes a
similar study or discovery first, potentially rendering years of experimentation unusable.
Preparing for the few university faculty positions requires at least a decade of training through graduate school and several temporary, low-pay postdoctoral appointments (Finegold, 2005; Radetsky, 1994; Teitelbaum, 2006).

Goldman (2002) called this trend a “plight of postdocs” and “deplorable,” and Altschuld (2003) referred to these positions as “perpetual postdocs” because of the long years in training and poor pay. These phrases are commonly repeated in the university setting, suggesting the heavy toll this takes on the post-doctoral fellows. Benderly (2010) elaborated, calling the trend demoralizing and disguised unemployment. Given the high number of PhDs staffing university laboratories; post-doctoral fellows have been transformed from valued protégés to cost-effective labor.

An impressive publication record is essential to gaining a faculty position (Stephan, 2008). However, academic faculty members lack the necessary time to review manuscripts for journals, leaving tasks to students and fellows who may lack the experience needed to understand the broader context of the work and truly novel findings (Alberts et al., 2014). Mangematin (2000) determined that scientists pursuing jobs in academia have a much higher number of publications than those seeking employment in industry and the private sector. The focus on publications is less crucial in obtaining a position outside of academia. PhD advisors have additional motives for training PhD students. In the short-term, advisors gain many co-authorships, and in the long-term, advisors build an extensive network of PhD graduates and post-doctoral fellows (Mangematin, 2000). Many graduate students get “stuck” in long graduate school careers producing papers for advisors and working on aspects of colleagues’ projects rather than solely focusing on their own PhD project and thesis; postdoctoral fellows can also get caught in a long fellowship for similar reasons.
Publication records also affect grants awarded. With research funding tighter than ever, grant applications require more “preliminary” data; a project must be nearly complete before it is proposed (Omenn, 2006). Young PhDs and postdoctoral fellows are at a disadvantage when they seek their first grants. Obtaining grants impacts whether they can get jobs; most jobs for which they are being trained require a funding track record. New researchers wait an average of 4-5 years to receive federal funding for work compared with 1 year in 1980 (Alberts et al., 2014). Benderly (2005) and Levitt (2010) reported that the average age a scientist is awarded a first NIH grant is 42.

Van Reenen and Freeman (2008) stated that the average age of receiving first grants rose from 35.2 years in 1970 to 42.9 years in 2005, which is slightly higher than Benderly and Levitt’s estimate, but which concurs with Yewdell’s (2008) estimate of 43 years. Also, 22% of grants in 1980 were received by scientists under 36, while only 3% of scientists under 36 years old received grants in 2005 (Van Reenen & Freeman, 2008, pp. 30); less than 15% of grants were given to researchers under 40 years old (Benderly, 2005, pp. 718). Even this number seems inflated, given the specific grants supporting graduate students and postdoctoral fellows with short time limits, little funding, and zero impetus to start a career. After obtaining a faculty position, an immense amount of time and effort is dedicated to grant writing. If funding is ever lost or cut, scientists must rely on their institutions and departments for continued employment (Yewdell, 2008).

Publication and grant reputation influences departmental hiring practices. PhD scientists face a fierce market to become stars (Stephan, 2008). It is difficult enough for even stars to secure tenure track academic jobs; it is much more so for average and even excellent PhD scientists. Benderly (2010) stated that PhDs previously spent around a year applying to three or
four faculty positions before accepting a job, while they now spend multiple years applying to
many jobs, usually without receiving offer. Only a small number of PhDs will ever become
principal investigators (PIs) and direct their own research; therefore, many trainees will pursue
careers fundamentally different from their mentors (Yewdell, 2008). Many PhD scientists decide
on careers in more stable, financially rewarding fields (Altschuld, 2003) and often even enroll in
law, medical, dental, pharmacy, veterinary, journalism, or business schools for additional
degrees to increase their job opportunities.

More PhD holders are forced to prolong their period of training, and new employment
opportunities in other fields are not likely to open up for biomedical PhD scientists. Waiting for
more positions to open, and a lack of alternative employment opportunities, has contributed to a
buildup of PhD holders and to prolonged postdoctoral periods. The increased number of
postdoctoral appointments and the average amount of time spent as a postdoctoral trainee are
indicators of an imbalance between the supply and demand for PhD scientists (Coggeshall et al.,
1978).

It has become increasingly difficult for PhD scientists to publish, and more publications
are required for special training opportunities or junior faculty positions than ever before.
Publications affect the awarding of grants as well, and most often, new biomedical science
faculty members are required to have at least one independent grant before consideration for a
job; the expectation exists that new appointees will bring their own funds to relieve the
institution or department of completely covering salary, students or postdoctoral trainees, start-
up funds, and lab equipment and supplies.

The increase in both the difficulty of publishing and receiving grants, and the rising age
of individuals reaching these goals, combined with the length of time in graduate school and
postdoctoral training have led to significant delays in scientific independence. This trend is not limited to PhD scientists in the United States, which has promoted an influx of international students and scientists, creating an even more competitive and strained system in the United States. Other countries face similar issues of oversupply, and yet others seek to increase enrollment and offer solutions for mitigating the strain by sorting some scientists into professional science positions in industry and business.

**International Patterns**

As American scientists leave research laboratories in favor of industry and non-academic positions, foreign graduate students and postdoctoral fellows fill laboratory positions, edging out the remaining American PhD students and scientists (Altschuld, 2003). These foreign students and scientists receive advanced training and remain in the United States, often filling the limited number of quality jobs that are available. Many hope to become permanent residents. The fourth section of this chapter focuses on international patterns of academic biomedical science.

Intentions and career trajectories in some other countries match patterns found in the United States. Scaffidi and Berman (2011, pp. 690) found that 85% of Australian postdocs were very interested or interested in an academic career path, 63% were very interested or interested in an industry or government career, and just 42% were interested in a teaching career path. Academic stratification affects faculty hires at least by the time students are in their undergraduate years. Attending one of the 125 prestigious Research I universities in the United States or a Grand Ecole in France greatly increases the likelihood a scientist will obtain a tenure-track faculty position after training (Gaughan & Robin, 2004; Mangematin, 2000).

Wendler et al. (2010, pp. 21) noted that 82% of doctoral degrees conferred in the United States were awarded to U.S. citizens in 1977, but as of 2007, that number had dropped to 57%. 
Additionally, the international students that make up 50-80% of doctoral students in STEM fields have options to pursue education in many countries and regions of the world. If the total number of degrees remains constant while the proportion of international doctoral students increases drastically, the number of U.S. academic jobs will decrease. Nearly two-thirds of international doctoral graduates remain in the United States to work for at least five years after completing their degrees (Wendler et al., 2010). The United States is second only to China in the number of doctoral degrees awarded, and Chinese PhD students make up a large portion of the U.S. doctoral student population; many, however do not return to China, draining their country’s talent and infusing the U.S. workforce with an abundance of skilled scientists (Cyranoski et al., 2011).

The issues that the United Kingdom and the United States face, the differences between them and France, and the indication that scholars in many countries are concerned with a decrease in academic jobs, points to existing differences in career patterns of science and engineering PhDs internationally (Lee et al., 2010). Several countries are seeing positive aspects, though, and are not sensing the strain of oversupply. Poland boasts less than 3% of unemployment for PhD scientists; Germany produces the most PhD scientists in Europe but is also well on its way to solving its oversupply problem, which will play a more official role in recruitment and development (Cyranoski et al., 2011). Indeed, just under 6% of German PhD scientists go into full-time academic positions, and most find jobs in industry, particularly because the long road to professorship and relatively low income of German academic staff makes leaving academia post-degree a very appealing option (Cyranoski et al., 2011).

In terms of enrollment in graduate education, additional variation exists. Enrollment nearly doubled in Egypt between 1998 and 2009, but funding for graduate education has not kept
pace, which translated to a shortage in equipment and materials, a lack of qualified teaching staff, and poor compensation for researchers; this has transferred a greater proportion of the funding burden onto students (Cyranoski et al., 2011). Though India increased enrollment by 50% between 2004 and 2011 and hopes to double that rate by 2020, little incentive exists for students to continue into lengthy PhD programs. Therefore, only 1% of undergraduates pursue this route in India (Cyranoski et al., 2011, pp. 279). The changes in enrollment could have similar causes to the changes seen in the United States -- more schools opening, more national funding access, and policies increasing access to and the availability of higher education.

Similar training and career patterns in biomedical science occur in many developed nations. Enrollment of budding scientists into graduate programs has not decreased, and yet, there are not enough faculty positions to meet the oversupply. International PhD scientists often take non-academic career paths. Many international students also come to the United States for training and stay for job opportunities, adding to an already competitive academic system in the United States. People in countries outside of the United States are as interested in biomedical science and face similar structural constraints as their U.S. counterparts. In the first four sections of this literature review, the emphasis has been on external forces. Individuals’ perceptions of the obstacles in their career paths are examined in the next section.

**Individual Perceptions and Hurdles**

Structural factors affect students on the track to become academic faculty members, but the perception about types of career options also has a major impact on whether or not a student will pursue academic science. This section begins with an overview of the desires and intentions graduate students and postdoctoral fellows have when they begin their post-baccalaureate
training; it then discusses perceptions students have regarding the pressures inherent to pursuing an academic career.

**Desires and intention.** When students begin graduate school, most consider the faculty research path to be extremely attractive and among the most desirable career options (Kemp et al., 2012; Mangematin, 2000; Sauermann & Roach, 2012). Indeed, most interviewees in a study by Välimaa (2001) did not wish to leave academia after graduating, but they felt forced to do so. Deciding a direction at the beginning of a PhD program, when information about career options is limited, may subject students to a lock-in phenomenon (Mangematin, 2000). Mason et al. (2009) surveyed PhD students and found that most want to pursue careers as professors with an emphasis on research at the beginning of their graduate programs, but far fewer intend to do so closer to the end of their programs.

Sauermann and Roach (2012) observed that these later-stage changes to intent may result from students realizing over time they are not competitive for scarce academic jobs; they thus subconsciously stop desiring them. Junior scientists opt out of academic science in greater numbers because they are discouraged by the nature of future life in academia and the options available to them, rather than because other options are considered attractive (Alberts et al., 2014). Some students even go to graduate school to postpone job hunting. When science students can easily get stipends and tuition assistance, they commonly drift onto the PhD path (“The disposable academic,” 2010).

When academic positions are not available, accepting temporary contracts often seems to be too demanding and insecure, so scientists seek opportunities outside of academia (Hakala, 2009b; Välimaa, 2001). Even though many intend to work in academia after graduation, intentions may change as their career paths are molded by immersion in graduate school culture.
and as they obtain a more realistic picture of academic life (Wendler et al., 2012). Students often find themselves expanding their options as they identify new goals, learn new skills; they expand their goals, however, without fully abandoning their initial ones.

Career patterns reflect an imbalance between the supply of scientists looking for academic positions and the availability of those positions (Sauermann & Roach, 2012), and more studies are needed to explore what motivates researchers to engage in academic work and what characteristics are crucial in forming academic identities (Hakala, 2009b). Little evidence exists on whether or how career preferences adjust over the course of doctoral education and the role and extent to which advisors intensify this tension (Sauermann & Roach, 2012).

The goals of graduate programs and federal funding agencies may not align with those of PhD students. Mangematin (2000) postulated that PhD students invest in doctoral research and education to get a job in either academia or the private sector and questioned when students should choose their trajectory and how flexible it is. If students make different career decisions and self-select prior to enrollment, potential changes must likely occur in the design of laboratories and graduate programs. Changes in career preferences and in the organization of scientific labor in academic research may be beneficial both to the students and the system on a larger scale (Sauermann & Roach, 2012).

Altschuld (2003) stated that many academic scientists decide on a career path well before reaching high school. Career path preferences often shift during the third year of graduate school (Fuhrmann et al., 2011), especially as students begin to struggle with a different understanding of the academy than they had originally envisioned and anticipated (Austin, 2002). The experience students have in graduate school can negatively affect their passion and desire for the academy. Students generally put in long hours in laboratories learning to become independent scientists.
Yewdell (2008) suggested graduate students ask several questions to determine whether the professoriate is right for them, including examining whether or not the laboratory is a place where they like to be. If they do not, Yewdell asserted, they perhaps should not seek a faculty position. Choosing a direction before graduate school would be advantageous to students because changing trajectories later may be costly in terms of time and money (Mangematin, 2000).

**Perceptions and pressures of academic life.** The pressures of academic life, the disappointments of the academy and research, the low availability of jobs, loss of interest in basic research or in a specific sub-area of interest, isolation, lack of collegiality, juggling multiple and possibly conflicting professional responsibilities, stress, work-life balance, the lack of family-friendliness of institutions, household income, availability of child care and health insurance, and competition lead some students away from their initial planned career path and also lead some new faculty members into industry or government positions (Austin, 2002; Fuhrmann et al., 2011; Gibbs & Griffin, 2013; Mason et al., 2009; Roach & Sauermann, 2010; Wendler et al., 2010).

Stress is especially high and constant before faculty members receive tenure (Nir & Zilberstein-Levy, 2006), but it also persists afterwards given the increasing pressure to publish, to work with graduate students, to serve on committees and in administrative positions in addition to conducting research, and to continuously write grants. To engage in academic work, scientists need to be able to tolerate a high level of stress, which may deter some of the most talented students and researchers from entering the academic field (Hakala, 2009b). Alberts et al. (2014) argued that these concerns and a pessimistic view of the future of a chosen career are valid and justified for even the most successful scientists and the most promising trainees.
Teitelbaum (2006) cited the starting standard salary for academic scientists between $55,000 and $62,000. While academic salaries are low, the main concern is they are flat. Salaries have not risen with inflation (Hermanowicz, 2003; Stephan, 2008), and teaching loads have increased though research budgets have decreased. Faculty members are being asked to do more with less with the hopes this will be offset by the intrinsic rewards of academic work. Scientists make trade-offs between pay and non-pecuniary job characteristics such as social reasonability, job location, or autonomy on the job (Sauermann & Roach, 2014).

Millenials are rightly concerned about their future as academic faculty. Scaffidi and Berman (2011) revealed that job insecurity and a lack of career structure are major concerns for postdoctoral fellows. The economic situation has given them reason to pause and adjust their short-term expectations for their first job, as they realize that such a position may not fulfill a majority of their expectations; a less-than-ideal position however, may be necessary to move them toward longer-term career goals (Ng, Schweitzer, & Lyons, 2010). Elevated expectations for quick promotions, pay increases, obtainment of tenure, security, and recognition may be grossly absent from their early academic life.

Postdoctoral fellows in biomedical sciences also are more pessimistic about job opportunities than their counterparts in computer, engineering, or medical programs. Their perception of what lies ahead is particularly grim. Many are concerned that obtaining a fixed-term or part-time position would damage a scientist’s long-term career, or in the least waste their effort and skill in a demoralizing situation, but Kidd and Green (2006) determined that individuals in fixed-term contracts are just as committed one year later as those with permanent contracts, and they are no more likely to intend to leave science. This may be due to “career
entrenchment,” where individuals compare career investments and the emotional costs of leaving against the limitedness of career alternatives.

More females (28%) have dropped out of science, primarily because fewer went into industry positions, whereas sixteen years after males start their postdoctoral fellowships, only 9% had dropped out of science (Levitt, 2010, pp. 80). The mentor’s publication record has a huge effect on the grant success of female scientists, though it does not significantly affect grant success of male scientists (Levitt, 2010). Surprisingly, men are less likely to obtain a permanent academic faculty position within three years after receiving their PhDs than women in the United States; being male is also not an advantage in securing a faculty position in France (Gaughan & Robin, 2004, pp. 578). Since nearly 80% of science faculty members in the United States are male, the authors deduced that the women hired have already overcome hurdles and are strong, competitive candidates.

“Nontraditional” Versus “Alternative” Careers. Though many postdoctoral fellows prefer an academic research career path, 64% are interested in a career path outside academia, while a majority (70%) of advisors do not discuss nontraditional career paths, and about 20% are not supportive of non-academic careers (Scaffidi & Berman, 2011, pp. 691). Advisors may not discuss career paths outside of academe because they have only spent their careers in academia and they lack the knowledge and contacts needed to advise and help build networks for PhD scientists to pursue careers in other sectors. The bias may be unintentional, but it still exists, and mentors do not usually encourage paths other than academic research (Sauermann & Roach, 2012). Stephan (2008) observed that faculty advisor involvement with industry and other non-academic research career sectors can provide job and research opportunities and influence the curriculum and training of graduate students and postdoctoral fellows. The lack of knowledge
and contacts outside of academia of many advisors produces a gaping hole; the many students and postdocs who have or will have to pursue nontraditional positions are ignored (Fuhrmann et al., 2011).

Junior researchers in soft and hard sciences answer differently regarding the encouragement they received for a particular career path, and some elements of the traditional academic path continue to appeal strongly to PhD students, while others are rejected or overlooked (Hakala, 2009b). Some students have expressed that nontraditional careers in industry and teaching primary and secondary grades are explicitly discouraged (Sauermann & Roach, 2012). There is value in investing in different kinds of work, and this should be studied more thoroughly. Sorting patterns and average earnings information would be useful for students to make decisions based on their ability and preferences (Agarwal & Sonka, 2010). Many careers outside of academia do not require a postdoctoral fellowship, yet many PhD recipients in the sciences seek those positions as ways to postpone looking for a job and because these scholars are not sure which options are available to them or which skills will be useful. Postdoctoral fellowships do not provide the additional skills necessary for most nontraditional careers, and yet one-third of scientists preferring nontraditional science careers have had postdoctoral training (Coggeshall et al., 1978).

In fact, a shift of academic culture to embrace a branching science career pipeline is required, yet little is known about this dynamic (Fuhrmann et al., 2011). National funding agencies, academic faculty, and graduate programs continue to use the traditional academic pathway as the definition of success. Programs are often evaluated based on the success of alumni in academia, with the main measure as being whether an alumnus holds a principal investigator-level faculty position in an academic setting (Fuhrmann et al., 2011). Yet, is has
been established that many trainees follow diverse career paths that are often leave academe. “Nontraditional” career paths should not be referred to as “alternative” (Fuhrmann et al., 2011), because “alternative” brings a negative connotation to many viable and strong career options. A better term may be “career choices” (Benderly, 2005), or “career path” and “career options.” A shift in the descriptions of sectors and career paths would ultimately begin to change the stigma now associated with PhD scientists seeking jobs outside of academia. A changed perspective and descriptive shifts could significantly alter both the perceptions and the job search experience of PhD scientists.

Equilibrium Efforts to Move from Pipeline to Pathway

PhD programs prepare students for a traditional career path, though there are few academic research faculty positions available. Scholars have increasingly advocated for the development of a broader curriculum to prepare PhD scientists for a wider range of career paths (Austin, 2002; Fuhrmann et al., 2011; Gaughan & Robin, 2004; Lane, 2011; Lee et al., 2010; Teitelbaum, 2006). Designing PhD programs according to a more diverse spectrum of the professional opportunities and plans students might encounter would encourage an adaptation of behavior in training and in the way research is undertaken by graduate students; these adjustments could potentially more closely align with recruitment criteria of a broader range of employers after graduation (Mangematin, 2000). The nation’s current demands for scientists in a diversity of arenas, and corresponding job opportunities largely exist outside of academic research; mentors, educators, institutions ought to adjust to meet this need (Teitelbaum, 2006). Alberts et al. (2014) recommended that mentors and institutions ought to help transition young scientists into a broader range of careers that would benefit from their specialized education and
abilities; they also suggested that the goal of institutions should be to gradually reduce the number of entrants into PhD training to better align graduates with available future opportunities.

Much of the international higher education literature has recently focused on how professional doctorate degrees could potentially answer to the needs and oversupply issue. A professional doctorate is an advanced or terminal degree designed to train applied and practical skills, which are used in direct professional practice rather than research or scholarship. Finland offers an alternative but not entirely successful model, according to the work of Hakala (2009a), because success is not defined or measured. Finland actually aims to increase the number of PhD degrees, but the goal is to shorten the time-to-degree, in essence creating more professional scientists who will be adequately trained to go into industry, rather than promoting longer training for academic scientists. Hakala (2009a) identified that graduate schools are key to attaining these goals (Hakala, 2009a). Similarly, Singapore has explored building and expanding universities to create more jobs for academic scientists (Cyranoski et al., 2011).

Cyranoski et al. (2011) outlined a solution proposed by one U.S. professor. Carpenter, a professor at MIT and Harvard, attempted to create jobs for existing PhD holders while discouraging new ones. She hired experienced staff scientists to achieve this, but she confronted many challenges trying to justify staff costs and the level of effort involved to grant review panels. Alberts et al. (2014) supported Carpenter’s vision that staff scientists can and should play an important role in the workforce, and they also recommend increasing the number of permanent staff positions as opposed to trainee positions like graduate student researchers and the number and length of postdoctoral fellowships. Poignantly, “The disposable academic” (2010) asserted that if top universities cut back on enrollment, other universities will step in to offer applicants slots in their programs.
A large number of Preparing Future Faculty (PFF) programs have been established in graduate schools (Coppola, 2009), but many graduate students and postdoctoral fellows are only granted scant exposure to different faculty cultures and expectations across an institution (Austin, 2002). This highlights the need for the encouragement of broad skills’ development to enable scholars to excel in industry, and even as faculty members, outside of simply conducting research. In short evaluating and modifying the terms and terminology used when discussing science careers could promote a positive spin on careers outside of academic research, encouraging early scholars to pursue a diversity of paths. Training has been traditionally carried out primarily through individual grants and initiated research, publically funded university-based research, or federal science agencies; the focus of training needs to be directed more consistently to intentional training and labor market impact (Gaughan & Robin, 2004). Many scholars and practitioners have called for reforms of academic settings, but Benderly (2010), recommended an evaluation and reconstruction of a career structure that might more adequately provide young American scientists a reasonable hope that spending years preparing to do science will land them in satisfactory careers.

The current needs of and job opportunities for U.S. academic scientists largely exist outside of academic research; graduate education paths must be increasingly designed to meet this need and these options (Teitelbaum, 2006). For example, as Teitelbaum observed, specialized Professional Master’s Degrees in science could prepare students in a reasonable amount of time for opportunities beneficial to them, the industry, and the nation (Teitelbaum, 2006). Though a limited number of faculty or principal investigator positions exist, many labs run on the efforts of other permanent career employees, such as technicians and PhD senior scientists. Staffing labs with these permanent career employees long-term, instead of focusing
funds and efforts on low-paid transient graduate students and postdoctoral fellows (Benderly, 2010), would be beneficial to productivity and growth and would provide solid career opportunities. Reasonable salaries and benefits provided to these permanent career scientists would reduce some competition for tenured academic positions (Goldman, 2002). This would enhance respect for the time, talent, and high level of acquired skills of technical lab staff, and it would perhaps raise incomes by limiting the numbers of PhD scientists produced and imported. Specialist knowledge is valuable in academic research, and it is gained through PhD education; however, general and transferable skills that are valued in technical positions may need to be gained through other types of education (Lee et al., 2010). A Professional Master’s Degree would give technical workers the skills needed to perform their jobs, limit the number of years of training, unclog the pipeline, and would potentially return some financial resources of tuition and stipend often paid back to the institutions.

To prepare graduate students and postdoctoral fellows for the positions they will seek post-graduation, opportunities for career development are needed. Three ways of facilitating this growth are through science career clubs, career development courses, and apprenticeships or internships. For biological scientists, training at the PhD and postdoctoral level usually involves an apprenticeship, but this experience does not prepare students and postdocs to be competitive in biotechnology and other nonacademic research careers (Gravagna, 2009).

A science career club or career development courses might provide additional needed training opportunities, teach soft skills, and establish a venue to develop both. These opportunities would also give students and postdocs a chance to explore career paths and would create possibilities for the development of networks within the nonacademic community (Gravagna, 2009). Austin (2002) similarly stressed the importance of career clubs, career
development courses, or other systematic approaches for the development of much needed skills and abilities. PhD scientists have opportunities to develop research skills; however, they often do not receive as much preparation and mentorship in areas such as writing grant proposals, securing funding opportunities, designing curricula, or implementing various technologies and pedagogical approaches. Other aspects of the diverse skills a faculty member must command are generally also left out of training, such as advising, institutional service, public service, ethical training, and outreach or recruitment (Austin, 2002). Setting national standards for training and mentoring to include career and professional skills planning and development has been recommended by Fuhrmann et al. (2011).

Internships and apprenticeships are also important arenas though which skills can be developed. Commercial and industry experience transfers skills to PhD scientists that enhance their ability to adapt to various workplace and professional situations; these skills are rarely garnered through PhD programs (Manathunga & Lant, 2006). Radetsky (1994) stressed that these experiences in industry offer practice in areas such as managing budgets, working and communicating with people as a team or in collaboration, and writing patents. Working for an industry through internships and apprenticeships also can help PhDs to refine intended career paths, establish preferences for their work environment, and provide more generalized skills useful in any scientific career.

Given that many graduate students and postdoctoral fellows get “stuck” in training and possible exploitation by their advisors, the creation of and dedication to individual development plans (IDP) is one effective way to facilitate focused training. An example of an IDP is the research student virtual portfolio (RSVP), a career development package designed to develop graduate students’ broad attributes (Manathunga & Lant, 2006). The RSVP process has had a
positive impact on graduate students’ learning and career development and has been proven highly effective as a framework for postgraduate/postdoctoral fellow advising. Fuhrmann et al. (2011) found that PhD students who receive research mentoring such as the RSVP submit more abstracts, papers, and grants during their training. Postdoctoral fellows who receive similar training and participate in career development activities also submit more first-author papers and grants. Both PhD students and postdocs have reported better relations and fewer conflicts with their advisors and higher satisfaction of laboratory environment and research progress when they participate in this type of initiative.

Many schools have already instituted committees, rather than individual PhD advisors, responsible for overseeing student and postdoc career development (Fuhrmann et al., 2011), but this should be widespread for maximum effect. The goal of an advisor is to identify, nurture, and move the next generation past what the advisor could accomplish (Coppola, 2009). Individual development plans and RSVP initiatives are important ways of facilitating growth through training. They also provide focus to particular projects and aspects of research and career development. Creating an IDP involves thinking strategically, gathering data and information, and evaluating results (Benderly, 2005). Benderly (2005) also noted that IDPs were recommended by the NIH in 2005. However, they were not widespread or required in early 2015. Developing and following an IDP or RSVP is a crucial skill that might effectively support PhD scientists through their career paths.

Not all biomedical science graduate students and postdoctoral fellows hope or intend to pursue an academic career. Academic stratification begins prior to the time when graduate students and postdoctoral fellows are heavily encouraged and pressed to apply for and seek academic positions. Junior scientists rightly have complex perceptions of career options and face
many hurdles during and after their training, all which affect their perceptions of and actual access to career pathways. Some schools and countries are attempting to find equilibrium for the oversupply of biomedical PhD scientists. Since many trainees do not follow the traditionally defined pipeline, research is needed that explores more in depth the career pathways biomedical scientists take.

**Conclusion**

Faculty mentors, institutions, and funding sources encourage biomedical PhD graduates and postdoctoral fellows to enter academic research; however, not enough positions are available to sustain the number of graduates. The number of graduate students and postdoctoral fellows studying and training in biomedical sciences, often with academic careers in mind, has not decreased even with a decline in demand. Although fewer positions are available for junior biomedical scientists, academic faculty positions are still prized and encouraged. This study has identified that the current system of training biomedical scientists is inadequate for the career opportunities available to these scholars, post-training. The number of academic positions available, combined with structural restraints and perceptions about work environments, contribute to a tension between academic versus nonacademic sectors. Additional factors contributing to the tension of oversupply and academic versus nonacademic sectors include: fewer vacant faculty positions, the rising average ages of first publication and first funded grant, economy fluctuations, and internationalization.

Applications and enrollment in graduate school have remained steady despite the number of available positions available for graduating students. As financial resources from the U.S. federal government -- the largest investor in higher education -- shrink, institutions are pressed to fulfill their mission, boost their academic quality and integrity, while reducing budgets and
spending. The economy is always ebbing and flowing, which impacts federal research grant funding streams and affects the resources institutions receive from federal allocations; this slows to a trickle, however, in impact for graduate school applications, actual enrollment, and postdoctoral fellowships sought.

Guiding students to careers that fall outside academia is challenging and may be met with opposition from current faculty members, institutions, and funding sources. However, when academic positions are limited and shrinking, new pathways must be encouraged and resources provided to help doctoral students strategically prepare for careers outside of academia. A number of researchers and nations have promoted changing the system to train more professional scientists to continue important discoveries and scientific productivity in industry and business; this would alleviate the strain of oversupply of qualified graduates that higher education institutions in biomedical science presently face.

Quantitative studies have reported on the career trends and outcomes of biomedical PhD scientists. These studies have used the traditional academic pathway as the definition of success. Very few studies, however, have been conducted on the job search experience of biomedical PhD scientists, especially in regards to analyzing the skills and training that could aid them in preparing for careers outside of academia. This case analysis aimed to contribute to understanding the profound employment dilemmas biomedical PhD scientists presently face
Chapter Three: Research Design

This study was conducted to gain a better understanding of the career search process of biomedical scientists. The purpose of this case study was to understand the process through which biomedical PhD scientists at a large southeastern tier 1 research institution are trained and supported for navigating a future career path. In addition, the study sought to determine whether career development support efforts and opportunities should be redesigned to account for the proportion of PhD scientists following non-academic career pathways. Though all career paths were reviewed in the previous chapter, non-academic careers were the focus of this research study.

This chapter describes the research design and approach that aligned the researcher’s methodological choices with the research questions and selected theoretical framework. First, the research approach and tradition are explained. The last section of the chapter details the research process, including how this study was conducted, ethical considerations, trustworthiness, and possible limitations.

Research Questions

The central research question driving this study is: How does a southeastern tier 1 research university train and support its biomedical PhD scientists for navigating their career paths? Data collected illuminated how the process influenced the outcome of the job search and explored other factors and experiences contributing to career paths sought and chosen. A practical sub-goal of this study was to uncover suggestions and ideas about skills that should be cultivated to benefit and prepare biomedical PhD scientists for employment after graduation.
Research Approach

As explained in the previous chapters, biomedical PhD graduates and postdoctoral fellows are pressed to enter academic research by their faculty mentors, institutions, and funding sources, but there are not enough positions to sustain the number of graduates. The NIH, a federal funding agency, is the main funding mechanism of biomedical science graduate students and academic research with the goal of ensuring there is an adequate biomedical workforce to sustain the future of scientific research (Wendler et al., 2012). Most studies have reported on trends in the outcomes of biomedical PhD scientists through quantitative methods (Agarwal & Ohyama, 2012; Basil & Basil, 2006; Coggeshall et al., 1978; Fritsch & Krabel, 2012; Mangematin, 2000; Martinson, Crain, Anderson, & De Vries, 2009; Matthews, Calhoun et al., 2011; Sauermann & Roach, 2012, 2014). These studies have used the traditional academic pathway as the definition of success. However, the focus of this study is on non-academic career pathways and understanding the process and experience for biomedical PhD scientists, not simply how many employees work in each sector. There has been little qualitative research conducted on the job search experience of biomedical PhD scientists, especially on the skills and training that would have best aided them in preparing for a career outside of academia.

Research Paradigm

Interpretivism conceptualizes the world as having more than one reality and not as an object that can be discovered, measured, and determined; rather, the world is constructed by human beings perceptions and interactions (Merriam, 1991; Ponterotto, 2005). While positivists and post-positivists see the world as objective and static, interpretivists see the world as subjective and dynamic. Instead of inquiring about facts and certainty, interpretivists seek answers to how and why, which is more suitable for qualitative research than quantitative.
Interpretivists, particularly social constructivists, emphasize human experience and meaning making. Therefore, social order and historical context are important aspects of interpretivism in the process of making sense and meaning; the paradigm asks and answers different questions than positivists and post-positivists. Interpretivism asserts that there is value in the co-construction of insight and meaning through dialogue and reflection between researchers and participants, and this paradigm provides richness and depth to the data. For these reasons, this research study uses the interpretivist-constructivist paradigm, which naturally aligns with a qualitative research design.

**Research Design**

A number of differences exist between qualitative and quantitative research, particularly the type of question(s) being asked. Though research problems addressed by either qualitative or quantitative studies may be similar, the specific research question(s) should determine which type of study a researcher should undertake. Quantitative studies generalize the aggregate behavior of populations by asking *how many*, and qualitative studies see issues as complex while asking *how, what, or why*. This study focuses on *what* and *how* questions in efforts to explore the career experiences of biomedical scientists through the interpretivist-constructivist paradigm; it does not seek to explain or generalize results to an entire population. In qualitative studies, a researcher may only have a rough idea about a phenomenon when beginning his or her study; in short, this research approach does not require, or often use, a hypothesis to begin or direct the study. Qualitative research is also more exploratory in nature and may begin with vague inquiries that are refined or that change over the course of the study as the researcher discovers, explores, interprets, and constructs understanding, meaning, patterns, themes, and theories. This
approach is inductive and asks the researcher to remain open throughout the research process to allow the data to shape the study as meaning is interpreted and constructed.

The role of the researcher using social constructivist perspective is to minimize bias and acknowledge positionality while seeking meaning, in this case, meaning that biomedical scientists have made of their career path process. The goal of this study was to explore multiple realities and perspectives through interactive dialogue, analysis, and reflection. The researcher acted as a facilitator of the interpretation to allow for the emergence of themes, patterns, and meanings. However, the researcher strived to remain neutral to interpret data responsibly and without imposing bias on the participants or data. Handling all interviewees with respect and discretion was essential to minimizing bias; the researcher took all precautions to protect participants when sensitive information was revealed. To minimize risks to individuals and their organizations, names and identifying information have been hidden in the findings and analysis. The details explaining how the researcher protected participants and minimized risk is discussed at the end of this chapter, following the descriptions of the research method selection and data collection processes.

Qualitative research uses a larger variety of methodologies than quantitative studies. Qualitative methodologies include case studies, conducting interviews or open-ended questionnaires to create a narrative, phenomenology, observation, content and context analysis, first-hand experience, and collecting field notes and reflections. This study employed the case study method; the rationale and reasoning for choosing this method is detailed in the next section.
Research Tradition: Case Study Method

The case study is a research strategy exploring a phenomenon within a context by using multiple sources of evidence (Yin, 1989). The case study approach allows for a detailed and in-depth look into data over time through multiple sources of information and data collection. Each data source type includes its own sampling, data collection, and analysis strategies (Boblin, Ireland, Kirkpatrick, & Robertson, 2013). A quick overview of case study methodology is provided below, followed by a more detailed description of the different approaches to case studies and a discussion of the reasons for choosing a particular case method for this research study.

The case study method or approach has been used by many disciplines and researchers for decades; however, the use of the qualitative case study approach has been used increasingly in the past 15-20 years and is gaining reputability. Many researchers could be included in a discussion of the rise in the case study as methodology, but two researchers in particular are instrumental to its acceptance and promotion: Yin and Stake.

Among the different scholarly perspectives of the case study approach, Yin broke methodological ground; he was foundational in outlining and describing the basic set of research designs for conducting single or multiple case studies. His design is the most frequently used approach. While Yin’s work has been employed with greater frequency, Stake adopts a different philosophical approach that is equally important in the field of case study research. Yin (1989) highlighted the importance of qualitative work even though the result of the methodology is not generalization. Stake and Savolainen (1995) also reiterated that generalizations are not the goal of case studies; rather, case studies aspire to know one particular case as it is, with differences and uniqueness emphasized. Stake and Savolainen (1995) thoroughly delineated the justification
for using the case study strategy to conduct research, describing the approach as a “naturalistic, holistic, ethnographic, phenomenological, and biographic research method” (pp. xi).

The case presented in this study includes a broad range of factors, namely those identified in the SCCT theoretical framework outlined in the first chapter. Yin (2009) defined case studies as explanatory, exploratory, or descriptive, while Stake and Savolainen (1995) delineated case study variations as instrumental, collective, or intrinsic. This study is an exploratory case study, seeking to understand the process through which biomedical PhD scientists navigate non-academic career paths.

The case study method allows the researcher to investigate the case in depth, while cross-analysis of individuals’ experiences supports the emergence of themes and patterns through inductive reasoning to explore a contemporary phenomenon. As the goal of research is to learn more about specific subjects, people, organizations, or issues, the researcher must rely on and use the method(s) that will make understanding and portraying the data most effective. The case study approach is not best for all studies, but it can provide a depth of understanding that cannot be as easily discovered by some other methods. For the research goals and questions this study addressed, a case study analysis provided more depth of understanding the search for a career and positions of biomedical PhD scientists than, for example, a narrative approach.

Participants

This case study provided an in-depth analysis of the individual experiences of biomedical PhD scientists from the research site, together with an analysis that identified themes; it contextualized the experiences of the scientists to aid in the interpretation of the meaning of the case. The unit of analysis employed was a “case” consisting of an individual, an organization, an event, another entity less well-defined than individuals, or multiple individuals as a multi-case
The choice to use the case study method related to the way the initial research questions and research purpose were defined. To understand the job search process and experiences of biomedical scientists, the researcher conducted a single case study at one research site with multiple individuals comprising the units of analysis. Typically the sample size for qualitative studies is fairly small, and the researcher may be familiar with the characteristics of the participants. This case study focused on biomedical PhD scientists in a specific training program supported by the NIH. Though this study’s intent was to learn about non-academic career paths, data was also collected about and from academic researchers for contextualization and cross-analysis.

**Research Site**

The specific research site and sample characteristics were selected for multiple reasons. First, the focus of NIH training grants is to train biomedical scientists to go into academic research; however, many do not intend to do so or do not enter academic positions. The training program examined at the research site is one of the largest and longest running in the United States, with trainees spanning many degree areas and most departments. This program also supports and trains both graduate students and postdoctoral fellows, which is not typical of many NIH training grants. At the time this study was conducted, the program was supporting eight graduate students and seven postdoctoral fellows for a total of fifteen trainees per year. Though this number has varied over the years, this is the average number of trainees supported per year. Some trainees are also supported for multiple years. The training program has existed for more than 40 years, so its longevity, the combination of pre- and postdoctoral trainees, and the number of trainees who have been supported by the program together create a large sampling frame.
Sample Characteristics and Procedure

Since several types of data were collected and the scope of the case study contains both depth and breadth, multiple sampling strategies and characteristics were included. In addition to initial and broad convenience sampling, quota sampling was employed in later stages of the study. The following four groups of participants comprised the sample:

All trainees. All past and current graduate students and postdoctoral fellows who have been supported on this NIH training grant, and have current contact information available, were contacted. This group included those in training, those who had recently completed training and begun careers, and those who had made several job changes throughout their careers. This group consisted of approximately 300 individuals and is referred to as All Trainees. As the data collection with this group was exploratory and helped to create a base sample for the third group, described below, a response rate of 15% was considered acceptable. Most responses came from those currently in training at the institution (In Training) or those who had completed training (Trained), though the researcher aimed for a representative sample with a mixture of those trained at the institution as graduate students or postdoctoral fellows, males and females, multiple departments and programs, and those in various training or career stages.

Of the 306 trainees who had been part of the training program before or during the time of data collection, 88 either could not be found or did not have current email information, at least two former trainees were deceased, and one was stationed in a remote international location without access to the Internet. There were 214 potential survey participants, and 98 completed the survey. Though all potential survey participants may not have received the invitation, the survey response rate was at least 45.79%, which far exceeds the proposed acceptable rate of 15%.
The age range of respondents was 24 to 67 years of age, with a mean of 47 and a median of 36. Fifty-six males and 41 females completed the survey. Fifty-seven survey participants trained at the research site as pre-doctoral students, 30 trained as postdoctoral fellows, and 11 completed both pre-doctoral and postdoctoral training at the university. These numbers are fairly representative of the biomedical science training program. Just over half (54 respondents or 56.3%) of survey participants reported the academic sector as their current career sector (see Figure 3), but the survey did not take into account those currently in graduate training or completing postdoctoral fellowships at research site or elsewhere, who also marked academic as their current sector. The distribution of prior career sectors (see Figure 4) is similar to the current sectors; however, the total number of responses is greater than the number of respondents, as respondents were allowed to choose multiple prior career sectors.

The final question asked whether the individual would be willing to be included in one of the next phases of the study -- a focus group or interview. One of the main purposes of the survey was to get a sample pool for in-depth interviews and focus groups. More than one-third (37) of the survey respondents volunteered for the next phase of the study. However, only 34 were considered, as three did not leave name or contact information in the anonymous survey. Details of these participants follow in the next two sections on In Training and Trained descriptions.

**In training.** This group included graduate students and postdoctoral fellows who were being or had been supported by the NIH training grant and who were still at the institution. Approximately 45 individuals were available from this group, which is referred to as In Training. Six survey participants, who were still in training, volunteered to participate in the focus group. Two trainees were unable to participate due to travel and clinic schedules. Demographics of the
focus group participants are shown in Table 4. As the focus group participants are currently in training and are fewer in number, their years in training were excluded from the table. Also, as focus group participants have not yet entered the workforce, the current and prior career sector questions were not applicable.

For document review, *In Training* participants submitted lecture notes from five career development seminars, a research statement and career objectives for application to graduate school, and a personal statement for application to the training program.

**Trained.** Individuals who were supported through this NIH training grant and had completed a PhD program or a postdoctoral fellowship made up the major focus group of the study as *Trained* biomedical PhD scientists.

The researcher aimed to select at least two former trainees from each non-academic sector to interview. There were 13 academic sector volunteers, six from industry, three from government, and two from other or non-research fields. Thirteen volunteers trained at the research site as pre-doctoral students, nine as postdoctoral fellows, and two completed both pre-doctoral and postdoctoral training at the university. These numbers are fairly representative of the training program makeup, so the researcher did not oversample any particular group. Several volunteers had experience in multiple sectors and were selected, even if they were currently working in the academic sector, because of their non-typical career path. Nine former trainees were contacted to schedule an interview, and one person was non-responsive. The demographics of participants in the individual interviews are shown in Table 1**Error! Reference source not found.**
Table 1:

*Demographics of Trainee Participants in Focus Group or Individual Interview*

<table>
<thead>
<tr>
<th>Trainee</th>
<th>Years in Training</th>
<th>Pre or Post-doc</th>
<th>Sex</th>
<th>Current Career Sector</th>
<th>Prior Career Sectors</th>
<th>Career Sector Interest Prior to Graduate School</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Current</td>
<td>Pre</td>
<td>F</td>
<td>Not applicable</td>
<td>Not applicable</td>
<td>Academia, Healthcare</td>
</tr>
<tr>
<td>2</td>
<td>Current</td>
<td>Pre</td>
<td>M</td>
<td>Not applicable</td>
<td>Not applicable</td>
<td>Industry</td>
</tr>
<tr>
<td>3</td>
<td>Current</td>
<td>Pre</td>
<td>F</td>
<td>Not applicable</td>
<td>Not applicable</td>
<td>Healthcare, Government</td>
</tr>
<tr>
<td>4</td>
<td>Current</td>
<td>Post</td>
<td>F</td>
<td>Not applicable</td>
<td>Not applicable</td>
<td>Academia</td>
</tr>
<tr>
<td>6</td>
<td>1993-1998</td>
<td>Pre</td>
<td>M</td>
<td>Non-research</td>
<td>Industry</td>
<td>Academia, Healthcare</td>
</tr>
<tr>
<td>7</td>
<td>1990-1998</td>
<td>Pre</td>
<td>F</td>
<td>Government</td>
<td>Academia</td>
<td>Academia</td>
</tr>
<tr>
<td>8</td>
<td>1998-2003</td>
<td>Pre</td>
<td>F</td>
<td>Non-research</td>
<td>Academia, Industry</td>
<td>Industry</td>
</tr>
<tr>
<td></td>
<td>1979-</td>
<td>1981-</td>
<td>Pre</td>
<td>M</td>
<td>Industry</td>
<td>Academia, Academia</td>
</tr>
<tr>
<td>---</td>
<td>-------</td>
<td>-------</td>
<td>-----</td>
<td>---</td>
<td>----------</td>
<td>-------------------</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td>M</td>
<td>Industry</td>
<td>Industry</td>
</tr>
<tr>
<td></td>
<td>1985</td>
<td>1988</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>1994-</td>
<td>Pre</td>
<td>F</td>
<td>Government</td>
<td>Government, Industry</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1998</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Industry</td>
</tr>
<tr>
<td>12</td>
<td>1979-</td>
<td>Pre</td>
<td>M</td>
<td>Industry</td>
<td>Academia, Academia</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1985</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Industry</td>
</tr>
</tbody>
</table>

**Faculty and administrators.** Faculty mentors who had trained graduate students and postdoctoral fellows supported by the main NIH training grant or other grants or means constituted the fourth group. When this study was conducted, there were 46 faculty mentors across 13 departments or divisions with a wide range of experience. A sample size of 4-6 faculty mentors was considered sufficient for exploring their perspectives on training for career path preparation. Four faculty members volunteered to participate in an interview. Faculty 1 was a female professor; Faculty 2 was a male assistant professor; Faculty 3 was a female associate professor; Faculty 4 was a male associate professor. One faculty member submitted a personal statement for a grant and a career development presentation.

Administrators of the departments, other NIH training grants, the Office of Postdoctoral Affairs, and the Graduate Programs Office were included in the *Faculty and Administrators* group to learn about the training process and opportunities available for graduate students and postdoctoral fellows outside of the research laboratory.

Thirty associated program administrators at the program management and program director levels were contacted. Several of the associated program directors overlapped with the program faculty mentors but none volunteered to participate; thus, there was no issue, which set
of interview questions to ask them. Two program administrators elected to participate in an interview. Both administrators were female; Administrator 1 had been in her position approximately 2 years, while Administrator 2 had been in her position over 10 years. One administrator submitted one new career development course description.

**Recruitment and Access**

The researcher gained initial access and interest in this study and population through her former job, where she maintained a large database of all applicants. This study was discussed with the director of the training program and verbal permission was initially obtained to use the database contacts. The director of the training program was serving as the gatekeeper of the database contact information and his approval was necessary to gain access to database. Written permission from the gatekeeper (Appendix A) was obtained prior to the submission of Institutional Review Board (IRB) applications. Once the database of contact information was provided to the researcher, it was contained on a server under two layers of password protection with access available only to the researcher.

Because the researcher, when the study was conducted, was no longer managing the training program, no issues regarding power imbalances with interviewees were anticipated. However, the researcher was constantly cognizant that, because she formulated questions, interpreted data, and reported findings, an informal position of power was always prescient. Handling all participants with respect and discretion was key to minimizing bias and also to protecting participants when sensitive information was revealed. Access and permissions; a brief written description of the intended case work and an extensive plan, when requested, with plans for report distribution or an opportunity to review and edit; and ways to provide anonymity and
make changes were crucial as the researcher explored each case in depth and made sure that risks to privacy were curtailed (Stake & Savolainen, 1995).

To minimize risks to individuals and their organizations, names and identifying information have been hidden from the findings. In order to minimize psychological risk, participation was voluntary and participants were informed of their right to withdraw from the study at any time. No incentives were offered. Participants received an informed consent form (Appendix B), which explained the purpose of the research study, its significance, how data was to be collected, managed, and stored, and the procedures for protecting the participants. Transcripts of verbal data collection were sent to participants for review. The participants had an opportunity to clarify or remove any statements they did not wish to have included. Participants also had the opportunity to withdraw from the study at any time and to have any data collected immediately destroyed. The researcher received approval for the study from the IRB at Northeastern University before contacting any participants. A form determining the researcher is not acting as an agent of the research site was also filed with the IRB at the institution along with the approved Northeastern IRB Study Protocol.

An email was sent to the All Trainees group describing the purpose and scope of the study, as well as potential risks and benefits, to recruit participants for the initial phase of the study (Appendix C). The unsigned consent email detailed consent, privacy and confidentiality, and the option to withdraw from the survey. The end of the consent email included a link to the survey. A thank you message was sent to participants upon survey completion (Appendix D). A reminder email with a link to the survey followed within a week (Appendix E) with a forward of the previous invitation and consent letter included. The final question of the survey asked whether the participant would be willing to engage in the next level of the study.
Those individuals who self-selected into the second level of the study were separated into two groups, those who were currently in training and those who had completed training. Participants belonging to the In Training group were subsequently recruited by email for focus group interviews to understand the support and training systems they were receiving, their experience in training, and their perceptions about career paths (Appendix F). The goal was to identify at least six participants through quota sampling; specifically, two individuals from each of three sectors: industry, government, and non-research fields (e.g. consulting or scientific writing). Individuals were selected based on the total of responses to further participation to gain maximum variety in the sample. The Trained participants received a recruitment email and consent letter to schedule interviews (Appendix G).

This group was more extensively interviewed in order to collect rich data from scientists who had entered different career sectors, which broadened the scope and provided a more thorough analysis of the issue. Six individuals in a case study is sufficient to gain variety and allow for in-depth interviews with each interviewee. The researcher reviewed individuals from the All Trainees survey who self-selected into the sample for the group 3 interviews and screened for the sectors of employment and time since training completion.

Similarly to the recruitment process for trainees, an email was sent to the Faculty mentors of the training program describing the purpose and scope of the study, as well as potential risks and benefits (Appendix H). The letter detailed consent, privacy and confidentiality, and the option to withdraw. The emailed letter asked whether the participant would be willing to engage in the study. The researcher selected faculty mentors to interview to gain maximum variety in lengths of mentorship, research and program areas, rank, and gender. Administrators of programs, departments, and career development were sent emails to request participation in
interviews about training opportunities (Appendix I). This group consisted of a smaller potential sample, and because they were participating for largely informational purposes, the researcher interviewed any and all who agreed to participate. Because this phase of the study did not depend on the other phases of the study, this phase ran concurrently with other phases. This technique was indeed beneficial because, as anticipated, data collected from faculty and administrators helped the researcher shape questions included in the focus group(s) or interviews, and participants were asked to reflect on and respond to data the researcher had collected from the informational, exploratory interviews with faculty and administrators.

**Data Collection**

The case study approach is time consuming; it requires the review of a large number of documents and can include quantitative data. Indeed, Stake and Savolainen (1995) agreed that researchers using the case study method often collect more data than they actually code and analyze, but the search for meaning relies on identifying patterns and maintaining consistency. The decision to use a case study as methodology inevitably influences the research design, data collection, and analysis. Initial data collection can change the case study plans and protocol and researchers should remain flexible to allow for these changes (Stake & Savolainen, 1995; Yin, 1989). This section details the data collection process used to conduct the study phases previously outlined.

**Phase 1: survey of all trainees.** The initial phase of the study was comprised of a comprehensive online survey sent to all trainees with current contact information in the training program database. The survey resulted in a broad overview of career pathways of 40+ years of PhD scientists who had been supported during a portion of their training at the institution.
The survey instrument is included in Appendix J. It included 19 closed- and open-ended questions spanning multiple factors as identified by the selected theoretical framework discussed in Chapter 1, SCCT and the literature review discussed in Chapter 2. The survey did not address the full scope of the sets of factors identified through SCCT; some factors were considered better suited for more in-depth questioning.

Table 2:

*SCCT Factors Addressed in Survey*

<table>
<thead>
<tr>
<th>Sets of Factors Identified by the SCCT</th>
<th>Addressed in Survey</th>
</tr>
</thead>
</table>
| Individual’s characteristics, experience, background, and interests upon entering graduate school | • Demographics  
• Interests or intentions prior to graduate school, including desire for an academic or non-academic career |
| Learning and performance in graduate school; skills acquired; the career search; interaction with mentors, faculty, and other students and researchers | • Likert scale responses on faculty interactions  
• Likert scale responses on career development opportunities during training  
• Likert scale responses on how training prepared participant for their career |
| Career path and necessary skills and abilities that should have been included in graduate school and postdoctoral training to aid in career development and the transition to work in or out of academia | • Current position  
• Previous positions  
• Open-ended listing of career development skills needed |
Google Forms was used to build and conduct the online survey because it was user-friendly, easily accessed by potential participants, tied to the researcher’s Northeastern University email account, and offered an anonymous option. The anonymous option allowed participants to respond to the survey without inserting personal information so only those volunteering to participate in the next phase of the study needed to share personal information. Data can be reviewed within the site as responses to questions or through various data visualization tools, and can be exported in multiple formats for further analysis. The survey was slated to take no more than 12-15 minutes to complete and was piloted with a biomedical graduate student in a different program than those included in the case study.

**Phase 2: focus group with in training and document review.** The next phase of the study utilized one focus group. Yin’s highly structured preference for use of a case study strategy recommends conducting a pilot test, which is not a pretest but rather is used to assist in the investigation to develop relevant lines of questions and to provide insight into the issues being studied (Yin, 1989). The focus group questions were piloted by a former biomedical science graduate student and postdoctoral fellow who was trained in another program. The focus group technique allows for triangulation of data and member checking, which is advised by Maxwell (2005) as a way to see different types of responses to compare with others data collection methods to strengthen validity, reliability, and confirmability of findings.

A topical focus group allowed the researcher to bring together people who had experienced similar training to allow the nuances of backgrounds, perceptions, and experiences to come through, which indeed differed from individual interviews (Rubin & Rubin, 1995). The moderator guided the conversation but also provided more active listening than questioning to
allow participants to interact and spark off of one another to co-construct themes together and to validate the analytic process, but not necessarily the data (Ravitch & Riggan, 2012).

The focus group allowed the researcher to interview those scientists who were actively in training. These individuals were at the institution and were easily accessed. Members of this group also had not experienced the outcome of the job search nor did they have information on which skills and opportunities would have been useful while in training, as their scope was limited. However, they were closer to their experiences prior to graduate education and generally had more accurate recollections of them. Three to four focus groups are usually recommended until there is saturation or until no novel information is arising; the groups can be used to lay the groundwork for more in-depth data collection (Krueger & Casey, 2014).

However, with a small group of current trainees and fewer self-selecting into the next phase, one focus group of current trainees was sufficient. In this study, the more in-depth data collection was facilitated through document review and one-on-one interviews.

The focus group session lasted approximately one hour; it proved easier to get graduate students and postdoctoral fellows working in the lab together at lunch time or after 4 PM, so refreshments were provided. Providing food increased the comfort level of the participants; they were more at ease and open, and the researcher believed this gesture did not influence participation in any way. The focus group was held in a large group study rooms in the library to keep the location neutral.

The researcher provided an outline of questions; however, as is typical, the focus group did veer from the original questions as participants responded to the researcher and one another. The researcher took notes during the focus group and recorded the session with an audio recorder. The audio recording was helpful for review once the focus group had concluded. A
co-moderator was also present to take additional notes and to clarify details of the discussion. After conducting the focus group, the researcher wrote additional notes and thoughts with important descriptions and episodes captured, and she constructed an account of the collective conversation using interpretive commentary (Stake & Savolainen, 1995). These reflections helped shape questions included in the interview phases of the study and were instructive in creating initial coding themes. The focus group protocol (Appendix K) was directly informed by the survey results, although it did change somewhat from the proposed protocol based on those findings. The focus group protocol included factors identified by the SCCT as follows:

Table 3:

*SCCT Factors Addressed in Focus Group(s)*

<table>
<thead>
<tr>
<th>Sets of Factors Identified by the SCCT</th>
<th>Addressed in Focus Group(s)</th>
</tr>
</thead>
</table>
| Individual’s characteristics, experience, background, and interests upon entering graduate school | • Introductions with brief background  
• Personal experience shared  
• Interests throughout school years and prior to graduate school |
| Learning and performance in graduate school; skills acquired; the career search; interaction with mentors, faculty, and other students and researchers | • How they plan to search for a career  
• Career search sector(s) that have been encouraged or discouraged  
• Formal and informal statements by faculty and other students and researchers about career search, trajectory, or positions |
| Career path and necessary skills and abilities that should have been included in | • Careers anticipated and skills they believe may be necessary |
graduate school and postdoctoral training to aid in career development and the transition to work in or out of academia

- Identifying the skills and topics they believe missing from their current career development

The researcher also asked the participants to send her application documents they had saved, such as cover letters or emails for postdoctoral positions, personal statements to graduate school, and if still available, undergraduate school application essays or statements. Participation was voluntary and thus not mandatory or expected. Participants were encouraged to supply the researcher with photocopies of original documents, send an electronic document, or provide original documents (of which the researcher obtained photocopies and returned originals to the participant). Identifiable information was masked from the documents for participant privacy and protection. The researcher anticipated receiving only a couple of these documents to review for words and statements, which affirmed or oppose their focus group statements or the later phase interviews with the other groups.

As approval for the study was received from the IRB at Northeastern University and the research site prior to phase 1, the researcher proceeded to phase 2 with participants who met the criteria and had opted to continue with the study. At the beginning of the focus group meeting, the researcher reviewed the purpose of the study, known potential risks and benefits, and the plans for disseminating the findings from the study. Participants all signed consent forms (Appendix B) and were reminded they could withdraw or retract statements or documents during any point of the study.

**Phase 3: interviews with trained PhD scientists and document review.** The majority of the data was derived from qualitative interviews with the Trained group of PhD scientists.
The interview is regarded as the most important data source in qualitative research, particularly for the case study approach (Yin, 1989). Unstructured interviews were not appropriate for this study, as they are too open to address the research questions and sub-questions. Qualitative interviews were thus semi-structured to address research questions, but the researcher also allowed the process to be shaped by the interviewees, who were viewed as conversational partners elaborating and providing depth and detail to form a rich or thick description (Rubin & Rubin, 1995). The interview protocol was edited after the focus group to address new data. The interview protocol included an introductory protocol and a few questions on the interviewees’ backgrounds; the interviewer then proceeded to ask the main open-ended interview questions about the research topic (Appendix L). The open and flexible design of a semi-structured interview or an interview guide allowed the participants to shape and introduce experiences and meaning to the topic that the researcher had not anticipated; the design permitted the researcher to probe for more information or clarification.

The structure and technique for conducting interviews was guided by Seidman (2013). Interviews were expected to last between 45 and 60 minutes; several were shorter, and two were double the expected length of time. Most interviews were conducted via telephone. Many interviewees did not reside nearby. If an interviewee was within a day’s driving distance, he/she was offered an in-person interview. If an interviewee was outside of reasonable driving distance or preferred not to meet in person, the researcher offered to conduct interviews via Google Hangout, Skype, GoToMeeting, or other web conferencing software or by telephone. Options were made available to participants based on their comfort level with conferencing applications. The audio of all interviews were recorded, with participant permission. The interview protocol
was pilot tested with one person who was trained in the biomedical sciences but who was not participating in the program that is the focus of this case study.

Similar to the protocol for the focus group, the researcher took written notes during the interviews. After conducting the interview, she wrote additional notes and thoughts, with important descriptions and episodes captured, and constructed the account through interpretive commentary (Stake & Savolainen, 1995). The audio recordings were extremely helpful in constructing the transcripts and reviews after the interview took place, and they were used as a reference for intonation and facial expressions that cannot be captured through a written transcript. Notes taken during the interview helped the researcher organize initial thoughts and themes, and to check for accuracy; they were also considered a back-up source of documentation in case the audio recording had failed.

As approval for the study was received from the IRB at Northeastern University and the research site prior to Phase 1, the researcher proceeded to Phase 3 with participants who met the criteria and who had opted to continue with the study. At the beginning of each interview, the researcher reviewed the purpose of the study, known potential risks and benefits, and the plans for disseminating the findings from the study. Participants signed consent forms (Appendix B), and were reminded they could withdraw or retract statements or documents at any point during the study.

Table 4:

SCCT Factors Addressed in Phase 3 Interviews

<table>
<thead>
<tr>
<th>Sets of Factors Identified by the SCCT</th>
<th>Addressed in Interviews</th>
</tr>
</thead>
</table>

| Individual’s characteristics, experience, background, and interests upon entering graduate school | • Introductions with brief background  
• Personal experience shared  
• Interests throughout school years and prior to graduate school |

| Learning and performance in graduate school; skills acquired; the career search; interaction with mentors, faculty, and other students and researchers | • How they plan to search for a career  
• Perceptions of career sector(s) and how those have been influenced  
• Formal and informal statements by faculty and other students and researchers about career search, trajectory, or positions  
• Listing career development skills acquired during training  
• Reflections on learning and performance during training |

| Career path and necessary skills and abilities that should have been included in graduate school and postdoctoral training to aid in career development and the transition to work in or out of academia | • Careers anticipated and skills they believe may be necessary  
• Identifying the skills and topics they believe missing from their current career development |

The researcher also asked the participants if they would be willing to send application documents they may have saved, such as cover letters or emails for postdoctoral positions, personal statements to graduate school, and if they were still available, undergraduate school
application essays or statements. Participation was voluntary, thus not mandatory or expected. Participants were asked to supply the researcher with a photocopy of the original, send an electronic document, or the researcher obtained a photocopy and returned the original to the participant. Identifiable information was masked from the documents for participant privacy and protection. The researcher anticipated receiving only a couple of these documents, and those received were reviewed for words and statements which affirmed or opposed the focus group statements or the later phase interviews with the other groups.

**Phase 4: interviews with faculty and administrators and document review.**

Qualitative interviews with *Faculty* and *Administrators* comprised the fourth phase of the study, though as previously mentioned, this phase ran concurrently with other phases of the study. These interviews were similar to those in Phase 3, in that they were semi-structured, flexible, and included mostly open-ended questions. The *Faculty* (Appendix M) and *Administrators* (Appendix N) interview protocols were somewhat modified throughout the study as new data was uncovered. The interview protocols included an introductory protocol and a few questions on interviewee backgrounds before the interviewer asked the main interview questions about the research topic. The protocol was tested in a mock session through which the researcher received feedback from a peer who had worked in faculty engagement and higher education administration at another institution.

Interviews lasted between 45 and 60 minutes; two were conducted in person and two were conducted over the telephone. As the faculty mentors were employed at the research site with easy access, the researcher offered in-person interviews, though participants were given the chance to elect to have a web/telephone conference interview instead. For the comfort level of the participant, the researcher provided several options for locations for meeting, such as the
participant’s office or a neutral conference room or meeting space. All interviews were audio recorded, with the participants’ permission.

As with Phases 2 and 3, the researcher took notes during the interview. After conducting the interviews, the researcher wrote additional notes and thoughts with important descriptions and episodes captured, and constructed the account with interpretive commentary (Stake & Savolainen, 1995). The recording was helpful in transcribing the interview and in reviewing after the interview took place. It also served as a reference for intonations that could not be captured through a written transcript. The notes taken during the interview assisted with initial thoughts and accuracy and also served as a backup in the case that the recording failed.

As approval for the study was received from the IRB at Northeastern University and the research site prior to Phase 1, no additional approval for this phase was necessary. At the beginning of each interview, the researcher reviewed the purpose of the study, known potential risks and benefits, and the plans for disseminating the findings from the study. Participants provided verbal recorded consent and were reminded they could withdraw or retract statements or documents at any point during the study.
Table 5:

*SCCT Factors Addressed in Phase 4 Interviews*

<table>
<thead>
<tr>
<th>Sets of Factors Identified by the SCCT</th>
<th>Addressed in Interviews</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual’s characteristics, experience, background, and interests upon entering graduate school</td>
<td>• Perception of trainees’ interests upon entering training and any changes during training</td>
</tr>
<tr>
<td>Learning and performance in graduate school; skills acquired; the career search; interaction with mentors, faculty, and other students and researchers</td>
<td>• Interactions with trainees about career search, trajectory, positions</td>
</tr>
<tr>
<td></td>
<td>• Perceptions of career sector(s)</td>
</tr>
<tr>
<td></td>
<td>• Listing career development skills covered during training</td>
</tr>
<tr>
<td>Career path and necessary skills and abilities that should have been included in graduate school and postdoctoral training to aid in career development and the transition to work in or out of academia</td>
<td>• Careers anticipated and skills they believe may be necessary</td>
</tr>
<tr>
<td></td>
<td>• Identifying the skills and topics they believe taught and missing from current career development</td>
</tr>
</tbody>
</table>

The researcher asked the participants if they would be willing to send documents or PowerPoint presentations they may have saved regarding career development skills.

Participation was voluntary, and thus not mandatory or expected. Participants were asked to supply the researcher with a photocopy of the original, send an electronic document, or the researcher obtained a photocopy and returned the original to the participant. Identifiable information was masked from the documents for participant privacy and protection.
Data Management

To minimize risks to individuals and their organizations, names and identifying information have been hidden from the findings and analysis. A pseudonym was used for each participant with an identity key stored securely in a password-protected file kept separately from the transcript files and recordings. Documents collected also had names and identifying information erased or replaced with pseudonyms. Electronic files were backed up through an online secure data storage system under two layers of password protection. The computer and online data storage was, throughout the entire process, only accessible to the researcher. Physical documents and consent forms were stored in a locked box with the key location known only by the researcher. The policies of both the federal government and Northeastern University require data destruction by shredding after three years, which will appropriately take place.

Stake and Savolainen (1995) recommend displaying the progress of the study through a data storage system with a calendar, list of phone numbers, observation notes, list of expenses, etc. A master list of data sources has been maintained so that the researcher can easily retrieve the information. Many recommend that researchers keep a journal to reflect on the research process, revelations, shifts in thinking and understanding, and interpretive decisions (Larkin & Thompson, 2011; Shaw, 2010; Smith, Flowers, & Larkin, 2009; Yin, 1989). In addition to using multiple sources of evidence, Yin (1989) presented two other principles of data collection: creating a case study database and maintaining a chain of evidence to increase reliability. The use of a reflective journal was instrumental in aiding the researcher in data management; it acted as an audit trail, and upheld decisions the researcher made.
Data Analysis

Research through the case study methodology is distinctive in explaining, describing, benefitting, illustrating, and exploring situations. The primary task of conducting research, according to Stake and Savolainen (1995), is to understand the case, discover relationships, probe issues, comprehend collective and categorical data, lessen the burden of clarifying descriptions, and make sophisticated interpretations accessible to readers through thick descriptive constructivism in a final report. The responsibility of the researcher to make the findings accessible means considerable focus must be placed on the data analysis process. Analyzing data and patterns does not begin near the end of the project but is ongoing because the interpretive researcher engages in observation, renewed inquiry, and explanation through a progressive focusing: “triangulation regularly sends us back to the drawing board” (Stake & Savolainen, 1995, pp. 114). This section describes the data analysis process.

Close-ended survey questions. The survey included close-ended and open-ended questions. The close-ended survey data was viewed within the Google Form data visualization tools and was also exported as a spreadsheet to allow the researcher to calculate descriptive statistics, look for outliers, and search for patterns and key words or phrases. The close-ended questions allowed for the use of pie or bar charts to demonstrate findings. A summary of data was analyzed and reported as descriptive statistics. Though this study includes some quantitative data, it is predominately a qualitative study and has been analyzed as such.

Open-ended survey questions, focus group, interviews, and documents. Open-ended survey responses and documents were loaded into MAXQDA, a software package that aids the researcher in analyzing qualitative data. Responses from the focus groups and interviews were transcribed word for word by an external service, Rev.com, and the researcher reviewed all
transcripts for accuracy. The transcripts were provided to the participants for review as a method of member-checking. Finally, the focus group and interview transcripts were uploaded into MAXQDA to code along with the open-ended survey responses and collected documents using Saldaña (2013) as a guide.

All responses to data collection methods were read through in their entirety at least twice to gain a sense of broad themes. Documents (for this section, documents refers to documents supplied to the researcher, as well as documents compiling survey responses and transcripts from the focus groups and interviews) were then analyzed individually before conducting a cross-analysis with the rest of the documents to discover overarching themes and identify outliers. The researcher continued to be reflective throughout the data collection and analysis process. An inductive approach allows researchers to let themes and patterns emerge from the raw data with less bias, thus the researcher used an inductive approach to analyze and make sense of many data. Analysis often reveals results in words, pictures, diagrams, and thematic mapping, and allows the researcher to highlight important direct quotations.

In first cycle coding, each focus group transcript, interview transcript, document, and documented survey responses were reviewed in isolation using MAXQDA, a qualitative software package with easily viewable display. This helped the researcher create an in-depth line-by-line analysis and an initial open coding of data. The researcher continued taking notes and writing journal reflections regarding lines of thinking, potential themes or patterns, and implicit meanings behind intonation and facial expressions. The researcher wrote descriptive summaries to capture the essence of what the participants had said.

Initial codes were consolidated into more general thematic codes in iterative patterns during the second level of coding. These themes created broad categories and condensed the
data into more manageable patterns to allow the researcher to begin understanding themes across transcripts and to analyze findings. Predetermined codes from the theoretical framework chosen, the SCCT, helped the researcher to further organize and analyze data, but these were only used after the first and second coding cycles.

The next step was axial coding and cross analysis of documents for emergent themes and patterns. Themes, categories, and patterns emerging from individual document analysis were reviewed for similarities and differences across all documents. A word table was created to display data from individual documents and among all documents. Code landscaping and mapping were used to highlight themes and conclusions across data sources. Finally, provisional coding was used with categories and themes from the literature review and the SCCT. Provisional codes were only be used after the first two levels of coding to prevent the findings from being distorted by preconceptions. These levels of coding are organized in systematic ways so as to compare data sources that increase the validity of analysis. Findings have taken the form of narratives because of the nature of qualitative data, but they also include tables and figures.

**Trustworthiness**

The study sought to uphold trustworthiness and verification with limited bias. As previously noted, it was unlikely that the study would have caused harm to participants, and the study was approved by IRBs at two institutions for the protection of human participants prior to contacting potential participants. The researcher maximized the confidentiality of the participants, collected data through safe and comfortable methods, and was mindful of any power imbalance or bias. The statements of the researcher’s bias in the first chapter and the purpose and lengths the researcher has taken during the study design to each potential participant indicate how the researcher has intended to minimize potential threats to internal validity.
For representativeness, the researcher surveyed all past trainees, interviewed two individuals in each of the non-academic biomedical science career sectors, conducted a focus groups with current trainees, interviewed faculty mentors and administrators, and reviewed documents used in graduate school applications, career searches, and career development. The multiple types of participants and data collection methods were used for representativeness and triangulation of data. Outliers, surprising, or conflicting evidence have not been eliminated from the findings.

Member-checking was facilitated by providing participants with a copy of the transcript to review for any edits, clarifications, issues, or omissions. Feedback and clarification were used to increase the authenticity of the representation of the participants’ views. External validity was sought with fully described participants, and settings, processes. The ability (or inability) to generalize findings to other settings or contexts has been acknowledged. Additionally, for external validity, the study design was evaluated by non-participants for clarity and question congruence.

Terms have been defined within the methodology section of the dissertation and within the research questions. The researcher sought validity of the instrumentation by asking the same questions within each phase of the study and by using the same analysis procedure to analyze the data from each phase. The researcher sought to use rich and meaningful descriptions. The researcher has discussed whether the findings are transferable and applicable to other populations and settings. Emerging patterns have been used to code data, rather than deductive coding methods to also lessen bias and allow the data to speak for itself (Rubin & Rubin, 1995).
Limitations

The case study portrays multiple views of the case, and it has been the responsibility of the researcher to assist the readers to gain a high quality understanding of the issue (Stake & Savolainen, 1995). Though the study encompasses multiple sample pools and data collection methods, and the researcher has detailed the research design, analysis, and measures to increase trustworthiness, the study is not without its limitations.

The main limitation is generalizability of the findings. Participants were recruited from a specific pool that had participated in a specific program at one highly selective institution. Their experiences as written in the findings must not be understood as representative of all biomedical PhD scientists. Yin (1989) regarded case studies as significant if they are either unusual but have general public interest or if the underlying issues are nationally important. This case study fulfills the latter criterion. Though the study population and sample may not be generalizable, the literature review demonstrated that similar issues are found at institutions throughout the United States and around the world. Though the findings from this study may not be exactly transferable to other populations and settings, there may be overlapping aspects, which can inform and benefit other populations.

Additionally, the number of factors incorporated in SCCT encompass more roles and intersections than can be discussed and understood. Though the researcher has taken lengths to inquire about the many factors that SCCT accounts for, there may be factors, which have been overlooked or are not yet discovered. SCCT considers individual characteristics and experiences, interactions with others, and external influences, which is a scope larger than any one research study can discover and explain.
Chapter Four: The Report of Research Findings

The purpose of this study was to understand the process through which biomedical PhD scientists are trained and supported in navigating a future career path. In addition, the study sought to determine how, and to what extent, career development support efforts and opportunities might be redesigned to integrate and account for the proportion of PhD scientists following non-academic career pathways. This study’s research questions were:

**Central question.** How does a southeastern tier 1 research university train and support its biomedical PhD scientists for navigating their career paths?

**Sub-question 1.** What was the process and outcome of the job search of biomedical scientists?

**Sub-question 2.** What factors of personality, environment, experiences, perceptions, etc. influenced the job search process for these scientists?

**Sub-question 3.** What skills (outside of laboratory/bench research) should biomedical PhD scientists be exposed to, and encouraged to develop, to prepare them for employment after graduation?

This chapter begins by detailing the sample characteristics of the case. After describing the participants of the study, the researcher uses the words of those trained in the program, program faculty mentors, and associated administrators to build a narrative of the training and career path experience of biomedical scientists. The findings are categorized into themes, which are organized according to social cognitive career theory (SCCT).
Ways the Research Site Trains and Supports its Biomedical PhD Scientists for Navigating a Career Path

The research site trains and supports its biomedical PhD scientists to navigate their career paths through planned activities, various forms of communication, and interactions with faculty; each has varying degrees of success. Survey respondents rated the career development opportunities they received at the university as fairly favorable, with 60.1% selecting a seven or greater on a 10-point scale (see Figure 5).

**Planned activities facilitate training support.** Some of the planned activities used by the research site included seminars, career development workshops, internships, and coursework.

**Seminars provide presentations on novel and updates to research.** All faculty and trainees mentioned seminars as critical, important, and desired for training and camaraderie. Research seminars initiated by departments and centers were thought to be necessary for learning other research and technical perspectives. Faculty and administrators regarded seminars as immersing trainees in departmental culture. Faculty members regarded seminars as an important way of train PhD scientists to relate to audiences, providing examples of how to present research and answer questions. However, the trainees and administrators noted that faculty members are a poor example of the scientific engagement the trainees were supposed to be learning. Multiple trainees said faculty often do not go to departmental seminars, even if the speaker is an invited guest from another institution. If they do go to the seminar, faculty members do not pay attention, but instead do work during the whole talk, or check phone and email messages.

Administrator 2 relayed a particularly disastrous story with a positive teaching moment outcome:
We had an unfortunate situation where one of our speakers last year thought he was sending a text message to his wife, and instead sent it to the host, who had invited him here to speak. He thought he was responding to the question, "So, how did it go?" He was quite blunt with his wife about how he felt received, and it came as a shock to the PI who had invited him. It was good feedback for us, because it allowed us to pull the students and the faculty and say, "This is not okay. This is not how we treat people that we've asked to come here. It's not okay."

Trainees and faculty admitted to being preoccupied in seminars, due to there being so many per week: Each department or training program hosts a seminar series and usually a bimonthly or monthly journal club. The trainees and faculty reported that seminars took time away from the laboratory bench, which was a real concern for trainees trying to finish graduate school or a postdoctoral fellowship, and move on. Faculty members expressed similar concerns about time constraints. Administrator 1 expressed a desire for a single streamlined, well-run seminar series and journal club for all biomedical science departments and programs. This individual acknowledged, however, that, if these changes were made, the administrative time and departments’ costs would be reduced but so too would be the ties and community-building each of the departments and programs cultivates. The result would be that a larger, cross-program seminar series would not mean cohesiveness or enhance seminar quality, and would not aid training purposes.

**Career development workshops facilitate career path skills training.** Career development workshops were viewed by trainees as helpful sessions, yet they proved disappointing when workshops dwindled or were not planned and supported by departments and faculty members. These workshops offered lectures and practical skills on scientific writing, the
grant writing and review process, public speaking, and especially in understanding the kinds of careers available for biomedical scientists. These workshops were most often requested and planned by trainees, but were not funded or usually endorsed by faculty or departments.

According to trainees and administrators, if there were career path workshops, too much emphasis was placed on faculty appointed positions or skills only needed at research institutions. Administrator 1 summarized the issues highlighted by both administrators and most trainees:

[Workshops on faculty positions are] what [faculty] push when they talk about career development. The problem with that is only 10% of the people that do research like this end up taking a faculty-level position at a university or research institution. So when you have so much focus on such a narrow career path, [trainees] do get really discouraged, and they do look for other ways to apply their education, their PhD, their interests in what they want to do. But it's not conventional and they're not teaching the students to be unconventional. [Faculty are] teaching [trainees] a narrow path, and part of it has to do with how NIH views successful research students and post-docs, because if [trainees are] not doing a faculty-appointed or a position of research at an academic institution, they're looked upon as not quite making it or that the training grant is not successful as it should be… Everyone's always pissed off after career development talks or after seminars. [Faculty] normally look at it as this meeting is helpful. It's not that helpful, but it's just so narrow that people aren't able to be like there's X amount of positions out there, and there is so many more people who are graduating with PhDs similar to what I do, so we can't all be fighting for that one position. I think there's also some room for understanding that if any department or [the biomedical sciences umbrella] were to decide, ‘We're going to create these career resources,’ they're going to give [trainees] the resources they think
[trainees] should have, which is maybe not necessarily the resources that [trainees] want, or need, for that matter. If we're all stuck in this idea that everybody has to grow up and be a PI of their own lab at an academic institution, those are the resources we're going to provide. If we're as a community open and accepting to the idea that [trainees] might be able to use this PhD to do something else, then we'll provide those resources.

Over and over, trainees mentioned not having enough workshop sessions to learn about career sectors and opportunities. Trainee 5 felt these sessions would help to even prepare post-docs, if you brought in folks from different walks of life, and industry, and kind of different opportunities. I don't think that [post-docs] really know what a lot of people do in their jobs. It could help direct [them].

Trainee 8 wished for more sessions:

I would have loved something like that, more availability to understand what other careers are out there because I had no idea. I didn't even know what a government job would look like…There wasn't a single person or group of people, besides [family, friends, other outside people], that pointed me in [a] direction.

Trainee 2 heard about an event in Maryland at NIH called Demystifying USA Jobs. He learned a lot about that system of listings and how to apply and avoid being eliminated before consideration. Even though this workshop was not at the research site, he felt fortunate to be close enough to NIH to make attendance possible. Other trainees expressed interest in having an employee from NIH visit to provide a session like Demystifying USA Jobs to a larger group.

Faculty 1 and Trainee 1 both talked about the research training program workshops teaching grant writing, networking skills and career path awareness and opportunities. Faculty 1 said,
Even if your mentor is not [providing career development training], I think if you're part of the training program you can get it through that as well…it's really good for them getting mentoring about how to think instead of just how to pipette.

During the focus group, Trainee 1 spoke about the training program in the context of the graduate student society,

I'm [in a board role] for [Graduate Biosciences Society] GBS now. I'm connected with a lot of people throughout all different training grants through that. Every time we're brainstorming events to do for GBS, things GBS can do to improve grad training, without fail, it's always like, ‘Oh, [training program name] does this, whatever.’ Even someone like 2 days ago, it's like, ‘Yeah, I mean [training program name] is kind of the gold standard. We should just do what they did.’ As far as the outside perspective, that's the bar for all the other training programs.

Trainee 4 asked Trainee 1 about those opportunities, stating that they did not exist before. Trainee 2 nodded and confirmed that these opportunities had only been added over the last couple of years, at some point during his own training. Trainee 10 also mentioned that career development workshops were relatively new. Trainee 10 worked at a new institution and had noticed signs and flyers for career development and seminar series for graduate students and post-docs:

That's something that's organized and people go to. I know that's something that's changed. We really didn't have anything like that. It was very much an individual thing. You were either working for somebody who was interested in helping you with your career or you weren't.
He also commented that some people have good administrative and organizational skills that would lead to different career paths than those who want to focus on research; however, most trainees would not know about these positions and opportunities.

**Internships supported non-academic career development.** The faculty mentioned internships 14 times, and then again in a set of workshop notes during the document review. Faculty 2 encouraged students who were interested in an industry career to think about what they needed to do to achieve this, such as an industry internship. The administrators said there was interest in internships, but it was difficult to obtain funding for these experiences. The trainees were financially supported while completing graduate school or their postdoctoral fellowships; however, many internships could not be paid from research grants, and mentors often did not have flexible funds that would pay for an internship or time away from the mentor’s research lab.

Trainee 8 was set up with a summer internship at a small biotech firm by his mentor after his third year of graduate school, to see “how science can fit into the bigger picture and what a career in industry might look like.” While Trainee 8 found this experience beneficial, and other trainees seemed interested in internship possibilities, none of the others interviewed were able to take advantage of that kind of opportunity. Faculty and administrators understood the trainees’ hesitancy. “Yeah, I think they just feel really pressured because they have to have a paper or they can't graduate, so if they're worried that it'll impact on that at all they don't like to go,” remarked Faculty 1. Faculty 4 initially said he “absolutely” encourages trainees to go to seminars and workshops, to apply for internships, and to seek other career development opportunities; however, less than two minutes later he said, “If they're spending more than 25 percent of their time doing those things, then that'll start to have a productivity hit. So I want them to go, but not too much.” Administrator 2 acknowledged, “It's a good opportunity, but it takes [them] away
from here. I think they talk about it, but then in practice they don't really want to be [working on the degree] any longer than they have to be.”

**Coursework is a required element of graduate training.** Coursework was not mentioned by trainees or faculty mentors as part of the graduate school experience for pre-doctoral trainees, but Administrator 2 discussed coursework required by training programs, in addition to departmental and program degree requirements, as a key component of the educational experience. One course that was a requirement for all students was cross-listed for multiple departments but was being taught by one faculty member. This faculty member “made every student come in and sit down, and [the faculty member] interviewed them to determine whether or not they needed the course, which was annoying because they needed it to graduate.” What came across in the interviews was that, if a training program places inflexible demands on a student who also must meet a degree program’s demands, the student gets behind. This and other challenges with negotiating the coursework appeared to cause the students undue stress and frustration. On one hand, the students needed the courses to complete degree requirements; simultaneously, administrators needed to make sure students were enrolled in appropriate courses to fulfill degree requirements and minimize any issues that may have led to additional time in graduate school or costs to departments, mentors, or training programs. However, students perceived that some training programs posed unreasonable demands on them, given the course and seminar offerings already determined.

A few trainees and one administrator mentioned that during courses, feedback was not received until it was too late to do anything about it. Trainees expressed frustration about learning they were getting a B in a 10-credit class at a point in the course when it was too late for them to affect their final grade. If a student found out at that late point that he or she would
receive a B-minus in the course, it would be seen as a failing grade. The student would not be able to offset the GPA with other courses, and the department had to justify why the student should stay in the program. For this reason, a consistent lack of feedback proved to be a much more serious issue for students than the instructor simply being too busy to provide grades or input into a student’s performance.

Administrator 2 detailed her department’s course offerings. All courses in her department were organized by one or two faculty members, yet they were team-taught. She observed:

Faculty teach based on their content knowledge to deliver sections of the class. Then, for our [specific] class, they do the grant thing with…faculty volunteers, like with the NIH panel. Then [those are] also peer reviewed, so the students in the class read the work that [other students] submit, so they get two levels of feedback. We try to keep the entire faculty engaged.

_The ability to work independently trains biomedical PhD scientists in scholarship._

Doctoral training is an exercise in learning to work and research independently. Independent research and projects were talked about with pride by three faculty members, during two faculty seminars, in three document reviews of personal statements, and in interviews with five trainees. Trainee 6 said he thought the biggest skill he learned while in the training program was how to do research by himself. When he was investigating a new topic at his first job, the ability to conduct independent research served him well in being able to roadmap a problem, figure out how to solve it, and focus on the parts most relevant to the questions he was trying to answer.

Trainee 10 said he thought the training program at the research site provided him with the tools to figure things out and to conduct independent research. In his program, it was rare if
anyone finished in less than five or six years, because faculty did not hand them a project that could be completed in, for example, a year and a half. Instead, the faculty made trainees find something to work on; they simply directed them to dig in and struggle with it. The philosophy of the program was to teach trainees how to ask a question and find an answer by making them realize what knowledge they already had that could be applied to the question and to learn how to be resourceful in finding where to go, what resources were available, and what might be most applicable. Trainee 10 ranked this just below bench skills as the most useful talent gained while in training.

Faculty 2 had a particular focus on training students to learn how to do work independently. He said his undergraduate students wanted to be spoon-fed answers, but his method of training students and postdoctoral fellows consisted of teaching them how to be curious and how to learn for themselves; this often meant failing along the way and adjusting for mistakes made. He explained that this increased trainees’ hunger for data, passion, and it actually bolstered the trainee’s confidence when they continued to revisit the question, when they considered yet again how they were trying to answer it, and eventually, when a solution worked. Indeed, Trainee 1 experienced this: “[W]hen things work, it's very encouraging. It's good. It's exciting. It's exciting to see new things and new findings.” He stated that this iterative process drove him to conduct more experiments, ask new questions, and continue to probe at the research question.

**Communication skills are crucial in careers.** Various forms of communication were developed and bolstered by experiences in lab meetings or journal clubs, networking, collaborations, and dealing with conflict. This honing of communication strategies took place through writing papers and grants, presenting ideas, networking, collaboration, and interpersonal
communication. Faculty said they tried to have trainees read, write, and present as much as possible, given that those skills are important for any career sector, and they are crucial to success in academia. Faculty 3 described how they approached this aspect of training, stating that they “start out with writing a review that we publish, because basically that will be the background of what they’re trying to do.” This shaped the basis of the trainee’s ideas and thinking, and led the trainee into readiness to write papers or grants, and to start presenting at workshops or conferences. Trainee 10 affirmed that this approach to teaching communications was essential to career success: “Gosh, if you can't write a grant, if you can't write a paper, you're not going to have any kind of career.”

**Lab meetings and journal clubs provide trainees with presentation skills.** The terms lab meetings and journal clubs were used interchangeably in interviews. Some lab meetings were actually journal clubs, others were collaborative with multiple labs, and some journal clubs were organized by the department, or were research area-based. The purpose of each structure was similar: to practice presenting to smaller groups to get comfortable and proficient at telling the scientific story, to learn to relate to the audience and answer questions, etc. and to practice engaging with an audience to further the thought process behind a specific experiment or interpretation of findings. Faculty members all said they believed it beneficial for trainees to present many times: conferences, they asserted, represented an excellent venue for this practice. They expressed that, ideally, trainees would be able to attend more than one conference per year, but those decisions were usually contingent on funding.

Administrator 2 said that not all faculty members provided constructive feedback to trainees. That individual expressed that two faculty members had been known to be problematic by asking difficult questions of trainees; this individual acknowledged that some of these
questions might be impossible to respond to, even for experts with many years of experience. In this context, trainees, especially graduate students early in their studies, Administrator 2 observed, would get “really flustered” and become “afraid to do journal club.” This example was from a departmental or research area journal club and did not seem to be typical of journal clubs and lab meetings of individual labs. Trainee 5 referred to this type of exchange as “training under fire” and said he found this type of interaction helpful because it helped him think through how he was presenting information or answering questions, although he did admit at times it seemed brutal.

Trainees mentioned several times that presenting in lab meetings and journal clubs helped them refine presentation skills and learn how to talk about their projects in a way that audience members could understand. Trainee 9 described the process of learning to provide different types of presentations based on the setting, audience, and time limits:

I guess I got better at that as time went on. You get to the point where you're comfortable talking about your own work. I guess it's not quite fair, because my boss took me to a conference one time, and I was in some competition for a young investigator award, and it was a 12 minute talk, which was...I quickly realized to be an extremely different format from the 45 minute academic seminar, and there was a whole lot of her sitting in front of me as I tried to say things in a succinct way, and her going, "No, no, no, no. You can't say it that way." But that was good. That taught me how to deal with that kind of format, and I think that's something people don't really understand until they have to do it. But that's the same thing that you would have had to do if you were a platform speaker at a conference also, and I hadn't had experience with that. But it was good to get that experience, so she did provide me that. She also taught me how to, if I was presenting a
poster, how to take somebody through the poster from introduction to so and so, and also figure out who this person is. What's the audience? Is this person who's interested in my poster vaguely familiar with the topic, or are they completely unfamiliar, which is going to require me to explain a lot more background? That was also helpful.

Trainee 10 had a positive experience with a member of his thesis committee as he was preparing a presentation for a conference. The faculty member reviewed the presentation, which was set up chronologically, and told him that a different organization of the material would be much better received. Instead of telling the story chronologically, the mentor guided the trainee to present “this stuff first and then they'll be wondering, well, what happened to that and then you give them boom, you give them the answer just when they're asking the question” to create a sense of drama to engage the audience. This practical skill was a component that was difficult to teach in a formal class setting, and Trainee 10 and several other trainees stated that some people just have the skill of presenting, and some do not.

**Networking was a skill fostered in training found to be beneficial in finding a job.**

Networking was mentioned 68 times through the survey, interviews, focus group, and documents reviewed. Networking occurred when trainees met seminar speakers, attended conferences or annual meetings, and interacted with pharmaceutical and device company representatives. Interacting with colleagues within one’s lab and other labs and departments was recommended by faculty through interviews and workshop presentations included in the document review, but no one mentioned networking more broadly within the institutional context. Networking was thus generally siloed.

Trainees, however, were afforded an easy opportunity to meet individuals outside of their particular institutional context when seminar speakers visited. Trainee 8 said she found value in
the opportunities to interact with seminar speakers invited by her department. However, Trainee 2 found it difficult to network with seminar speakers because the events were so popular, with 50 or 60 students attending, yet the informal time to connect after the event was limited because those 60 people were vying for the guest’s time. That left no time for substantive networking to happen. He attempted to address this by volunteering to take the speaker to lunch or dinner in order to spend time with the guest; often he was unable to carve out this space with highly popular guests, who had a packed schedule meeting with faculty also competing for the speaker’s time.

Faculty 2 helped facilitate interactions between trainees and visiting faculty members. If “the visitor has a closely related topic of expertise with my postdoc, then I always invite them to that meeting because I think it’s important for them to know and network, et cetera. [The postdoc] almost always goes out to lunch with the seminar speakers. That I think is important,” explained Faculty 2. This was the only mention of faculty helping trainees network during training. A few trainees reported receiving assistance in networking after training when searching for a job. These connections proved invaluable to trainees in landing a job.

Multiple trainees and one administrator spoke to the difficulties in networking without a mentor connecting trainees to colleagues and speakers. Trainee 4 regarded this as a shortcoming of the faculty mentors and said they typically kept to their own conversations with people at meetings or conferences, rather than introducing the graduate student or post-doc. She continued by saying the mentors often talked about networking and spider web-like connections, but there was no guidance, assistance, or introductions to aid the trainees in networking. Likewise, Trainee 10 had this experience, but when giving advice to graduate students about a post-doctoral position, he now tells them
Work for someone who knows their stuff and you're going to learn something too and who is interested in helping you with your career because that's your best opportunity right there to get a good position. Somebody who's going to promote you, who's going to bring your name up to other people, who's going to teach you the skills that you need, someone who has connections.

Administrator 1 saw faculty making connections only for the “very influential, passionate” trainees who were “all stars.” Most trainees are between “strongest” and “weakest” by the very definition of the terms, and these did not garner as much attention as the very few at the top. Administrator 1 had seen faculty members traveling the world for conferences and speaking invitations, developing relationships with colleagues, and yet they did not take the time or make the effort to connect their students and post-doctoral fellows with others.

**Collaboration and teamwork were important experiences for trainees.** The survey, faculty, administrators, trainees, and documents all repeated the importance of being able to work on a team and in collaboration with others. The document review found mentions of “keeping the lab motivated,” “working as a team,” and becoming an “effective” team. Administrator 1 summarized the importance of these connections, stating: “[S]ometimes it's better to bring a lot of minds together to do the research rather than one lone island who runs it all.”

Trainee 12 referred to training as “a collaborative environment with a team mentality.” He mentioned that his program constantly reinforced teamwork and collaboration and even had a softball team to encourage social interaction outside of the lab to bolster interactions in the lab. Trainee 11 reflected on “many good relationships with most people in the lab” spurring from collaborations. She worked on a project with a post-doc to get the post-doc’s experiment set up
and working. She remembered all individuals involved as being supportive by teaching each other techniques, reading each other’s papers, and acting as sounding boards for ideas and presentations.

Trainee 11 also had the experience of collaborating with other labs when her mentor joined with another faculty member who began a position in the same year. Both faculty members worked in a similar research area, with one lab working on the in vivo side while the other lab was working on the in vitro side. The labs worked very closely together and even held a combined weekly lab meeting. Administrator 2’s department had an annual retreat to capture what was going on in each lab with poster sessions for post-docs and graduate students so they could have an opportunity to present their work to others, potentially fostering other collaborations and causing cohesiveness within the department.

Some mentors selected individuals to work in their lab who would be able to collaborate. Trainee 10 had a discussion with his mentor once about how well and efficiently the lab members worked together. The faculty member said that it was no accident that he picked people with the ability and openness to work together in collaboration within the lab and with collaborators in other labs and institutions. This mentor looked for signs that a graduate student or postdoctoral fellow “wanted to be a lone wolf and work by themselves,” because they would not fit into his lab.

**Faculty support and train PhD scientists.** Interactions with faculty mentors and other professors also impacted biomedical PhD scientists training; it shaped their navigation of their career paths. Mentors had a tremendous effect on the process and support of trainees. Two trainees in the focus group stated that some people have had good mentorship experiences and
Interactions with mentors were greatly influential. Interactions with mentors was a key aspect of training and support given to graduate students and postdoctoral fellows. This was evidenced by data collected from surveys, interviews, and document analysis. An analysis of the interviews with trainees revealed a split regarding their evaluations of whether or not their interactions with their mentor were positive or negative.

Those who responded to the survey described the extent to which their interactions with their mentors were favorable during and after training. During training, interactions were quite favorable, with 69.4% of respondents selecting eight or greater on a 10-point scale (see Figure 6). Interactions after training were slightly less favorable, with the bulk of answers starting at seven, but 74.2% of respondents still selected seven or greater on a 10-point scale (see Figure 7). The document review provided the following list of traits of a good mentor: “Accessibility, empathy, open-mindedness, consistency, patience, honesty, savvy, responsive.”

Positive experiences with mentors. Trainee 6’s mentor was always willing, when he was available, to give guidance, and the trainee expressed feeling sure that if they connected even now the mentor would “be happy to pick up the phone if he had the time.” Trainee 7 had two rotations within her department and one in another department, and she maintained good relationships with all faculty members. She regarded her graduate school mentor as one of her best friends, and said, “I have her come give a seminar where I am now, every other year…We talk pretty often. I really respect her and I think that she is an excellent mentor, and a very good scientist.”
Trainee 10 had a very positive experience with his mentor, who he held in high regard. He elaborated at length about his late mentor being “very supportive intellectually and academically and personally, too” and “just fun…and really challenging.” Trainee 10 expressed that he had dealt with some “rough, personal struggles” in his life during graduate school and he said his mentor “was very understanding and supportive.” He outlined how the mentor had profoundly affected his life:

I don't think I would've gotten through my graduate career or perhaps my life if I didn't have that support from him. I can't underestimate how important it was to me to know that he was really...that he really cared on a personal level. It wasn't just about my academic work. He cared about me as a person which was very important.

In Trainee 10’s estimation, his mentor was perceptive and intentional in guiding his lab experience and training. He said the mentor individualized each person’s training and did not impose his ways of getting things done – he empowered each trainee to reach his or her best potential. The trainee said the mentor intentionally picked individuals who would work well as a team and who would collaborate with other labs. He said the mentor also “had a very fine skill at discerning what each person needed to be motivated” and tried to figure out how to help each trainee learn in the way he or she learned best. Trainee 10 stated that he appreciated the way his mentor interacted with him and the other lab members; this guided the trainee toward a solid career path; “It was very much an individual thing. You were either working for somebody who was interested in helping you with your career or you weren't.” Unfortunately, before Trainee 10 finished his postdoctoral fellowship and made his way into a career path, his former mentor died, but he left a legacy of giving his trainees the best training and encouragement possible.
Two faculty members individualized training for their graduate students and postdoctoral fellows. Faculty 1, for example, asked trainees about their goals and interests and tailored training to each individual’s goals and plans, resulting in a “very different training process for each of those paths.” Faculty 1 was trained as a medical doctor. She had decided later in his career to become a physician-scientist, and had previously run training programs. Faculty 4 wanted to help prepare trainees for a “career where they can make a big impact overall.” This meant he discussed trainees’ long term goals and what they wanted to accomplish along that path, and then passed along opportunities and career articles to help the trainees gain the necessary skills and connections.

Faculty members emphasized the importance of providing constructive feedback and recognizing individual and lab achievements; this component was also prominent in the document review as an important aspect of mentoring. For example, one document from a workshop advised future mentors to “provide feedback regularly and time well [sic]. Be direct and objective; constructive, not punitive.” Administrator 2 said the annual progress report assessed growth throughout the year and allowed for objective feedback. Administrator 1 discussed the importance of individual development plans (IDP) now required by the NIH, which are aimed at helping trainees align their career goals with their training and progress. However, faculty viewed this process as a burden or another requirement, rather than a helpful tool to assess and guide their trainees.

Negative experiences with mentors. Several trainees had negative experiences with mentors. Trainee 1 could not get help or guidance with interpersonal issues in the lab affecting her work, and she described the responses from her mentor about this and other issues as “no real support there.” This caused her to have to reach out to other faculty members, the department,
and the chair to see if anyone was willing to assist her. Trainee 4 replied to the story by Trainee 1 and a few other similar stories from other focus group members:

Your mentor should have dealt with your issue, right? I mean their job is to protect us and stuff. They're supposed to be like our greatest advocate and most of the time they end up stabbing us in the back. It's just kind of discouraging.

Trainee 4 stated that she was being paid through training programs and a grant she had received during her postdoctoral fellowship. When her grant was ending and her mentor would become responsible for paying her salary and lab costs, he told her to find a job and said she should find a job in a second faculty member’s lab because she probably could not run a research lab herself. She perceived that he was uninterested in helping her find academic positions. One week before she was supposed to start the second postdoctoral fellowship, she received a fellowship grant from the American Heart Association, and her mentor stated to her that he wanted her to stay on under his purview. She said she thought he wanted her to continue having her produce under his lab and name. This individual experienced a tug-of-war between the two faculty members that lasted for a full year, with both requiring her to do work for them; the trainee expressed that this resulted in an awkward, stressful situation for her. She said that she believed mentors were supposed to guide their trainees and help them reach goals and a strong career trajectory; yet her experience was that the mentors were more concerned with their own names, publications, and grants than with providing support to young scholars.

*Perspectives on career sectors and paths influencing trainees’ perceptions.* Trainees received implicit and explicit messages about career sectors from their mentors. Figure 8 shows how trainees perceived the levels of support – favorable or unfavorable -- from mentors in each career sector. A majority of mentors encouraged academic careers (79.6% selected 8-10 on a 10-
point scale); non-research careers were mostly not encouraged (71.3% selected 1-5 on a 10-point scale). The clinical healthcare and government career charts look about the same with most selections for 5 (26.6% clinical healthcare; 30.9% government) and the remainder spread out across the other selections. The chart for the industry sector is interesting, with the most responses at 5 (21.1%) and 8 (22.1%), and the rest of the responses spread among the remainder.

Trainees repeated that their mentors encouraged them to pursue an academic track, but a few said that when they told their mentor they wanted to go in another direction, the mentor eventually stopped discouraging them and tried to provide direction. This was the case with Faculty 2 while he was in training. Faculty 2 was very open to supporting mentees in careers in all sectors. He stated he was not sure if it is because (a) he was foreign and had not received the same messages about academia being the preferred option as his colleagues, (b) he had recently come out of training and begun his career and maybe messages to trainees were changing, or (c) he was in a department and research area heavily tied to industry where many people move back and forth or collaborate between the sectors. He said he hoped advisors had become more open-minded than they used to be about career options, because “really nothing is more important than having a successful trainee in the end. A successful and happy trainee. That's the bottom line,” but he explicitly acknowledged that often, if a trainee wanted to go into another career sector, it could become problematic for an advisor outside of that career sector to know how to train or guide them toward this goal. He stated that, when he learned a trainee might want to go into industry after a postdoctoral fellowship, he would send the trainee to a biotechnology industry organization conference. He said that often, faculty might not know how to support trainees who want to go into other sectors because their own experiences are limited to the realm of academics. He felt, however that it was important for faculty and trainees to talk and that faculty
must realize that “a non-academic career is a good career also and people make that choice for multiple reasons.”

Trainee 3, contemplating her career path with anxiety, said she would feel better about it if she had support and guidance from her mentor. In this same vein, Administrator 1 said she had heard from many trainees, especially females, that academic positions are pushed as the only valid professions. She noted that mentors do not talk about industry, government, or any other venue for professional development; students are discouraged from pursuing allegedly “non-research” careers like “technical writing, patent law.” The only people who went into industry from Trainee 9’s recollection were those who had mentors with a start-up in town, so the trainee would transition from training in the lab to working for the mentor in another setting. Otherwise, he said, nobody ever got a job in industry. Trainee 7 summed up words of many trainees when she relayed:

They're teaching them a narrow path, and part of it has to do with how NIH views successful research students and post-docs, because if they're not doing a faculty-appointed or a position of research at an academic institution, they're looked upon as not quite making it or that the training grant is not successful as it should be.

Administrator 2 found that the fight against the academic culture and the NIH might be mitigated by a path for trainees “who want a higher degree, but don’t want a PhD.” There was no admittance into a Master’s program; thus, the Master’s program became synonymous with a “fail-out option.” Many graduate students in her program would do a Master’s level program, particularly because employment options are greater at that level than with a Bachelor’s degree, and for those individuals who do not want to follow the PhD path. In the programs at the research site, graduate students may earn a Master’s as they advance to candidacy or on the way
to a PhD, but mostly the Master’s was only for those “who would not be continuing on to the PhD,” adding to the stigma of failure.

**Trainees need lab management skills.** Trainees expressed a need to learn lab management skills for future success in academic careers. The code “lab management” encompassed several aspects of management: personnel, project, and financial. Though some labs have permanent staff to manage the lab, faculty mentors are ultimately responsible for managing their labs.

*Personnel management was an often overlooked, but important, skill for lab management.* Personnel management was discussed at length during the focus group and was only briefly mentioned by a couple of trainees during interviews. Though personnel management is the responsibility of the faculty mentor, several trainees were left to manage personnel issues and deal with conflict, which they said hindered productivity. Some conflicts were not directly related to science or research, but still negatively impacted their desire for an academic career.

For example, at the beginning of her graduate studies, Trainee 1 experienced significant success with her first project. She became the first author on one article, the second author on another, and was asked to provide review consultation within the first 18 months of her studies, which represented a high level of performance for a graduate student. This seemed to create a competitive edge with at least one of her peers; she stated that another student began harassing and being aggressive toward her to the extent of stealing equipment from her and committing other actions that hindered her projects and progress. The situation was brought up to her advisors, as she was being co-mentored, but the issue was dismissed for one and a half years, and the trainee was discouraged at the lack of recourse and felt it was not handled properly. The
inappropriate situation was difficult to handle; she was unable to find someone or somewhere to turn to address the dynamic appropriately. The graduate school had no official HR department to support students. She said,

I expected [graduate school] to be hard. I expected that [some] months [my particular project] will not work. I expected all of that which now getting to mechanism work that's starting to happen too which is kind of a refreshing problem to have. I never expected to have an interpersonal issue affect my grad career or academic career.

Trainee 1 expressed that the faculty’s ignorance of the issue enabled the other student to continue interfering with her personally and professionally, making the lab a difficult place for Trainee 1 to continue her scientific work; it seriously decreased her productivity. She stated that the situation was disregarded; no one confronted the student causing all of the distress. In short, she had no venues through which she could address this distress or future issues. Trainee 4, meanwhile, spent a great deal of her time in the lab managing students. She reported that she was actually running the lab since her mentors in graduate school and during her postdoctoral fellowships were not managing their lab personnel. Her mentors either did not have technicians and lab managers or they had delegated them to other tasks, leaving the personnel and lab management up to her as a senior postdoc. She expressed that her mentor did not positively view her level of productivity; and she stated: “My papers don't get written because I'm managing all of your people.” In short, she was dealing with interpersonal issues and mismanagement of people in the lab; she described trainees as being treated like “grunts” and as being “disposable.” She expressed that, from her experiences, she determined academic scientists have a hard time managing—or they outright fail to manage—personnel. Little training had been provided to
students like her who were being asked to assume middle management or leadership instruction roles to address “disgruntled people in the workplace.”

Trainee 4 had several experiences in graduate school at another institution and during her postdoctoral fellowship at the research site that deterred her desire to pursue academic science. During graduate school, a difficult family issue arose, and she took a leave of absence for a couple of years to go home and take care of a sick parent. She found it difficult to return to the program after the leave of absence, with many obstacles to confront to return, and her perception that she had been judged for leaving. She expressed that, during her postdoctoral fellowship, she seemed to hit a wall of issues and needed to learn how to climb over the wall. No one provided guidance or pointed out resources to help her deal with personal issues and those arising out of the ebb and flow of success that comes with conducting experiments. Additionally, she was faced with an assumed lab management role, discussed in the following section, that prevented her from being as productive as she and her mentor desired.

One faculty member, Faculty 3, anticipated and acted to prevent conflicts. She may have had a different perspective than many other faculty members, perhaps because she was also running a company outside of the institution. When any student or postdoctoral fellow simultaneously worked for her company, she appointed an ombudsman to serve as a resource for these students and postdoctoral fellows in case they felt exploited or encountered any other issues. She noted that policies existed stating that students cannot be exploited, but those policies did not really have a practical effect – they were more of a formality in place to assure that the institution or the organization could not get sued. The ombudsman she employed provided mediation; she expressed that the presence of having someone acting in that role created a much more cohesive and pleasant environment for trainees.
Project management skills are necessary for trainees preparing for a career. Project management was a major focus of faculty mentors, but was also mentioned as essential by trainees and administrators. Faculty 3 felt that the projects selected for trainees were appropriate for the amount of time available to training; “We always choose [a project] that's really high risk, high reward, middle, and then oh yeah, that's no problem [like one] building on 5 years of data…[The one undertaken is the latter so] there's never a risk for the trainee.” She told a few stories about labs that did not share her approach. One faculty member was well-established and had funding that afforded supporting 15-20 people. A postdoctoral fellow had been in a position for just three months; that individual was let go because the faculty member did not think the trainee was producing fast enough. In another lab, two or three postdoctoral fellows were put on the same project to compete against one another, where the “victor” got the “spoils” to assure the faculty member would have a paper published as soon as possible. She regarded this type of training as “treating people like commodities” and less of a training environment than a production facility.

Faculty 3 described issues with productivity within the context of thinking trainees needed to spend more time and effort on a project – they needed to persevere and “keep plugging away.” If they cannot “cut that…they have to go into other areas of science” (Interview with Faculty 1). The impression Trainee 9 said was received from faculty was “either you get out in 5 years or you get out in 8 years, and if you get out in 8 years, the faculty's looking at you going like, ‘This one probably needs to work at the FDA (Food and Drug Administration) or be a patent lawyer or something.’”

This message was discouraging to trainees. Many considered productivity and success in part as the luck of the draw of the project to which they were assigned; they also confronted the
stress of their project and thus their publication being pre-empted if indeed another lab found an answer to the same research question and published first. Additionally, experiments would not necessarily work or contribute to answering and evaluating the research question. This was indeed the case for Trainee 2 -- the experiments assigned to this post-doc simply did not work, and it was not possible to replicate previous results. This individual had been working with another post-doc who got a job and left, and he had no one to help him maneuver the project’s issues. One would assume that in such a case, the mentor would have stepped in to guide, train, and advise him, providing additional resources during this time of transition, at least during at certain points along the way; however, the trainee was left to struggle through these difficulties alone. He said he felt there were a lot of situations left to the trainees in the lab to independently manage because the mentor was disengaged with their training – the mentor’s focus was on his or her own papers and grants. Eventually, this individual received a performance review from his mentor; he was judged as not making any progress, not doing anything, and basically, the evaluation ended with the message of “do more and do better.” The project was eventually dropped, and a new assignment went well, which meant he could start looking for a job and left shortly thereafter. Still, Trainee 2 was frustrated and said he felt like he had wasted 1.5-2 years of training due to a lack of personnel support and project management.

Trainees expressed that, when they felt they were not being trained or supported by their faculty mentors, they turned to administrators for guidance. The administrators, however, were poised to assist with altering stipend and course schedules and providing resources and information about career development and other general advisement; however, they were unable to provide specific research direction. This was especially apparent when the trainees were required to submit a grant with no direction from their mentor. Administrator 1 shared a lengthy
but comprehensive summary of the support and guidance provided by many faculty and the experiences of trainees and administrators. Trainees approached her to get help writing a grant as they were “left to drown really.” She told several postdoctoral fellows:

I don't know your research, and I'm not a scientist, so I can't write it for you. All I can tell you is what documents are needed, what that looks like. I can help tweak and get information for you on that, but I can't do much else other than hopefully collect that information.

Postdoctoral fellows were not given the proper training for this process, and “there's obviously a lack of support by either the PI or just the whole process in general.” The administrator said she saw many grant applicants re-submitting their grants after they had received rejections, and many of the re-submissions were not funded either. This led to trainees feeling they had failed. The faculty mentors’ perspective was, “These are post-docs, so they should know how to do this now.” However, Administrator 1 noted that trainees often were not taught grant application skills while in graduate school; their educational and professional histories likely did not include the complex skill of developing grant submissions. The administrator likened the situation to trainees “constantly feeling their way in the dark to know how to get funding.”

Trainees need to learn budget management skills. Financial or budget management was mentioned by trainees -- only in their desire for learning these skills -- but two faculty interviewees and an administrator spoke about it as part of lab management. Faculty expressed frustration regarding the level of spending by trainees -- and they identified a lack of thought about whether a project was necessary or how it would fit into the financial scope of the institutional structure. Faculty 1 did not believe many peers provided any training in financial or
budget management, but one faculty member was known for doing so. This faculty member would provide each person in the lab a budget and tell her or him to keep the work and project within the budget. The trainees were required to make decisions about which experiments they conducted based on whether they had sufficient funds to carry out their work successfully. Faculty 1 recommended other faculty also try experiments with financial stewardship with trainees.

*Engagement with secondary faculty members provided additional training and support.*

Engagement with faculty other than one’s own mentor was generally positive. The document review showed that trainees tended to underutilize their committee members and other primary faculty advisors. Trainee 1 said she was attracted to a research site over her second and third choices because secondary faculty reached out to individually after her visit. Usually the reverse is expected, with prospective trainees needing to send a thank you email for spending time with or interviewing them, so this experience was a significant impact on which school she chose for training.

Trainee 7 had multiple committees that exposed her to “interactions between the conversations between medical science research and basic science research, and where the money comes from, and where the money doesn't come from, and technical aspects like that.” That institution had a pre-doctoral committee, which advised trainees while they were doing their research or trying to test their hypothesis. The thesis committee was separate, however, and the members of that committee judged the written and presented thesis in its more complete form. Committee members from the two groups were not the same people; some came from different backgrounds; others worked at different institutions. Trainee 10 said they saw the benefit of faculty engagement and thesis committees, and that they thought the only trainees that had “a
rough time in their dissertation defense” were those with committee members who were too narrowly focused and did not appreciate the implications of the trainee’s work for other ideas. This was the only negative issue reported by trainees about faculty engagement, although most trainees mentioned they wished faculty could have been more engaged; they asserted the importance of those interactions with faculty when they happened.

Administrator 2 observed how important faculty engagement was to the effectiveness of the director of the training program. If faculty members did not participate in the training activities, they were removed from their role in the program. This particular director met with the program faculty, or preceptors, annually to go over expectations, goals, activities, etc. for the year. He would tell the faculty members if they did not or could not meet the expectations outlined in the training structure, they would be removed from the list of participants. The program faculty were also vetted by a program steering committee that reviewed the preceptor list; individuals who were evaluated as not adding value to the training community were dismissed. This latter point is important. Some faculty members appeared to consider training activities as simply checking an attendance roster; some did not add value to the program or commit to the other activities that could have benefitted the trainees. In this case they were seen as only taking money for a student’s stipend support. This demonstrated the importance of faculty engagement for Administrator 2’s program.

The Process and Outcome of the Job Search

The job search process for these scholars was made easier by having strong networks and openness. Figure 3 shows the current career sector for survey respondents, and Figure 4 shows the prior career sectors survey respondents worked in. Both figures show an over-response for academic careers, as current trainees at the research site and those in postdoctoral training at
other institutions selected academic as career sectors, even though none have technically entered a career path. Almost 75% of survey respondents said they felt relatively prepared for a career (see Figure 9 for responses 7 and above), but responses were much more spread out for whether respondents felt prepared for the career search (see Figure 10).

Interviewees used multiple processes to apply for jobs: from submitting applications or resumes to job postings, using headhunters, or especially using networks and connections to learn about, submit interest in, and have recommendations for positions. Several PhD scientists followed their intended or desired career path; however, most pursued unintended or undesired career paths. Those who were most content with the outcome of their career navigation credited their openness to considering employment in multiple sectors.

**Application process.** Several of the current trainees began the job search process with varying levels of success. Two mentioned being anxious about their next steps after graduate school, expressing apprehension about where they would find jobs, what careers they would discover, and their long-term career success. In the focus group that contributed to methodological triangulation for this study, a majority of participants expressed that they felt they would need to pursue non-academic jobs based on the lack of employment opportunities in this sector; however, those who were considering that path said they did not know how to land academic positions, where to look, or even what possibilities were available. Trainee 1 explained the overall sense of uncertainty best when she said, “I feel like I don't know what I'm going to be when I grow up.”

Trainee 4 was the only postdoctoral trainee in the focus group; she was in her second postdoctoral fellowship. She expressed frustration with her pursuit of academic positions, and she had also applied for positions in industry, without any success. She pursued and completed
an MBA while still in her second postdoctoral fellowship because she was having such a difficult time finding a job in industry. She said the completion of this additional degree did not open up any viable additional job prospects and that she felt “kind of like disgruntled with everything at this point in general.”

Past trainees had varying experiences in finding employment; several said they thought current or PhD scientists who finished training in the past two or three years would have a much easier time finding a job because of increased access to the Internet, Facebook, and LinkedIn for easier access to job postings and networking. Trainee 9, for example, said he used cold-call applying online for half of his applications, and he found a quarter of jobs to apply for through headhunters and a quarter through personal or professional connections. However, Trainee 9 said, despite these efforts, he also felt stuck because he was not finding many jobs posted and did not seem to have many connections. He thought networking and connections were necessary since all the other applications and resumes that were sent to companies seemed to go into a “black hole” without any requests for interviews or even a confirmation of receipt, or any response at all.

Several trainees talked at length about the difficulties in finding funding and in opening the door to a first academic position. Research grants were key in gaining scientific independence to leave a mentor’s lab. Trainee 7 also talked about looking for an academic research position, where she said it would be necessary to get her own funding to run the research lab. She said:

[I] kept trying new and different strategies [and] applied to every university in the state that had a job open over [seven to eight years], many of which I hadn't heard of before. Some of them were just teaching positions. Some of them were academic positions.
Some of them had some startup money. Some of them were totally dependent on your funding to pay your salary.

She finally took a position as a research assistant professor, which was not tenure-track eligible; it would also not lead her into a research career. The trainee said she felt she had entered a glorified second post-doctoral fellowship. She continued to apply for grant funding individually and with various collaborators; however, she said she felt she “couldn't get a grant, because [I] didn't have face, and [I] couldn't get face because [I] didn't have the money. It was a nonstarter after years of trying.” She gave up applying for those positions and applied to positions in other sectors.

Trainee 7 was not the only one interviewed who had shared this experience of disjointedness between training and the job market.

Trainee 5 explained this conundrum:

I was trained to be a research scientist in an academic setting, but I couldn't get a job to do that… I could have stayed there and just kind of worked out of [my mentor’s] lab. It was kind of hard to get independent. That was one of the issues that you find, that it's hard to write for entry level grants if you're in someone else's lab. I didn't have my own space, and it was hard to get academic positions, because you didn't have your own grant. It was kind of this catch-22 that you find yourself in this terminal post-doc position that was very difficult to get out of.

Trainee 5 began going to five minute informational interviews at conferences to hear about other opportunities, particularly in the industry sector of bio-medicine. One sounded really interesting and led to a follow-up interview. Trainee 5 said these sessions were helpful because he had to navigate the process of interviewing, and had to consider whether or not a company and position were a good fit for him. But it took several years of following up with these companies in
industry until one turned into a job; he gained some ground-level experience, and then the company disbanded. He decided to try applying to academic institutions again, focusing on teaching rather than research. However, as is common in graduate programs, he did not have training or experience in teaching, a problem which was initially an issue with his job applications. However, because he had extensive experience in a pharmaceutical industry company, he was able to make the case that he would be a competent instructor in the institution’s pharmacy program. It was not his original focus area, but with the outside experience he had gained, he was able to reach his initial goal of teaching in an academic setting. He summarized his situation of combining his academic training and his hands-on experience positively, “It's hard getting that first job, but once you get that experience it's easier to land other ones, and you can kind of pick and choose which direction you're going to go a little bit easier.”

Trainee 9 also found meeting with companies during large conferences beneficial. He looked through the list of participants and found a person who worked at a company where he had sent his resume. He “stalked” her, had a conversation, and told her he had sent in his resume. Shortly after this meeting, his resume was pulled to the top of the pile, and he was invited to interview. For him, this company and position were an ideal match, so he spent a lot of time preparing for the interview, which paid off as he was hired and has worked there ever since.

Other trainees found networking to be key in obtaining a position. Faculty 2, for example, had a friend who worked on a project in collaboration with a company in industry during graduate school, which turned into a job offer after training. Trainee 10 and Faculty 3 both said they never had to apply for a job – they had always been directly recruited or had found positions through people willing to put in a good word for them. Faculty 3 said, “Networking is
the difference between success and failure, because it is so much easier if you know people.”

Trainee 5 talked about networking as a web of connections. He was hired at a small biotech company across the country after putting in substantial effort and time seeking academic positions, as detailed above. The hiring manager at that company had known and collaborated with his mentor; in fact, that employer had hired a colleague with whom the trainee had attended graduate school. The hiring manager said that his most important tools regarding hiring included his Rolodex, business cards, and contacts. In this context, networking was mentioned by each trainee, faculty member, and administrator as a critical tool in finding a job.

**Intended and desired career.** The desired career path of survey respondents is shown in Figure 11. Respondents were able to select multiple options, which accounts for a higher number of responses compared to the number of individuals who completed the survey. Participants desired mainly academic careers, followed by options in industry.

Only a few interviewees said the career paths they had taken led to their intended or desired career. Faculty 2 found that approximately 50 percent of graduate students were interested in an industry career, based on conversations during recruitment, which he said seemed typical of his own graduate experience. He said most of his colleagues had found positions in industry; a few went into other areas; a few went into academia.

Trainee 6 commended the training program for its preparation of the trainees. Of his peers who had reached their goal careers, he said, “If you look at the class I graduated with it and the one immediately after that, I think most, if not all of us, have gone on to be quite successful, whether it's in academia or in industry. The proof is in the pudding as far as that's concerned.”
Unfortunately, some trainees went into their intended careers and were not favorably looked upon. Administrator 1 provided an example of a common situation, according to trainees, faculty, and administrators:

One of the post-docs I know is in a position like that. It's 80 percent teaching, 20 percent research. You are a success if you do 80 percent research, 20 percent teaching. She's looked upon now as a failure on the training grant. I think it's unfair. It's what she wanted to do from the beginning--teach, so I just think that it's...people sometimes go through all this trouble. They love teaching, and they love the subject matter, and they want to be in the forefront when things change or when science changes or whatever. They want to be part of that, the teaching process. I think it was kind of wrong how it was looked upon that she settled and too bad that we put so many resources into her, and this is what we're going to get out of her.

**Unintended or undesired careers.** Trainees, faculty, and administrators spent a considerable amount of time talking about biomedical PhD scientists taking unintended or undesired career paths. Two main reasons why these scientists took different career paths were: (a) there were not enough positions in the desired career sector or a job was lost through a company dissolution, and (b) interests changed or other opportunities came along.

**Compulsory changes diverge the career trajectory from linear approach to pathway.**

All trainees and faculty members spoke about the low number of available academic faculty positions compared to the number of trainees receiving degrees and vying for positions. Several regarded grant funding cycles as erratic, which contributed to trainees’ struggles. In many cases, this dilemma led young scholars to pursue multiple postdoctoral fellowships to extend gain additional skills or extend time to search for full-time positions. While Trainee 9 did
not experience this directly – he indeed found an academic position -- he said many of his peers wanted a position like his, but there was stiff competition for the few opportunities available.

Trainee 7 summarized these views:

One of the big things we talk about at work is there's so many PhDs graduating every year, and there's just not enough academic positions, so there have to be other options, and there are. I think there should be less pressure put on students to say, "You're in graduate school, this is what your career is going to be." That's a little bit of what I felt. Just knowing what else is out there.” Of course, NIH is putting less and less money into funding extramural grants. It's totally non-sustainable. I can't tell you, between 50 and 100 post-docs who were trained well, in good labs, that have not been able to get jobs, and who have jobs now are like waiters. It's a non-sustainable cycle. It's not like the people who I worked for when I was trying to get those jobs didn't feel bad about it. It's not like they were non-supportive or mean. They would do what they could, but it just is not a very good model.

Personally, Trainee 7 said she felt that she had not been prepared for a non-academic career, which is what was available. She went on to say,

I never achieved the career I thought I would, so I don't think that I was prepared at all, but I think that that's just the fact of because there's just not enough positions to go around, and not enough grant money. I didn't really have a steady job until I was almost 50. It's just a waste of time and money. I'm never going to be able to retire. I don't think I was prepared at all for the career that I ended up having.

Trainee 5 was discouraged at the few options and went to pharmacy school after completing a post-doctoral fellowship. He had a colleague who left after his first graduate program and
enrolled in another program for better practical prospects. As already mentioned, Trainee 4 completed an MBA during her second postdoctoral fellowship to increase her opportunities. Other trainees and the administrators recalled other graduate students and post-doctoral fellows who either left their program and/or began training for another type of program, such as a degree in business, law, medicine, or physical therapy.

The other type of change that occurred involved a company dissolving, merging, or changing focus. Faculty acknowledged the academic environment they are in as volatile given grant funding, sequestration, and the difficult road to tenure. In contrast, faculty viewed industry as the most difficult as entire divisions can be laid off if the company takes a new direction or if it is a pharmaceutical company and the FDA bans the use of a drug. Trainees who found themselves the victim of a layoff or a change in a company’s direction had to cobble together adjunct instructor positions, go through nearly a year of unemployment, or change to a drastically different area in order to obtain work again.

Trainee 8 was at a company that started disbanding research teams before finally dissolving. Her group was the first to be disbanded in May 2008, and another group was disbanded in September, which occurred during the financial crisis of 2007-2008. Her group initially wondered why they were disbanded, and the other group got to stay; in retrospect, however, they said they felt fortunate as the first group all landed jobs and that the second group had a difficult time finding jobs.

**Non-compulsory changes allow for career pathways to develop.** A few trainees pursued career paths different from their initial interests -- goals changed. For example, Trainee 9 found a job posting for a molecular biologist, which was not his area of training, but he thought the job description sounded interesting, and he applied. He did not hear back from the institution for a
long time, but he ultimately got the job and has been there happily since. Trainee 9 followed what sounded interesting at the time, but in looking back thought he should have stepped back to consider “Where is science going, and what do I want to be involved in, now that I still have a chance to do training?” to avoid a year and a half he spent in a job he found he really did not want to be doing for the rest of his life.

Trainee 8 changed direction from basic science labs to applied labs when looking for a career to do “something with an impact on people living with disease.” During graduate studies and postdoctoral training, her goal shifted to research with a direct impact on people and a position where she would continue learning and acquiring new skills.

Ten trainees also talked about their graduate program, research areas, or career path as accidental or falling into it haphazardly. They used phrases like “never really on my radar,” “stumbled into it,” “fell into it,” and “haphazard.” Trainee 1 said she did not always want to be a scientist but fell haphazardly into it. Trainee 4 did well in her first biochemistry class and when offered a grant to pay for her to get a PhD in biochemistry; she finished with, “They said they would pay for my PhD, and so that was how I ended up getting a PhD. I just kind of fell into it.” For some who fell into this or determined along the way this was not the desired path, many continued on to get the degree because of the time and financial investment already made.

Faculty 1 thought some trainees went along with expectations because of either the pressure or not knowing what else they wanted to do; they stayed with post-doc position thinking they would figure out what to do afterwards. Most of the people she was in graduate school with were “not still scientists that are doing experimental science.” Trainee 7 said she was initially was forced out of the academic path because she could not get a job, but after taking jobs in multiple sectors, she decided she would not try the academic career path again. Her goals
changed along the career path, and she said that although she missed pursuing her own science research daily, she traded it for what she considered was the security of a decent wage structure that would secure her future.

At least four trainees and two faculty members made decisions about which jobs to apply for and career sectors to pursue based on cities or areas of the country where they wanted to live. Trainee 10, for example, got offers in Boston and pursued those simply because he liked the idea of living in that city. Trainee 1 was very open to mobility and said she would move wherever was necessary to get the best medical training; she said she would go wherever she received a residency match, and if she were to pursue a postdoctoral fellowship too, she said she would go wherever is best for her professional advancement, regardless of partner or family.

Trainee 9 tried to balance and synchronize his career search with his wife’s medical residency in Boston. They picked the DC area as being near both sets of family, a large group of friends, and having a “government presence and the biotech presence in Maryland and NIH.” Trainee 9 was excited about a job opportunity in Baltimore working on a consulting team for government biodefense. He expressed anger that he did not receive that job, because it was the only interview he had never received an offer from, and it meant he had to expand his search outside of Baltimore. Eventually he received a job offer from a company within commuting distance, and he took it so the family could live in the area. Trainee 6 received an offer from his former mentor to work in St. Louis. However, his wife had an established career, and he turned down the offer to stay in their town even though his job there was not ideal and had little potential to lead to better opportunities. Trainee 5 was working at a large company in industry in San Diego, a high cost of living area. When his company dissolved his area of research, he said he felt pressure to move his family away to a less expensive location -- New Hampshire, Illinois,
Florida, or Maine, where the couple had family. They finally determined Alabama was close to halfway between Illinois and Florida, and relocated there. He also decided Alabama was preferable to staying in San Diego because there were trees, grass, seasons, bigger houses for the same price, and a lower cost of living. When he found a position posting in that area, he applied, received an offer with a large pay cut, and the family moved across the country to Alabama.

*Openness to career pathways impacted trainees’ perception of preparation and satisfaction for a career path.* The trainees who were pleased with their career path, when looking back, attributed their satisfaction to openness to exploring various career paths. Trainees who were initially interested in industry careers said they knew they needed to be open to change because companies dissolve or change directions. Trainees who were interested in academia knew they would need to be open to moving far away from family, friends, or where they wanted to live; they were aware that they would possibly need to take a faculty position in a less research-focused setting, or find non-tenure eligible positions.

Trainee 9 was open to a shift from focusing on research. Around the time of the Iraq war, conversations had turned to weapons of mass destruction and whether the scientists working for the government were correct in their pursuits. He said, at the time, he did not know anything about this area, but he decided it would be interesting to pursue and approached “a prominent, older anthrax toxic researcher…down the street” with his interest. The researcher had money and invited him to join the lab for a second postdoc.

Beyond openness to changing their research focus, trainees expressed that they felt being open to positions not previously known about or considered important was essential. For example, Trainee 8 applied for academic and industry postdoc positions and “wound up getting the industry postdoc.” At the time, she said supposed she could go back to academia if she
wanted, whereas she expressed that she felt it would be more difficult to later go from academia back to industry. She perceived that the world was changing, and perhaps trainees could go back and forth between sectors with ease, if they were open to those transformations. Trainee 6 said he had always wanted to enter into industry, and took advice from his advisor to heart: “You don’t have to be too picky at this time because you haven’t been in industry before. Just take a job that seems interesting and that pays you reasonably, and you can figure out whether or not you like it.” So, Trainee 6 took a job as a scientist and ended up advancing to the VP of research at the company. He looked at it as a gold mine as far as careers went and attributed how well this worked out to his openness to just following opportunities that presented themselves. Trainee 7 also ended up in a job different than what she expected; she was in an office position as a consultant rather than teaching. She found in this type of position more instant gratification than she said she thought she would have found in research – it was more “egotistical stroking” than a lab or teaching job. She said her advisees listened to her direction, which was satisfying. She summarized the experience

I think that people just need to keep an open mind. This job that I have didn't exist before the people thought they needed someone, and they didn't even know who they were looking for. I think that, depending on what your requirements are, you can find a job in science, even if it's not the job you thought you were going to get.

Factors Affecting the Job Search Process for Biomedical PhD Scientists

Factors influencing the job search process for these trainees included: diversity, personality, training environment, perceptions, influential people, goals, and interests. Perceptions and influential people were particularly significant in guiding the career path for these scientists.
**Diversity.** The findings were relatively gendered. Female trainees, faculty, and one administrator commented on the fact there were not many women faculty members available to mentor or act as a role model for graduate students and postdoctoral fellows. Three female trainees were dissuaded from seeking a faculty position because of the gendered academic environment and the perception of family, life, and work balance, which will be elaborated on later in this section. Faculty 3 said she had issues with teaching evaluations. She said students, even female students, criticized female faculty more harshly, which made male faculty appear to be better teachers. This in turn affected the reputation of women as teachers in the department and increased the hurdles women faced in being reviewed for tenure. Several trainees remarked that male faculty treated women faculty and trainees condescendingly; they observed that male faculty or fellow trainees harassed them or other women they knew, and that there was little to no recourse for these actions. However, Trainee 4 found that if too many women were together, in one lab for instance, a female power struggle commonly emerged.

Diversity of race and socioeconomic status was mentioned a couple of times by interviewees. Also, the diversity of experience, which correlated with underrepresented minorities (URMs) not having the same opportunities and experience, was stated as an issue by two faculty mentors. Faculty 3, for example, worked with several URMs, who were from socioeconomically depressed backgrounds and had to work hard at their academics and to earn money. These students were not able to complete for unpaid internships in high school or college to get the experience needed for graduate school applications. Their applications appeared to be lacking in comparison with students who were able to gain this research experience, and they were often judged as not as qualified for a position in a graduate school, training program, or a lab. Diversity was not as much of a factor influencing the job search
process – the dynamic there was about who was being pushed out or not allowed to “play the game.” Faculty 3 tried to get high school URMs to work in her lab through a special program that would pay them, and she desired a work study program for college students to get lab experience and be able to financially afford to do so.

**Personality.** A number of desirable personality characteristics for mentors were listed in survey and interview responses, such as: commitment, pleasantness, adaptability, ability to perceive different trainees’ needs and personalities, organization, decisiveness, and creativity. Several trainees also mentioned how helpful it was to have some knowledge about the prospective mentor’s personality, which affected the training environment, and to know one’s own personality and preferences, which can affect a career path. Trainee 1 met with prospective mentors at a conference and picked the one she “just clicked with” for graduate school.

Nearly half of the interviewees described personality characteristics ideal for certain career sectors. Faculty 3 stated that extroversion was more helpful if a scholar chose the academic sector, because faculty members spend many hours talking to people, which can drain introverts. Faculty spend a great deal of time talking to faculty and trainees in individual and group meetings, presenting or teaching, and talking with others at conferences. Faculty 2 compared academia and industry, and thought academia could “tolerate different personalities a bit better than industry.” This person said that, based on his and his friends’ experiences in industry, people must work in groups -- there was no place for loners. One could be a loner in academia and sculpt forth a difficult but successful career. Trainees who went into non-academic sectors after previously intending to go into academia after graduate school remarked that the academic environment was a factor in their change of career focus; they specifically
reflected on how the environment would be taxing on them individually to pursue that career path.

Expression of natural intrigue, curiosity, and academic freedom was identified as desirable by four trainees and two faculty members. Faculty 3 said she was initially drawn to science from an early age due to curiosity in trying to figure out how things work. She asserted the importance of being able to choose her own classes to make up a major during undergraduate education that allowed her to “satisfy some intellectual curiosity.” This led to her desire to enter graduate school and academia to continue pursuing those questions with a more sophisticated focus. Trainee 1 said she was interested in practicing medicine and academic research, rather than the private practice of medicine, to follow her broader intrigue and to be embraced in an environment that cultivated “the freedom of thought.”

**Availability and awareness of positions.** The availability of academic positions and awareness of career sectors and opportunities was a central theme that arose in the interviews. The trainees in the focus group discussed the availability of positions but also stated it was equally important to know what other types of positions were out there. Indeed, there were 64 mentions of an awareness of possible career opportunities. Faculty 2 sought advice from the institution’s career center and learned that PhDs are often sought after for consulting jobs, but unfortunately that individual had no other useful information and did not have a list of organizations or jobs a student could use to start a search. All faculty interviewed briefly mentioned the availability of academic positions but only once each, and one regarded the situation in an academic job search as “stable.”

Faculty 1 said she knew that a number of people wanted a job like hers, but she realized that they faced a very competitive market given the limited number of positions available. She
said she observed an increasing interest in other options once trainees learned how few positions were available in academia and how tough it was to land one. Trainees also showed interest when they gained exposure to and awareness of other career sectors and opportunities available.

Once graduate students and postdoctoral fellows were in training, they discovered and accepted that academic positions were in short supply, and they began looking for other opportunities. Awareness of other types of positions was “crucial to succeed in a career” (Trainee 12) and trainees “absolutely have to have an informed decision” (Faculty 2). Most trainees said they wished they had been informed about the “alternate” or non-academic careers available, and that they would have been told about academic career limitations. Trainee 8 participated in an alternative careers event after training and had already had career experience. This individual’s reflections echoed statements other colleagues iterated:

I would have loved something like that, more availability to understand what other careers are out there because I had no idea…There just, to me, wasn't a lot of communication about what other opportunities were out there. ..Also just understanding the alternate careers available, that would have been a really big help because I was struggling the last year and a half when I knew I was getting close to graduation and I had no clue what I wanted to do.

Trainee 8 also expressed that it would have been helpful if staff and mentors had provided more comprehensive information to trainees, like a workshop series or a list of alumni contacts as a resource for graduates who wanted to talk to someone who had found employment in one of these alternate careers. The focus group also brainstormed ways to provide information about alternative career opportunities or job listings to trainees. Trainee 2 suggested the creation of a central communication system for job listings and alumni contact information. He also
mentioned that it would be beneficial if mentors and staff had recorded career development workshops or had provided notes and PowerPoint presentations on a website for trainees unable to attend on-site workshops. That individual expressed that, in this way, the resources could be reviewed during the trainees’ personal time.

**Lifestyle.** Lifecycle significantly affected the career path an individual chose. Overwhelmingly, participants discussed family, work, and life balance, and stated that they were able to have more balance outside of academia. Most participants regarded the academic lifestyle as less than ideal, though three found the lifestyle suitable for them because of its scheduling flexibility.

Faculty 1 said she thought trainees chose to enter non-academic careers because they felt that path would offer a better quality lifestyle. Trainee 6 expressed that he did not know whether he wanted to be in an academic career – he said he did not “really know what it mean[t] to devote all [his] energies to that.” Administrator 1 also saw that the energy of many trainees was being tried and that they faced multiple issues over the years in graduate school, postdoctoral fellowships, and the journey to receive tenure. Faculty 1 regularly overheard comments from trainees expressing that they did not want to work weekends, but would rather get a PhD and pursue a science career that allowed for a 40-hour work week. She said she understood that each person had a different personality and motivation and believed that they should pick a career that will allow him or her to have a happy life, however definitions of that life varied. She said she felt the graduate students needed to know their own personalities, their likes and dislikes, and what environment would be best for them; if they need a lot of recreation time, for instance, she thought they should look for a job opportunity like teaching which might provide summers off. Administrator 2 expressed essentially the same idea as Faculty 1, but also said that past graduate
students that she knew had entered careers, for example, at the FDA, and they were able to enjoy life with their families and to contribute to their communities. Administrator 2 noted that when many faculty talked about these situations, they viewed the “alternative” career path as a “lesser choice.” However, some trainees changed their minds about desired career paths after seeing the lifestyle of faculty members – this was a major theme that emerged from the data.

A few trainees and administrators acknowledged that PhD scientists often look outside of academia because they see faculty struggling in the lab with funding and job pressures to the extent that they are unable to leave the lab at reasonable times, they cannot spend much time with their families, and they find it difficult to disconnect from work when they are at home or with their families. Trainee 1 ranked academic faculty as the last sector in order of preference for future employment, because of these very issues. Administrator 1 recalled stories of several trainees and faculty members who were incredibly intelligent and inquisitive, they went to Ivy League schools, and they put the work in the lab to produce papers and secure tenure, only to keep being rejected, despite the sacrifice of personal life balance. In the case of one faculty member, tenure was denied even though this individual’s colleagues were impressed with the faculty member’s research; he, however, had not secured grant funding sufficient, apparently, to support his promotion. In summary, both seasoned faculty and graduate students determined that, despite the time and energy – and personal sacrifice – they had dedicated to the academic career path, they needed to pursue other options to achieve success and a better lifestyle. A career would not even begin until around age 40 or after in order to meet the requirements of multiple post-doctoral fellowships at a low salary for years. Administrator 1 stated: “It used to be [a] career opportunity for people, but now it's a serious gamble.”
The experiences of Trainee 7 and her colleagues was to work as many hours as necessary to generate the data that would be published under the faculty advisor’s name, since the grant was considered the propriety of the advisor. These individuals expressed that they would become discouraged, feeling that they were in a pipeline to support their advisors to produce more papers, write more grants, and advance their own careers. They consistently expressed that they did not feel faculty were interested in training them for career paths in academia. For example, Trainee 7 observed the number of hours she and her colleagues put into the lab, and how they felt disregarded; other aspects of their professional and personal lives did not seem to matter, yet they needed guidance for the next stage. This disjuncture, in some cases, embittered them toward the academic career sector. Around 50-100 post-docs she knew, who were trained in good labs, spent all this time working toward a career path and have jobs “like waiters” now, but they still found these jobs preferable to academia.

Administrator 2 knew of a trainee doing well in a government job who had a spouse and family. She had discussions regarding whether the trainees should consider whether they want to go home at 5 p.m. and be with their families, or whether they wanted success and prestige. Trainee 4 brought up these concerns of career path and lifestyle in the focus group. She talked with several people about technology transfer, which was regarded as the “other” or non-research career path. Those people confirmed that they had 8:30 or 9:00 a.m. to 5:00 p.m. jobs without the pressure or expectation that they would stay later if they were working on a large project or deadline. Trainee 4 compared this with academia and said that these hours are below the minimum of what one should or needs to be doing.
Faculty 3 did not like the terminology of “work-life balance. She said this terminology blended the personal and professional lives, but it did not keep them equal: In a presentation to her alma mater, she shared:

Assistant Professor, [department name]
Wife, Mother, Coach, Friend,
Boss, Mentor, CSO (Chief Scientific Officer)

She shared this with students to show that she felt it is possible to be a faculty member and “have it all.” She claimed it was possible to both work hard when trying to get a paper or grant submitted, and then take time to unplug and be with her family. Trainee 6 said he wanted to pursue a postdoc position at a new institution when his former mentor took a new job, but he had just gotten married. He turned down the job because his new wife had an established career, and he understood the academic life might mean moving between academic institutions for postdoctoral fellowships and shorter-stint positions before finding a tenure-track position. To him, blending also meant taking into consideration his spouse’s career path.

However, two trainees still at the institution and one former trainee, who is currently in an academic faculty position, regarded academia as an ideal work environment for its flexibility. Trainee 1 intended to go to medical school after graduate school. While she was applying to schools and studying for her MCAT, the flexible schedule of academia allowed her time to study and prepare for her next training phase. Although this was technically discussed in relation to graduate school, not a faculty position, this flexibility was mentioned by others. Trainee 4 and others often worked from home or other locations when writing grants or papers, which may not be permitted in an industry or government job. Trainee 4’s sister worked in the government sector and faced inflexibility in time and scheduling. Academia appealed to Trainee 4 because
she worked evenings and weekends, depending on the project, but if she wanted to leave in the middle of the day to go to the gym, take a kickboxing class, or for other reasons, she was able to do that. She stated one of the reasons she was able to be flexible is because research could still happen at 7:00 p.m. or at times outside of normal business hours.

From the perspective of both a trainee and faculty member, Trainee 5 regarded academia as a flexible career sector. He had a technician who did a great job in the lab and got her work done, but she would also leave for two or three hours in the middle of the day to go for a run. He understood that the schedule was flexible enough to allow her to take an exercise break and had no concerns about it, as long as she got her work done and put the time in at the lab. When he had children, Trainee 5 and his technician felt he became a better boss too. All of a sudden, he realized that when trainees and faculty had children and other demands on their time, he needed to be more flexible with those demands and understand they needed to tend to life outside of work too.

**Perception and expectation.** All trainees, faculty, and administrators stated in interviews that the intended career path for biomedical science trainees was in academic research. These perceptions and expectations strongly influenced biomedical PhD scientists. Every single one of the eight interviewed trainees, and four of those in the focus group, said the expectation was that they would pursue an academic career. Both administrators said they were expected to follow the academic path as well.

Trainee 4 was in graduate school 15 years ago, and her advisor said, "Go academic. Everybody goes academic. Nobody does anything else.” Two other focus group participants agreed that the expectation is to be in academia and that faculty said and implied it was the way all trainees are “supposed to go.” Administrator 1 emphasized that the faculty pushed academia
and did not talk about industry, government, or any other “avenues.” Administrator 2 also perceived academia as faculty’s expected career path for trainees, and their “perception is, ‘You get this PhD to do this kind of work.’”

Not only did faculty expect trainees would pursue a career in academia, but they viewed other sectors as inferior. Faculty 2 thought the perception was that faculty felt if one goes into industry, that person was not as good. He did not agree or believe this to be true, at least for himself. Faculty 3 also thought perceptions and expectations bent toward academic faculty careers, but that there was a sense of elitism surrounding academia by faculty and the general public. Faculty 1 thought that the perceptions and expectations for academia were old and in the past, but admitted that those who entered non-academic careers were previously viewed as failures and embarrassing. While Trainee 10’s advisor did not speak negatively about non-academic career sectors, there was a definite bias. His advisor asserted that academic faculty were of the highest caliber, and the hierarchy was academia, then government, then industry, and then other careers.

**Influential interactions.** Current and past biomedical science graduate students and postdoctoral fellows named people who had influenced their academic focus or career path. Several were influenced by family, friends, peers, or colleagues, but the majority of trainees mentioned that their largest influencers were their mentors and advisors.

Some trainees also formed relationships with people in related labs during journal clubs and collaborations, and found that they leaned on those peers more than their own lab members or found someone at a similar stage but in different area of study during the courses. Trainee 8 listed friends of parents, who suggested engineering based on her interests, as strong influencers, as well as fellow graduate students who completed training and went onto careers before she did.
She reflected that she may not have “relied on the other faculty enough.” Trainee 1 also found that other trainees and their experiences guided her choice to pursue medical school after the PhD.

Family members and people trainees had networked with influenced their career path decisions as well. Trainee 5 had many family members who influenced his interest in science, and ultimately his career path. His three older brothers were all in science-related fields, and he was able to talk about his interests and learn more about their career sectors. His oldest brother was focusing on basic research, and he decided to follow in his “oldest brother’s footsteps” as far as having a science focus. His career focus shifted toward industry, based on input from a post-doc with whom he was connected. Trainee 5 had never thought about a career in industry, but as he talked with the post-doc about his interests and what he wanted out of a career, the post-doc recommended a career in industry as most suitable for his goals.

Trainee 11 also had family influences on her career path from a brother and brother-in-law. She was already interested in and pursuing a career in science, but was not sure which sector to pursue. Her family members connected her with employees at a patent office to discuss non-academic careers, which is ultimately the path she took. Trainee 10 met with the head of a research section at the National Institute of Mental Health, who was excited about his research interests, wrote a recommendation letter, and laid out his whole life, telling him to apply to three specific institutions

because they have the best programs and you'll get in. You'll get the degree; do a good dissertation. You'll come back to do a post-doc in the laboratory, and then after a few years, you do well, you can get a staff position, and then you'll get married and have children.
Half of the trainees struggled even to think of an influence other than an advisor or mentor. Trainee 4 regarded her undergraduate mentor as fantastic and as the person who “really motivated [her] to pursue science, like consider science as an actual career.” She attributed this influence to being at a small institution with a lot of one-on-one attention in the lab environment to boost learning and growth. Although his family included scientists and medical professionals, and he knew he would go into some area of science, Trainee 12 considered his mentor to be driving the career path he chose, after training and “even today.” Faculty 2’s mentor influenced his career path by encouraging trainees to remember funding “goes through cycles, [they have] had this before, this is going to get better, this is not something [they] can worry about too much if [they] want to be a scientist.” The positive attitude, as opposed to complaining about writing or not receiving grants, made a big difference in not discouraging him from seeking an academic career.

**Interests, goals, and motivation.** Personal interests, goals, and motivations certainly guided PhD biomedical scientists’ interest in science, area of focus, and career paths. Self-efficacy and interests seemed to be reciprocal influences.

Faculty thought students had a good idea of their interest and career path when they began graduate school. In her experience, Faculty 3 found about 50 percent were interested in academic careers and 50 percent were interested in non-academic careers. Their personal statements discussed getting a PhD with hopes of a career in academia, which is the only sector most of the graduate students knew of when they entered school. Indeed, the survey showed that trainees’ non-exclusive career sector interests prior to graduate school were: 77.6% academic, 33.7% industry, 20.4% clinical/healthcare, 8.2% government, and 10.2% non-research (see Figure 11). Trainee 9, who worked in an academic sector, saw a similar spread in trainees and
peers and called their interests “broad-based.” A couple of the trainees who had other experiences in undergraduate education, or after and before graduate school, such as taking a few years off to work, were more open and interested in industry and other environments.

Trainee 6 was “always good at science” and knew he would go into a scientific field, but he did not have a career path mapped out at a young age, or even into his late 20s. He did science because he liked it and followed research areas that intrigued him. Trainee 8 was attracted to math throughout school, but did not have an idea what to study in college as she neared the end of high school. During her last year of high school, she took and enjoyed an advanced placement (AP) biology course, which focused more on the process and thought behind science rather than the rote memorization emphasized in prior science courses. She decided to try to find a way to combine her interest in math with her new interest in biology and discovered biomedical engineering, which is the degree she chose for college and graduate school, and ultimately for her career path.

Most interviewed trainees experienced times of indecision or feeling that their path was unintentional. Ten trainees talked about “falling” into their research area, graduate program, or career path. No faculty interviewed discussed science or academia as unintentional choices. Trainees used phrases “never really on my radar,” “stumbled into it,” “fell into it,” and “haphazard.” Trainee 4 did not always want to be a scientist, but after taking a required biochemistry course and doing well, she pursued and was offered a fully paid graduate school education. Trainee 2 actually considered religious studies and ministry as a career during college. Trainee 9 was interested in medicine because of his father’s career, but did not want to practice medicine. He went to graduate school because he liked biology and was not sure what else to do. Trainees 1 and 3 were discouraged from the academic career sector and, although
interested in science and clinical trials, they did not have a “specific defined interest area” even nearing the end of graduate school. Trainee 1 also said if she were not personally interested in medicine, she would consider policy or government careers.

A passion for and a motivation to affect health and contribute to a larger purpose influenced biomedical scientists’ career paths. Some participants were interested in clinical healthcare from youthful experiences with siblings or parents, and wanted to either help by treating people or wanted to study and understand the pathology or reason behind the illness. Trainee 1 experienced medical issues at a young age, and this impacted her desire to conduct research and practice medicine. Administrator 1 heard trainees talk about wanting to cure cancer, find a new way to detect and treat disease, or develop some vaccine. She felt most trainees considered a career path after determining their aims or goals: “they look at the philanthropic side” and then decide how to best reach their goals. Trainee 5 wanted to develop medicines to help people, and bench work felt like “esoteric science at the time.” He liked the science but thought he needed to enter a career path and sector that he would feel better about.

Four interviewees were motivated by science and intrigue but could not see how to apply their interests in academia. Faculty 3 thought that trainees who entered non-academic sectors “still love science so they want to do something with it.” She thought all scientists have a degree of passion, but academics were portrayed as being more passionate about science and their research. Administrator 1 believed the trainees were passionate about science, the subject matter, and wanting “to be in the forefront when things change or when science changes,” but they wanted to be a part of the teaching process for new scientists rather than pursue their own research. Trainee 2 was motivated by being able to see end results and did not find academia as a setting fostering or satisfying this need. Trainee 11 realized during training that she “didn't
really have a passion for research, which [she thought] was one of the critical things that you
needed to be a successful [scientist]” and concluded “that that career path was really not for [her]
even in [the] non-academic sector.” She lacked the passion for research and entered a
government career to use her skills in a different arena.

**Career Development Skills Biomedical PhD Scientists Need for Employment**

Trainees were asked in the survey about the skills needed in a career, and then whether
they had received the listed skills during their training at the research site. Over half (54.3% or
51 survey respondents) selected “no.” The skills needed for careers both in general and in
specific sectors were a major focus of interviews and the focus group. They were also
mentioned in many of the documents provided for review. This subsection will summarize the
skills needed for getting and being successful in a job. The skills discussed for getting a job
were how to write a curriculum vitae (CV) or resume, networking, and interviewing. Skills
mentioned for career success were communication, including grant writing and dealing with
conflict; projects, lab, business, and classroom management; critical thinking; and adaptability.

**How to get a job.** During interviews with trainees and faculty, skills needed for getting a
job included how to write a curriculum vitae (CV) or resume, networking, and interviewing.

**CV building is a necessary skill for obtaining a job.** Trainees in interviews and focus
groups desired guidance in building a CV and cover letter to submit for job applications. It was
also noted that CVs or NIH Biosketches are necessary while in a job, particularly academic ones,
as they are often requested for any speaking engagements, listed on a departmental or laboratory
webpage, and required for grant submissions. Although necessary for getting a job and often
needed while in a job, it seemed that no one received instruction on how to construct a new CV
or feedback on an existing one. In general career centers, instruction was broad—such as advice
on how to trim a CV into a two page resume. However, Trainee 5 stated that while hiring managers in other fields may not want to read a full resume, in science, employers want to see everything the person has ever done.

Trainee 5 spoke extensively about CV building and scientists at all levels needing guidance in listing experience, publications, skills, certifications, grants received, trainees mentored, and organizing a CV. At the time of his interview, he had just served on a search committee recruiting for faculty, department chairs, and even the provost of his university. Combing through the applications made him realize that even at these levels, many of the CVs were a mess. Some were chronologically organized and not categorized. The search committee found it difficult to look through CVs like this to figure out what experience or accomplishments the applicant had, which is never ideal, especially not for higher positions such as department chairs or an institution’s provost. He also said trainees could benefit from guidance on tailoring CVs based on career sector, noting that a generic CV that does not enhance what each recipient is looking for is useless. He provided a good rationale and advice for trainees:

In academia, we look at service and teaching, and in the industry no one's going to care about that. It's going to be, ‘What'd you do? What'd you publish?’ You've got to really tailor it each time, and your cover letter, focus on the things that you've done that pertain, specifically, to the job that you're applying for. You've got to emphasize what you've done, because they're looking at maybe a couple hundred applicants, and they want someone that is a perfect fit, because they have this thing in mind, and it's like no one's going to be a perfect fit. You've got to make it look like you are, as much as you can.

**Networking was key in how scientists acquired jobs.** Networking was named by many trainees in the survey and in approximately half of all interviews. Networking was also
emphasized by faculty and administrators. Trainee 5 found networking to be helpful in landing a job. He named networking methods such as going to meetings, meeting people, passing out business cards, visiting colleagues and others, and shadowing people in interesting jobs. In her MBA program, Trainee 4 spent time discussing networking and considered making business connections to be more important than technical skills for getting a job. She referred to networking as a spider web: the more people one person knows, the more intricate the spider web, which increases the “chance of knowing somebody who knows somebody who then can help you get a job.”

Several trainees regarded networking as difficult, especially for some personality types, but Trainee 3 elaborated,

I'm someone who that doesn't come naturally to. I'm like, “Can you just give me like a script?”…I feel like being around people who are good at it is really helpful to just feel like, “Oh, that was really good what they said there. Next time I can do that sort of thing.” Having that sort of mindset, instead of seeing it as a really intimidating thing. It's like also learning from people who are doing it better has helped me.

Seeing an example of a good interaction during a low pressure time, and having a chance to practice when it does not matter, was recommended by two trainees.

**Interviewing skills boost confidence and job offers.** How to focus an interview on an applicant’s assets and to connect with the interviewer were two other skills recommended by trainees to practice in low pressure scenarios. Trainees and faculty did not practice interviews, but only developed those skills in the high-stress situations of actual interviews. Some accepted interview requests for jobs in which they were not interested to practice skills in preparation for interviews for jobs they really wanted. Trainee 5 spoke about interviewing skills from the
Interviewing skills, I think, could be something else that are taught, what to bring, and if you do a seminar, what to present…Really, in hiring people, I found that having someone that is kind of general that you can train, ads are often written very specifically, like, “We want someone who is a neuropharmacologist, that has skills in electrophysiology,” and it was like, “Well, I can't apply for that.”

He went on to say that trainees needed the ability to make their experience and skills applicable and beneficial to the job and company, and that not everyone is naturally able to make that apparent. Trainee 8 understood that interviewing also serves the applicant. The interview is not only for the company or hiring manager to determine whether the applicant is a good fit for the company, it is also for the applicant to determine whether the company, environment, position, staff, etc. were a good fit for the applicant. Mock interviews were suggested as a way to allow trainees to practice asking as well as answering questions.

**Skills for career success.** Skills for success in careers include verbal and written communication, management, critical thinking, and adaptability.

*Communication was a necessary career skill, regardless of career path.* There was an overwhelming response with regard to communication as a necessary career skill, regardless of sector. Phrases coded as communication were made 163 times, with some phrases comprising multiple types or mentions of communication. Nearly 40% (39 of 98) of survey responses included communication as a skill necessary for a career. Aspects of communication mentioned were: scientific writing, paper and article writing, writing grants, reading, analyzing how papers and ideas fit together, communicating to and with others, presenting, talking to a crowd, talking to people in other fields or at other levels, contract writing, writing business proposals, scientific
editing, and conflict resolution.

Communicating effectively and efficiently is necessary in formal documents, such as article or grant submissions, and in informal venues, such as in an elevator with a stranger, or via modern technological communications such as text messaging, email, Facebook, and LinkedIn. Administrator 2 noted how these technological communications were not usually thought of as affecting one’s work, but they did affect people’s jobs or reputation. Communicating at all levels of formality to a wide variety of people was mentioned repeatedly. Trainee 6 discussed communication for industry versus academia and said what several others alluded to:

Communication is a skill I think that, at least 20 years ago, was a little bit under-taught...I actually remember a couple of classes where the final project was a presentation to the class, and you very clearly had to describe the big picture and how what you're going to talk about tied into it, so they did make an effort to do it. It just wasn't as big a focus as I think it should be if the focus is going to be to try to prepare people to go into industry as opposed to academia.

Grant writing was a particular skill that virtually all participants discussed, and which appeared in both documents submitted for review and survey responses. Faculty 1 stated that grants and the publications that result from them required the ability to write well. Faculty talked about writing grants as an academic-only skill, but Trainee 10 said,

I'm in industry and I'm writing grants all the time because I work for a small business and for writing small business grants, and I write 7 or 8 small business grants a year and that's a big part of what I'm doing. It's a skill that can't be overlooked.

Another faculty member viewed grant writing as an important skill, but instead of talking about relating to researchers and scientists with different expertise, Faculty 3 felt “the ability to
speak to a lay audience [was] missing.” Often, she found scientists speaking in jargon with some measure of condescension, creating a perception of elitism. Faculty 3 has submitted grants to multiple foundations and organizations, such as the American Cancer Society, which have patient advocates on review panels. A former or current patient needs to understand why the research project will benefit him or her and others with similar diseases or treatments. Additionally, she said, “I've seen a patient advocate actually get a grant that was borderline fundable and push it over fundable because the advocate was so passionate about that grant.”

Trainees in the focus group mentioned workshops on grant writing. Though they found value in having junior faculty speak at workshops about career sectors, getting a job, and topics those faculty members may have recently encountered, the group wanted to hear from senior, more established, faculty members regarding grant writing (or creating lab budgets, dealing with personnel, etc). Trainee 2 especially wanted to hear “from someone who's done it and who hopefully has done it successfully, rather than someone who's in the process of doing it, just drawing on that experience. The engagement from [senior faculty] is extremely low.”

Other aspects of communication that trainees, administrators, and documents listed, but the faculty did not, were interpersonal skills and dealing with conflict. This ranged from not being unpleasant in seminars and group meetings, or to colleagues and trainees, to being able to deal with interpersonal issues, which may not be work related but may affect one’s work. Administrator 2 had much to say about this topic. Some faculty members were labeled as “unpleasant,” “extremely racist,” misogynistic, “dismissive,” defensive, “hostile,” and “being a jerk.” Faculty advisors were also described as disrespectful, condescending, unwelcoming to collaborators and guests, hardened, and acting out of insecurities. These attitudes contributed to poor communication, as people were not listening to or hearing what others were saying, were
trying to formulate one’s response while another is still talking, or were becoming defensive during discussions. She did not know how to train for this skill, other than to practice and send people to training workshops on unconscious bias and communication skills.

*Project, business, lab, personnel, and educational management skills prepare trainees for various career sectors.* Over 60 responses declared that various kinds of management—project, administrative or business, organizational, laboratory, team or people, and educational management—were required expertise for all career sectors. Project, team, and educational management will be covered more in depth in this section.

Project managers need to be able to think strategically, create goals, measure progress, and plan carefully in order to maximize success. Faculty 3 believed perseverance was an important aspect of project management, as experiments fail or papers and grants are rejected about 90 percent of the time. Trainee 10 thought project management skills were especially useful in industry as timelines are fairly strict; careful planning and projection are crucial to meeting those deadlines. Trainee 9 also thought project management was a useful and necessary skill for a career, but said he did not gain that skill during graduate training.

Team or lab management was described as having two areas: the management of people and the management of a budget. Leadership, being a team leader, or leading a lab meant influencing others. The focus group participants discussed leadership and lab management from the perspective of not having an opportunity to learn the skill during graduate or postdoctoral training. “How can you expect people to manage labs that have never had training in management or experience in outside management?” asked Trainee 1. Team management also included time management, balancing various roles and tasks, and hiring and mentoring people.
Financial management and budgeting was described as a part of team and lab management. Faculty 1 spoke on behalf of faculty who were worried about their budgets while trainees come up with experiments, procure the expensive items needed, and start conducting the experiment while not even being sure what their research question was. He said, “You wonder if they were in charge of that budget if they would have thought twice before they launched on something like that.”

However, trainees also talked about needing the skill of financial management and budgeting in a career, especially an academic career. Trainee 11 nicely stated the trainees’ perspective,

You still have to manage a lab, right, and that’s the first time you’re going to really have an opportunity to manage your own lab. I’ve seen people struggle more than succeed in that area. Especially for the post docs who are getting ready to basically head a lab, I think that kind of skill could be really useful.

Trainee 4, who was in her second postdoctoral fellowship, listed questions and considerations necessary to run a lab that trainees do not often have experience in: financial management, how to budget for experiments, how much to budget to pay staff, what a start-up financial package can purchase, whether one should order new or refurbished equipment, and how mouse protocols or human trial protocols affect lab work.

Educational management experience was needed for classroom management, curriculum design, and practice lecturing. Twenty survey respondents said they needed teaching experience, which Faculty 1 acknowledged was “a different skill set than doing research.” Focus group participants also talked about needing experience teaching and designing curricula and assessments. Trainee 5 had worked in industry and applied for a position in an academic
institution after his company closed. His lack of teaching experience was an issue, and he had to work extra hard to convince the search committee that he had relevant experience from his time in industry.

**Critical thinking skills prepare trainees for career success.** Fifteen survey responses listed critical thinking, problem solving, analytic skills, understanding how one’s work fit into a big picture, and why it is important or people should care. There were 56 total mentions of these concepts through all data collection methods, all of which spoke to critical thinking.

Trainee 12 defined critical thinking as an “ability to transfer thinking to new problems.” According to Faculty 1, it is critical for trainees to learn how to ask the right questions, how to design an experiment with the right controls, anticipate possible outcomes in order to carry out procedures, understand whether the design fits the objectives, or as Trainee 5 said, to see the bigger picture more clearly and understand why one would pick a specific target.

According to the trainees, having a PhD is synonymous with critical thinking. Trainee 12 said, “The PhD provides a structured way of thinking and teaches people to become problem solvers.” Similarly, Trainee 8 believed trainees should not be afraid of what they do not know "because a PhD means that you have the ability to learn at a high level, so if you don't know things, you have the ability to know them." As trainee 12 remarked, “Technical skills help and the PhD opens doors, breaks barriers, allows you to be taken seriously.” Critical thinking is a necessary skill in careers for this reason, and having a PhD implies one has the ability to conduct this level of thinking.

**Adaptability helps biomedical scientists cope with compulsory career changes.** Similar to the skill of critical thinking or possessing the creativity to understand a bigger picture and design a project to answer questions, trainees and faculty listed adaptability as a necessary skill
in careers. Many stated that people need to be adaptable for company mergers, closings, layoffs, and to be mobile, but even more than this, interviewees recommended adaptability for changing projects, challenges, working with others, and the ever-changing nature of science and discovery. Trainee 10 summarized many other participants’ comparable words:

   In the field of biomedical research, it's changing all the time. You have to constantly be retraining yourself in things and you have to know how to do that and you have to know how to learn new things. Plus, [in industry], you can get moved from one thing to another, pretty quickly. You have to be adaptable, you have to have the ability to dig into a topic on your own and find out about it.

   Faculty 2 advised embracing technology, being flexible, and taking some risks because those who did not adapt or who kept using the same methods and tools to ask slightly different questions were unsuccessful. Trainee 5 also had advice along those lines—to be adaptable and flexible—and additionally suggested that trainees should figure out how to market their adaptability to organizations to give them an advantage when applying for jobs.
Chapter 5: Discussion

As noted in Chapters 1 and 2, the number of biomedical PhD scientists being trained and graduated far exceeds the number of academic faculty positions and academic research jobs available. This trend compels biomedical PhD scientists to increasingly seek career paths outside of academia. Thus, more needs to be known about their intentions, desires, training experiences, and career path navigation. The purpose of this study was to understand the process through which biomedical PhD scientists are trained and supported for navigating future career paths. In addition, the study sought to determine whether career development support efforts and opportunities should be redesigned to account for the proportion of PhD scientists following non-academic career pathways. As a reminder, the research questions were:

Central question. How does a southeastern tier 1 research university train and support its biomedical PhD scientists for navigating their career paths?

Sub-question 1. What was the process and outcome of the job search of biomedical scientists?

Sub-question 2. What factors of personality, environment, experiences, perceptions, etc. influenced the job search process for these scientists?

Sub-question 3. What skills (outside of laboratory/bench research) should biomedical PhD scientists be exposed to, and encouraged to develop, to prepare them for employment after graduation?

The study employed the social cognitive career theory (SCCT) framework to help inquire into this problem of practice. SCCT was used in formulating the survey and interview questions to take into account personal characteristics, background, experiences, influences, goals and interests, and choices and actions. SCCT was also used for final provisional coding, to sort and
organize codes for analysis, and to review the interrelatedness of codes. The theory and model combined to help explain and predict the processes by which students’ vocational and academic interests are developed, how those choices and pursuits are made, and the levels of work and academic performance the students attain.

The literature review also informed the questions in the survey and interviews. The interpretation of the findings seems consistent with the literature review, with the exception of international patterns, which were not a theme found. This could be expected for this particular study, as the trainees eligible for the training program at the research site must be United States citizens or permanent residents. The one faculty participant who was from a foreign country did briefly mention international experiences and implications.

This qualitative case study used a descriptive survey, a focus group with current trainees, interviews with three areas of stakeholders (former trainees, administrators, and faculty), and document review to generate data. Data were organized and analyzed after a multi-step coding process using Saldaña (2013) as a guide. The support from the findings for the research questions, theoretical framework, and literature review will be provided throughout this final chapter. An interpretation of the findings categorized by major themes follows this introduction. Next, the practitioner implications and limitations of this study will be described. Then, areas for future research will be identified. Finally, a summary of the research study will conclude the discussion.

**Interpretation of Findings**

The following section will discuss the major themes which emerged from the findings. The themes were factors influencing career preference and job search process, activities training
skills for a career, and finally, how both of these impacted career path preparation and navigation.

Theme 1: Many factors influence PhD scientists’ career sector preference and job search process, but the most influential were relationships with faculty, particularly the mentor advisor. The research study considered personal, environmental, and experiential factors, as guided by SCCT, which influenced trainees’ career paths. Personal characteristics and background influenced PhD scientists to a lesser degree, or at least not as overtly or consciously, than experiences during training, especially interactions with faculty. This section of the discussion focuses on these influential factors.

Biomedical PhD scientists go into graduate school or postdoctoral fellowships with interests, goals, and motivations. Many of these scientists followed their interest in science or math through school to get to their current position. Those in academic sectors wanted to fulfill their curiosity about the world and how it works, enjoy the research process and discuss ideas with others, and seek academic freedom or freedom of thought. Participants in non-academic sectors had different interests, goals, and motivations. Some had philanthropic motivations; wanted to see the results or impact of research; or needed control or agency over the research. Scientists interested in non-academic careers did not want to be dependent on grant funding and wanted to spend time at the lab bench, conducting research, or dealing with a practical aspect of science. Non-academic scientists craved “doing” science and felt academic faculty do not get to “do” science as much as when they were in training, as they are busy writing grants, editing papers, mentoring trainees, and giving talks at other institutions or conferences. At Research 1 (R1) universities, faculty often teach few courses per year or perhaps just organize a course or
teach a lecture of another faculty member’s course. These personality characteristics, interests, goals, and motivations influenced which career sector scientists followed.

Personal characteristics and background influences impacted the job search process among biomedical PhD scientists. Personal characteristics are gender, race or ethnicity, personality, disability, health, predispositions, and other similar factors. Disability, health, and predispositions were not evident in the findings. Likewise, international patterns or experiences and race or ethnicity were not mentioned often. It is worth noting that international students and racial minorities are underrepresented in biomedical PhD programs and specifically in this kind of NIH training program. NIH training grant programs are open only to United States citizens and permanent residents because they are publicly funded federal grants. Therefore, very few foreign scientists were included in the sample pool. Race and ethnicity often correlate with socioeconomic status, which is outside the scope of this project, but as noted by one faculty member, opportunities are not provided equitably from a young age to all groups.

Gender was the most frequently mentioned personal characteristic, but only by females. Levitt (2010) noted that more females were dropping out of academic science, which the findings of this research study imply could be true. Gaughan and Robin (2004) believed that more males dropped out of academia, as females had already faced and overcome many hurdles, which does not seem consistent with the findings. Females faced challenges pursuing science throughout school, but especially in higher level studies and training and in careers. Female trainees admitted to being harassed or often spoken to condescendingly and treated with disrespect by male colleagues and faculty. Female faculty even noted being judged more harshly than male colleagues on course evaluations by male and female students, by their academic peers, and even in tenure or grant review committees.
Perceptions about the availability of academic positions and the lifestyle associated with each career sector led biomedical PhD scientists to the sector in which they searched for a job. Job availability and lifestyle were actual and perceived barriers as expected by SCCT. The findings supported research claiming the lack of academic positions was known (Benderly, 2005; Fuhrmann et al., 2011; Goldman, 2002; Hakala, 2009b; Levitt, 2010; Sauermann & Roach, 2012; Taylor, 2011; Wendler et al., 2012) and trainees wanted a career in a more stable environment for job and financial security (Altschuld, 2003; Scaffidi & Berman, 2011), less grant dependence, and no tenure review process (Nir & Zilberstein-Levy, 2006). Awareness of other positions and sectors available was key in deciding which sector one would pursue.

The perception of the lifestyle afforded by each career sector contributed to the perceptions and desirability of that sector. Family, work, and life balance was incredibly important to PhD scientists, and thus working hours were the most important aspect of lifestyle. Academia is known for having long hours, evening or weekend work, and often travel, if a researcher is trying to succeed. Academia also seemed to be the most flexible because of those hours and pushes to deadlines, allowing them a more flexible schedule than non-academic sectors for pursuing personal interests during typical business hours. No one mentioned the sabbaticals available for academic faculty to promote professional development and research. Academia was also perceived as the most stressful career sector, because of the long and odd hours to keep up with research, write papers, travel, write grants under deadlines, deal with the stress of grant funding, and manage projects that fail, all while trying to train the next generation of biomedical scientists. As with previous research (Alberts et al., 2014; Austin, 2002; Fuhrmann et al., 2001; Gibbs & Griffin, 2013; Hakala, 2009b; Kemp et al., 2012; Mason et al., 2009; Mangematin, 2000; Sauermann & Roach, 2012; Scaffidi & Berman, 2011; Wendler et al.,
2010; Wendler et al., 2012), these findings confirm that many PhD scientists initially desired a career in academia, but after they saw the lifestyle, they decided to go into a non-academic profession for regular or predictable hours, time for leisure or with family and friends, and lowered stress due to more financial stability.

Faculty, specifically mentors and advisors, greatly affected the training experience and career paths of biomedical PhD scientists. Nearly all trainees, faculty, and administrators focused on the great impact mentors have on trainees’ career path choice, and on how trainees felt about this choice or where they ended up. Overall, interactions between faculty and with the trainee’s mentor were very positive. The mentors with the highest regard cared about trainees personally, supported their career path goals, challenged them intellectually, and had compatible personalities.

Expectations influenced trainees’ preference for certain career sectors. Faculty did not feel their bias toward academia was overt or visible, but trainees and administrators felt the message received from faculty was biased toward academic positions. It was commonly understood that people get a PhD to be academic faculty, when in reality few can do those jobs because of their availability, and some PhD scientists are not even interested in working in academia. Faculty viewed other career sectors as inferior. There was bias and a hierarchy implied by most faculty to trainees and administrators, which seemed to be consistent with the implicit message passed down from the NIH. In agreement with Scaffidi and Berman (2011) and Sauermann and Roach (2012), faculty often do not talk about, or at least not favorably, other sectors, which contributed to the trainees’ lack of awareness. It is worth acknowledging that the blind spot or narrow focus was partially due to people discussing the path they took and knew, as discussed by Fuhrmann et al. (2011) and Stephan (2008). Faculty are under pressure, especially
from grant funding sources (of which the largest is the NIH), to maintain the definition of success for a biomedical PhD scientist as entering a full-time tenure-track academic faculty position at an R1 institution, receiving continuous and high grant funding, and publishing often in high-impact journals.

Faculty claimed to be open to non-academic careers, and perhaps the interviewed and some other faculty were; however, the trainees, administrators, and the researcher’s own experience did not show this to be the case. Faculty continued to use phrases like “alternative” careers, which gave a negative connotation to such career options, choices (Benderly, 2005), and paths. Past trainees in academic careers were more positive about interactions with their mentors, whereas those who entered non-academic areas were less positive about their mentor interactions. Though faculty pushed academic careers, some trained and supported trainees who expressed interest in non-academic careers, as they should according to Alberts et al. (2014).

This assistance came in the form of helping trainees acquire skills necessary for their chosen career path; the faculty would help trainees apply and network or generally be supportive and encouraging. If the mentor is such an integral part of the decision making process and has such influence, this offers even more rationale for trying to broaden the definitions of success and encouraging mentors to be more open to other career sectors and change how they talk about these sectors.

The relationship with mentors was less strained when faculty appropriately handled personnel issues within the lab, and when the lab was adequately staffed with employees to manage ordering, equipment schedules, or technical work, allowing graduate students and postdoctoral fellows to focus on their projects. Otherwise, these tasks often fell to senior graduate students or postdoctoral fellows, taking time away from their projects and lessening
productivity. Permanent career scientists were lauded by Benderly et al. (2010) and Teitelbaum (2006) as giving indispensable support to the research lab, and by providing these employees with reasonable salaries and benefits, the competition for some academic positions would be reduced (Goldman, 2002). While trainee participants did need skills in lab and personnel management for career preparation, receiving the experience in this way caused a lot of resentment and a sense that they were training in a poorly-run lab. Also, some labs were too competitive, and if the mentor encouraged a “dog eat dog world” mentality instead of teamwork and collaboration, trainees were negatively impacted. Trainees felt success was often due to the project chosen or assigned, but faculty emphasized that trainees simply needed to work longer hours, work harder, or think more strategically. Perseverance was identified by faculty as a required characteristic for biomedical scientists wanting to enter academia; however, trainees’ description of their experience illustrated perseverance even among those who wanted academic careers but were forced to pursue a non-academic path.

Those trainees who approached faculty for guidance and did not receive it turned to administrators who were unable to appropriately direct them. Faculty engagement with committee members and departmental or program faculty was beneficial and impactful. Committees were recommended by Fuhrmann et al. (2011) for overseeing trainee career development. Collaborations with other faculty members were a highlight of some trainees’ experience. Trainees underutilized faculty as resources and support. These experiences and the thrust toward academic careers impacted whether trainees saw academia as a favorable career option worth pursuing.

**Theme 2:** Planned activities are a significant aspect of the training process and provide skills for career success. All participants found value in planned activities, which are
key learning experiences. The SCCT model demonstrated the influence of learning activities on self-efficacy, interests, and outcome expectations. Planned activities included seminars, career development workshops, lab meetings and journal clubs, internships or shadowing experiences, and coursework. Trainees wanted more career development workshops, internships, and teaching experiences. Faculty were taxed with these activities and disengaged when present, or felt these activities took time away from trainees learning technical skills. As a result, faculty wanted fewer planned activities.

Trainees were required to attend their department, center, or program activities, and “encouraged” to go to others of interest, as long as the time spent did not impede productivity. Departments, centers, and programs generally have seminar series. A streamlined series for all biomedical science programs was suggested but would have counteracted the collaborations and relationships in departments and programs. Interacting with seminar speakers was imperative for networking.

Faculty were poor examples of scientific engagement, as they often conducted other work, answer messages on their laptops or mobile devices, or asked presenters difficult or impossible questions during seminars. Often they did not even attend planned activities unless absolutely required or the presentation was on a directly related area that would benefit the faculty member. Career development workshops by established scientists with much experience or success in the field were desired, but trainees found it difficult to get senior academic faculty to commit to presenting even one session.

Workshops were lauded as the most beneficial and helpful for career development skills and were usually run by trainees for each other. Workshops, also called science career clubs or career development courses in the literature, would support the development of necessary soft
skills and abilities (Austin, 2002; Fuhrmann et al., 2011; Gravagna, 2009). These workshops were key learning experiences and necessary for bringing awareness of non-academic careers and skills to trainees, as only academic careers and skills were introduced in workshops organized by faculty. Outcome expectations were indeed influenced by workshop learning experiences, as had been posited by Lent et al (1994) in the SCCT framework. Invited guests provided career development workshops and networking opportunities for trainees. Several trainees connected with invited guests and were able to network for postdoctoral fellowships and job openings after completing training. Other career development skills taught and trained in workshops were curriculum vitae (CV) building, interviewing, networking, verbal and written communication, and lab and financial management. These other career development skills provided learning experiences that impacted trainees’ feelings of self-efficacy and preparedness for their career search, as expected by SCCT.

No or little department, center, or program funding was provided for a career development workshop series at the research site, which prevented trainees from being able to invite non-academic scientists to present their career sector or skills to interested graduate students and postdoctoral fellows. When working for the training program in the past, the researcher dealt with this conundrum by (a) inviting local industry scientists, who did not require travel funding; (b) inviting government employees, who could not be paid for activities; or (c) convincing faculty to invite a guest the trainees had identified to provide a seminar (which could be paid for by the department, center, or program) and request that the speaker arrive a day early to provide a career development workshop.

Internships and shadowing experiences were found by trainees and faculty to be beneficial for gaining a larger perspective on how the science fit together, or determining if
industry or other career sectors were ideal for a trainee. However, faculty usually could not pay the trainees’ travel costs or stipends for internships because of grant funding constraints and the lack of any other available funding sources. Trainees were also under faculty, department, and cultural pressure to be in the lab as much as possible, and internships would extend the amount of time needed to complete degree requirements or training. Trainees who participated in shadowing experiences with clinical faculty or with scientists in other areas found the experiences interesting and informative. Trainees did not often shadow others, though, because of the time the activity would take away from the lab. Gravagna (2009) promoted apprenticeships for biological scientists interested in applied science careers, and Manathunga and Lant (2006) advocated for commercial and industry experience to develop skills useful in workplace and professional situations that could not be garnered in academic training. When internships were not provided or financially supported as learning experiences, trainees’ interests, outcome expectations, and self-efficacy suffered, confirming the impact of learning experiences shown by SCCT.

Required coursework sometimes placed hurdles on graduate students trying to complete degree programs or training grant program requirements. Team-taught courses increased faculty engagement and created a collaborative environment for trainees. Feedback was received too late for students to rectify their grades. When students received late feedback and had to retake a course, the student was out of the lab for increasing amounts of time in his or her graduate program, which costs the faculty mentor and department. Additionally, feedback is an important measure of efficacy that drives interests and outcome expectations. The learning experiences aspect of SCCT could be expanded to include not just what the trainee learned in an experience but also how feedback from the learned experience cycled back to influence other model factors.
Currently, learning experiences appear to be a single item or action, but based on these findings there may be factors impacting one another within learning experiences that in turn influence other SCCT factors.

**Theme 3: Planned activities were learning experiences facilitating skills development necessary for a career, but influential factors directed the career path navigated.** Intended careers varied, and those who always intended to take a non-academic path were not viewed favorably. Many changed their minds as they progressed in training and learned more about what academia entailed and what other options were available to biomedical PhD scientists. Trainees sometimes pursued additional training in applied sciences after completing graduate school or a postdoctoral fellowship in biomedical science research. Trainees who felt prepared for a career after training at the research institution were those who went into academia; those who entered non-academic sectors did not feel as prepared for a career. Networking, CV and resume development, and interviewing skills were crucial for both academic and non-academic career sectors. The ability to communicate well in writing or verbally was also essential to obtaining and doing well in a job. Non-verbal communication was not taught or trained, even though it was an implied need. Financial and personnel management were skills useful in academia and perhaps in the non-academic sector, depending on the specific job. Planned activities provided valuable learning experiences for trainees, which supports the SCCT model. However, findings showed that planned activities prepared trainees who were largely interested in academic careers, while trainees who were interested in non-academic careers lacked training for their career paths.

Self-efficacy, or one’s own judgment of his or her capability to conduct a task or execute a course of action, is an aspect of performance, productivity, and success. Self-efficacy is an
aspect of SCCT, impacting career path and sector choice, that was not often mentioned by participants. It is a facet of how prepared trainees felt as they entered a career path that is based on one’s own level of performance, as participants repeatedly referred to their preparation as what had been taught, demonstrated, or trained by others. Personal competence was high for technical skills, but moderate or non-existent for navigating a career path.

According to the SCCT, strong efficacy and persistence enable individuals to face and triumph over barriers and hurdles, but these findings showed other mitigating factors. Biomedical PhD scientists used cold application submissions, replying to job postings, headhunters, and connecting to job positions via network contacts. Graduate students and postdoctoral fellows currently in training did not know how to get a job, where to look, or even the possible job types available. This uncertainty was referenced by past trainees who had found the job search difficult and arduous, sometimes meaning years of applying to faculty jobs with nary an offer. This finding confirmed Benderly’s (2010) results regarding the length of time and number of positions applied to before receiving a job. Past trainees also voiced how much easier current and future trainees would likely find the job search process to be with the advent and increased availability of online postings and professional networking sites like LinkedIn. The length of time searching for academic positions was greater than for non-academic positions, as it was necessary to have at least one active grant, which would support salary and the many costs of running a research lab (equipment, materials, and personnel). The hurdles to getting a grant caused a significant delay in scientific independence, which meant a delay in obtaining a first job, which supported the work of Benderly (2005), Benderly (2010), and Levitt (2010). Hurdles to getting a grant acted as learning experiences, which definitely impacted self-efficacy, interests, and outcome expectations, as mapped by SCCT.
Several trainees had anxiety or a challenging experience searching for jobs, but this may be the nature of the job search process, especially for people looking for first jobs. The length of time it took individuals to find a position (or before giving up and pursuing another sector) seemed unique to academia. Networking was integral in finding a position at the beginning of a career search and especially when forced to leave a position. Though academia was the most difficult sector to break into, it was more stable than industry, even with the erratic grant funding cycles as detailed by Alberts et al. (2014) and Teitelbaum (2008). Companies or divisions in industry dissolve or merge, and with a new company focus, biomedical scientists often found themselves looking for new jobs. These external or environmental factors played a primary role in how academic and career interests mature, change, and move the trainee from training to a career path. Openness was a factor in making career path decisions and being more satisfied with the path one ended up on. Flexibility, adaptability, and openness facilitated positive changes in direction or path, particularly for those who initially wanted academic careers. Openness to research focus, career sector, and geographic location reduced the amount of time spent in the job search process and propelled trainees more quickly onto a career path.

Success in obtaining the intended career was attributed to both internal and external factors, but failure in obtaining the desired career was attributed to external factors undermining the individuals’ efforts. Motivation was met by conflicting outside forces, reducing the number of career sectors trainees were able to even attempt navigating. Perceived and real barriers contributed to outcome expectations, reduced the number of choices individuals had, and impacted the career paths trainees were able to navigate. SCCT shows personal, background/environmental, and experiential conditions and events as regulating individuals’ goals, actions, and performance domains. Though the SCCT model emphasizes that trainees are
not passive in their career paths, this study shows that environmental or “background contextual affordances” can mitigate or erode trainees’ interest, efficacy, and obtainable domains. Background contextual affordances and contextual influences by others can adversely or beneficially affect trainees. Several researchers applauded a change in career preference as beneficial to the trainee and the system as a whole, and as demonstrating that the training process was working as it was supposed to (Sauermann & Roach, 2012; Wendler et al., 2012). SCCT demonstrates the strength of a model considering multiple potentially countercyclical aspects impacting one’s training experience, career expectations, and career paths.

Implications for Practice

This study yields implications for practitioners and programs. This section of the discussion lists implications that emerged from the data.

Internships were beneficial for gaining awareness of and experience in an area, especially for trainees interested in non-academic careers. Internships seemed to extend the time to graduation for graduate students, and time in training for postdoctoral fellows, and also seemed to be difficult to financially support. Planning ahead may help the project timeline and identify ways to pay for the internship experience. By joining research interests with career sectors early in training, a collaborative project with another institution or industry may actually increase productivity and contribute to a seamless transition from training to the workforce. Even a few months in an internship provides trainees with critical experience in a career sector, mentorship from experienced individuals in the field, and contacts for networking in the subsequent career search. Proactive planning for trainees desiring non-academic careers may enable the trainees to find paid internships to alleviate the financial pressure from the mentor, or allow for the
inclusion of this experience as a necessary part of the training in grant submissions or other financial planning.

Faculty and trainees were overwhelmed by too many seminars and workshops. Departments and centers prioritized seminars by guest lecturers and provided financial support for them, while career development workshops were not prioritized or financially supported. A consolidated seminar series for all of biomedical sciences on broader topics or cross-sectional research would encourage collaborations across departments, while also cutting planning or administrative time and financial costs for each department or center. Departmental or center seminar series are still beneficial to those groups, but could be held fewer times per month to allow scientists to attend multiple seminars without overtaxing their time. Reducing the number of seminars initiated by departments and centers, shifting some financial support to a workshop series, or integrating a workshop seminar once per month into a regular schedule would reduce the number of talks each faculty member or trainee must attend, provide focus for talks provided, integrate career development into the department and center culture, and sanction these activities for trainees.

Workshops and other career development opportunities should consider building in more skills-based training. Trainees expressed a desire to know about different career options, which are indeed important and should be maintained, but skills training is equally important and necessary for self-efficacy and career preparation. Workshop designers may be able to work with institutional career centers or resources to have broad skills sessions provided for little or no cost to the department or center. This would help balance the costs of inviting external speakers in various career sectors to present on their sector and position during other workshop sessions. Broad or widely applicable skills include CV and résumé building, cover letter writing,
interviewing, budgeting and financial management, presentation, and interpersonal communication. A broader curriculum that would prepare PhD scientists for a wide range of career paths has been overwhelmingly supported by many researchers (Austin, 2002; Fuhrmann et al., 2001; Gaughan & Robin, 2004; Lane, 2011; Lee et al., 2010; Teitelbaum, 2006).

Networking was crucial to career searches. Trainees need to learn how to network, but faculty must also be willing to boost their efforts. During conferences or society meetings, faculty should take an interactive and intentional approach to introduce their trainees to colleagues. As trainees progress through training, they typically present a talk or poster at conferences and meetings. This is one opportunity faculty could use to connect with colleagues and encourage them to attend their trainees’ presentation. Informal connections and introductions during conferences are also helpful. As previously mentioned, departments and centers have seminar series. Faculty rotate inviting guests to visit and provide a seminar, and during the visit the inviting faculty member acts as a host. By allowing a trainee to help plan the visit, provide transportation from the airport, join the guest for meals, or just meet with the guest, the faculty member would be providing key networking opportunities. Even if the mentor is not hosting an outside speaker, he or she could connect trainees to appropriate visiting faculty. Faculty often meet with guests from relevant scientific areas and could include trainees in the meetings with these invited guests.

The definition of success needs to be redefined to include non-academic career paths. Faculty are biased and push a narrow focus, which is passed down from their own training, and ultimately the NIH. Biases are often implicit, but they impact which policies and grants are funded. While public funding should indeed support the training of biomedical scientists in high level research, the NIH should acknowledge and promote critical thinking scientists in non-
academic sectors as well. Wendler et al. (2010) also suggested a broad definition of success, as career prospects often follow a winding pathway rather than a linear approach. High caliber biomedical scientists are crucial in government, clinical healthcare, industry, and other career sectors too, and PhD scientists should be able to pursue careers in those sectors without stigma. For the benefit of science and public health, the NIH and faculty need to widen the definition of success. Additionally, grant review committees should consider including non-academic scientists to proactively strengthen perspectives and confront biases.

The endorsement of non-academic career paths by grant funding sources could occur in many ways. As detailed above, expanding the accepted sectors and changing the culture would be ideal. A practical course of action would incorporate various types of career training within training grant programs. For example, a number of training grant slots could be held open for graduate students and postdoctoral fellows interested in non-academic sectors. These slots would integrate three to six months of internship training within industry partnerships, institutional patent offices, or perhaps even federal funding or scientific agencies. Another way trainees could receive relevant skills exposure and training would be to reserve training grant slots for graduate students and postdoctoral fellows who are interested in teaching in surrounding schools, particularly in underserved communities. These partnerships would be similar to student-teacher experiences received by students majoring in education. Training grant program backing and support for these opportunities would greatly benefit graduate students and postdoctoral fellows who need an environment where they can hone these skills while determining whether the career path would be a good choice for them. Also, schools with inadequate staffing or resources may value the scientific expertise and contribution provided by such a partnership.
Academic and career goals need to be clarified early in the training process, which would be best done during an honest conversation with the faculty mentor. Faculty and institutions should address unrealistic outcome expectations based on the availability of positions and a given trainee’s skillset or progress. Too often, trainees claim interest and goals only in the areas that they are aware of, or what they have perceived to be endorsed by faculty. Based on the findings, it is clear that interests and goals develop and change throughout training, and this must be communicated without apprehension to the mentor to allow the mentor the opportunity to minimize barriers and facilitate growth and success. Faculty can train and support graduate students and postdoctoral fellows in directions appropriate for their aptitude and interests, instead of creating an additional hurdle in their path. Additionally, graduate students and postdoctoral fellows should continue to ask questions of their mentor, faculty committee, lab mates, and other colleagues to determine if academia is right for them, as advised by Yewdell (2008).

A professional science program may be added to the current curriculum. Currently, a graduate student who receives a master’s degree is seen as failing or leaving the PhD trajectory (Lee et al., 2010). Professional scientists could change the workload in academic labs and also be prepared to work in non-academic careers. This would also lessen the issue of PhD scientists entering non-academic positions for which they may be overeducated, but may take due to their inability to land an academic position (Verhaest & Van der Velden, 2012). An interesting solution in Finland, which could be integrated here, is to shorten the time-to-degree, essentially creating more professional scientists who can go into industry, rather than promoting extensive training for academia (Hakala, 2009a), which could effectively be obtained in the postdoctoral phase of training.
Graduate programs could monitor and adjust the number of graduate students admitted to match the supply with job demand more effectively (Matthews et al., 2011) and to mitigate the increasing production of PhDs (Cyranoski et al., 2011). This suggestion may be more difficult to plan, as graduate students enter programs years before they enter the job search, but it merits consideration.

**Limitations of Findings**

The case study provided multiple perspectives through data sources, and the researcher sought to minimize bias and include multiple data collection methods, but as with any research study, this case study and these findings have limitations. Limitations of this research project are described below.

The main limitation of the findings is their generalizability and transferability. Participants were recruited by sampling a specific program at one highly selective institution. Readers must understand that these findings may not be indicative of other biomedical science programs at this research site or at other institutions. The findings may not be transferable between institutions or populations, but the literature review did indicate similar underlying issues throughout the nation and world.

The researcher had to rely on contacts in the program’s database, in which some contact information had not been updated in years. Contact information was readily available for most past trainees who were in academia, as those institutions’ web pages are available and prominent. Past trainees in non-academic careers were more difficult to find, as large companies, healthcare facilities, independent consultants, and other employers may not make contact information for employees available to the public.
Data collection was conducted over a summer, when many people in all career sectors are on vacation, otherwise disengaged from work, in the middle of grant submissions, sabbaticals, writing books and publications, having elective surgeries, or otherwise unavailable. The researcher encountered responses of this nature from willing but unavailable participants.

This research project relied on self-selection for the interview phase and on volunteers contributing documents for review. Several prospective faculty and administrator participants did not want to participate for fear their feedback would highlight a negative training environment or that they may be identified by their remarks. This may have been true of current or past trainees as well.

This case study focused on non-academic career development. However, those sectors are still regarded as inferior, and perhaps this impacted whether scientists would be willing to participate in a study on navigating different career paths.

The SCCT model incorporates many factors influencing and causally impacting career paths. However, for this study, SCCT encompasses more roles and intersections than could adequately be understood in brief surveys and interviews. Although the researcher incorporated the SCCT factors in the design of questions, individual factors were not discussed at length. This study and the theoretical framework did not confirm unconscious bias and thoughts.

**Areas for Future Research**

Quantitative studies have most often reported on trends and outcomes of biomedical PhD scientists pursuing employment in academia. A review of the literature revealed hardly any qualitative research, and most publications were editorials and opinion pieces rather than empirical studies. There has been an insufficient amount of research regarding non-academic careers, the training and support biomedical PhD scientists receive, and the experience and
process of navigating a career path. Fuhrmann et al. (2011) recommended a shift in the academic culture to embrace the branching science career pipeline, of which little is known.

More qualitative studies should be conducted to better understand the job search process and experience of biomedical PhD scientists. This same case study could be replicated at other programs or institutions. Other research studies could use different qualitative approaches to analyze the problem of practice. Some factors identified by SCCT should be investigated in more detail at a larger scale. In particular, it would be beneficial to research how individual inputs impact career path choice and navigation. Additional research is especially important to validate or challenge the gender issues highlighted in the findings. Although this study is not transferable to other populations, additional studies could identify overlapping aspects and findings that would inform and benefit other populations. If this special program for promising graduate students and postdoctoral fellows at a large selective institution could improve its career development opportunities, how much more could be learned from other programs or institutions with fewer resources and connections? Perhaps other programs or institutions are using novel career development training and strategies, which could be reported and publicized to help other programs restructure their training and support.

Similarly, research should be conducted internationally to discover what training and support is provided to biomedical PhD scientists in other countries. The literature suggests this problem of practice exists in other countries as well. Some countries do not define success and failure by whether PhD recipients work in academic or non-academic careers, some countries have different needs and availability for academic positions, and some countries may train students differently or have different numbers of individuals pursuing biomedical science PhDs.
More research should be undertaken to find where issues intersect and identify solutions other countries employ. These could then be applied in the United States.

**Conclusion**

The central research question of this study has been: How does a southeastern tier 1 research university train and support its biomedical PhD scientists for navigating their career paths? This research study also looked at the process and outcome of biomedical scientists’ job searches and the influence of personality, environment, experiences, perceptions, etc. on the job search process for these scientists. Finally, this research project sought to determine which non-technical or bench skills biomedical PhD scientists should be exposed to, and encouraged to develop, to better prepare them for employment after graduation.

Prior studies used the traditional academic pathway as the definition of success, but this study used an open definition of success based on the SCCT model, incorporating trainees’ intentions, interests, and goals; their reported training and career navigation experience; and their perception of whether they were prepared for a career and satisfied in the sector or position obtained. Capable and successful biomedical PhD scientists are in varied professions in both the academic and non-academic sectors. Kemp et al. (2012) and Lee et al. (2010) agreed that scientists who have the technical skills, discipline, intellectual rigor, passion, and curiosity to make a significant contribution to biomedical science should be encouraged and trained to do so. The skills and training needed for careers outside of academia have been rarely researched, and this study contributed to the knowledge of essential career development for the large proportion of graduate students and postdoctoral fellows who enter non-academic careers.

While the researcher had observed many of the tensions of the training environment, this case study helped her evaluate and understand the training environment and career path
navigation of biomedical PhD scientists in a methodical way. Recommendations for skills to be trained and a reconstructed career structure emerged from the data, chiefly from trainees and administrators. This is appropriate and expected, as trainees and administrators were the groups most interested in non-academic career options, while faculty were most interested in academia as a career path. The findings also promote a career pathway where one can practice and conduct biomedical science in many professions, and the reconstruction of a career structure to provide young biomedical scientists with the hope and preparation necessary to become leaders in science-grounded careers. Our universities must encourage and facilitate creating these skilled scientists (Jaspers, 1953; Kemp, Newnham, & Chapman, 2012).

Finally, the dissemination of findings is crucial to advancing scholarship and shaping practice. The researcher plans to publish focused journal articles in peer-reviewed publications and may present findings at relevant conferences. Recommendations will be provided to biomedical science program directors at the research institution for integration into their programs where relevant and applicable.
References

http://doi.org/10.1287/mnsc.1120.1582


Figures

Figure 1: Social cognitive career theory model. This model demonstrates the relationship between personal, environmental, and experiential factors and their influence on goals, expectations, and actions (Lent, et al., 1994, pp. 93).
Figure 3: Current career sectors. This figure shows the distribution of survey respondents’ career sectors.
Figure 4: Prior career sectors. This figure illustrates survey respondents’ prior career sectors. Note that some respondents have worked in multiple sectors, while most current trainees have not been employed in a sector.
Figure 5: Career development support. This figure shows how supportive career development opportunities were at the research site.
Figure 6: Interactions with mentor during training. This illustrates how favorable survey respondents’ found their interactions with the mentor during training.
Figure 7: Interactions with mentor after completing training. This illustrates how favorable survey respondents’ found their interactions with the mentor after training.
Figure 8: Mentor’s encouragement of career sectors. This figure shows the mentor’s career sector preferences.
Figure 9: Career readiness. This figure demonstrates how prepared trainees felt for a career after training.
Figure 10: Career search preparedness. This figure shows how prepared trainees felt for the career search after training.
Figure 11: Intended career sector. This figure displays the career sectors trainees intended to pursue upon entering training at the research site. Note that this counts responses, not respondents, as each respondent could select more than one sector.
Appendix A

Permission Request for Access to Study Contacts

2/22/16

[name and address of training program director]

RE: Permission to Conduct Research Study

Dear [director name]:

As you know, I am currently enrolled in the Doctor of Education in Higher Education Administration program at Northeastern University in Boston, MA, and I am in the process of writing my dissertation. The study is entitled *Navigating the Path to a Biomedical Science Career*. I am writing to request permission and access to your program’s contacts.

The central research question driving this case study is: How does [a southeastern tier 1 research university] train and support its biomedical PhD scientists for navigating their career paths? Data collected will illuminate the how the process influences the outcome of the job search and explore other factors and experiences contributing to career paths sought and chosen. A practical sub-goal of this study is to uncover suggestions and ideas about skills that should be cultivated to benefit and prepare biomedical PhD scientists for employment after graduation.

If approval is granted, current and former trainees will be invited to complete an online survey. The survey process should take no longer than 15 minutes. Participants may self-select into the next phase of the study, which includes participation in a focus group or an interview, depending on training or career stage. Also, current faculty mentors of the training program will be invited to participate in an in-person or web conference interview. The focus groups and interviews will take no longer than one hour each. Individual results of this study will remain absolutely confidential and anonymous. Administrators of the departments, other NIH training grants, the Office of Postdoctoral Affairs, and the Graduate Programs Office may be included in the interview phase of the study to learn of the training process and opportunities available outside of the research laboratory for graduate students and postdoctoral fellows. No costs will be incurred by either your school/center or the individual participants.

Your approval to conduct this study will be greatly appreciated. I will follow up with a telephone call next week and would be happy to answer any questions or concerns that you may have at that time. You may contact me at my email address: zimmerman.an@husky.neu.edu.

If you agree, kindly return the signed form. Alternatively, kindly submit a signed letter of permission on your institution’s letterhead acknowledging your consent and permission for me to conduct this study with your program’s contacts.

Sincerely,
Andrea Zimerman
Doctoral Student, Northeastern University

cc: Dr. Kelly Conn, Research Advisor, Northeastern University

Approved by:

_________________________________________  __________________________  ________
Print your name and title here                 Signature                      Date
Appendix B

Signed Consent Form

| Title of Project: Navigating the Path to a Biomedical Science Career |
| Name of Investigators: Andrea McNeely Zimmerman (Student Researcher) |
| Northeastern University, Department of Education—Higher Education Administration concentration |
| Study Contact: 434-214-0394 or zimmerman.an@husky.neu.edu. |
| Faculty Advisor: Kelly Conn, PhD (k.conn@neu.edu) |

**Informed Consent to Participate in a Research Study**

We are inviting you to take part in a research study. This form will tell you about the study, but the researcher will explain it to you first. You may ask this person any questions that you have. When you are ready to make a decision, you may tell the researcher if you want to participate or not. You do not have to participate if you do not want to. If you decide to participate, the researcher will ask you to sign this statement and will give you a copy to keep.

**Why am I being asked to take part in this research study?**

I am asking you to participate in this study because you:

- a. have been supported for some amount of time by the [training program name] while in training at [institution name]
- b. are a faculty mentor of the [training program name] at the [institution name]
- c. are an administrator of programs related to biomedical sciences at [institution name]

**Why is this research study being done?**

This purpose of this study is to understand the process by which biomedical PhD scientists are trained and supported for navigating a future career path.

**What will I be asked to do?**

If you decide to take part in this study, we will ask you to answer open-ended questions in either a focus group or one-on-one interview about career development opportunities, perceptions, and preparation. You will be asked to also share documents, which may include graduate school personal statements, postdoctoral position cover letters, notes or slides from career development sessions, or other relevant documents.

**Where will this take place and how much of my time will it take?**

For those taking part in the focus group, participants will meet in a library group study room or neutral conference room or meeting space. The focus groups will last approximately one hour and will be audio recorded with the participants’ permission.
For the comfort level of the interviewee, the researcher will offer several locations for meeting, such as the participant’s office or a neutral conference room or meeting space. Interviews may also be offered as web or telephone conferences for participant comfort and convenience. All interviews will be audio recorded, with the participants’ permission.

**Will there be any risk or discomfort to me?**
The foreseeable risks or discomforts of the study are minimal; however, you may feel a little uncomfortable answering personal questions.

**Will I benefit by being in this research?**
There are no direct benefits to you from participating in this study. However, your responses may help us learn more about and strengthen the career development support efforts and opportunities for biomedical scientists.

**Who will see the information about me?**
Your part in this study will be handled in a confidential manner. Any reports or publications based on this research will use only group data and will not identify you or any individual as being affiliated with this project. Data will be stored in a double password protected server without identifying information.

If you have any questions regarding electronic privacy, please feel free to contact Mark Nardone, NU’s Director of Information Security via phone at 617-373-7901, or via email at privacy@neu.edu.

**If I do not want to take part in the study, what choices do I have?**
The decision to participate in this research project is voluntary. You do not have to participate.

**What will happen if I suffer any harm from this research?**
No special arrangements will be made for compensation or for payment for treatment solely because of my participation in this research.

**Can I stop my participation in this study?**
Yes. You can refuse to answer any question. Even if you begin the focus group or interview, you can stop at any time. At the end, you will be offered an opportunity to review the focus group or interview transcript for clarifications and omissions.

**Who can I contact if I have questions or problems?**
If you have any questions about this study, please feel free to contact Andrea Zimmerman, the person mainly responsible for the research, via phone at 434-214-0394 or email at zimmerman.an@husky.neu.edu. You can also contact Kelly Conn via email at k.conn@neu.edu.

**Who can I contact about my rights as a participant?**
If you have any questions regarding your rights as a research participant, please contact Nan C. Regina, Director, Human Subject Research Protection, 490 Renaissance Park, Northeastern
University, Boston, MA 02115. Tel: 617.373.4588, Email: n.regina@neu.edu. You may call anonymously if you wish.

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<th>You will not be paid for your participation in this study.</th>
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<td><strong>Will it cost me anything to participate?</strong></td>
<td>No.</td>
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<td><strong>Is there anything else I need to know?</strong></td>
<td>This study has been reviewed and approved by the Northeastern University Institutional Review Board (# xx-xx-xx). [protocol # will be provided to you by the HSRP office].</td>
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<td><strong>I agree to take part in this research.</strong></td>
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Appendix C

The Unsigned Informed Consent Email for Web-Based Online Surveys

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<td>Name of Investigators:</td>
<td>Andrea McNeely Zimmerman (Student Researcher)</td>
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<tr>
<td>Northeastern University, Department of:</td>
<td>Education—Higher Education Administration concentration</td>
</tr>
<tr>
<td>Faculty Advisor:</td>
<td>Kelly Conn, PhD (<a href="mailto:k.conn@neu.edu">k.conn@neu.edu</a>)</td>
</tr>
<tr>
<td>Study Contact:</td>
<td>434-214-0394 or <a href="mailto:zimmerman.an@husky.neu.edu">zimmerman.an@husky.neu.edu</a>.</td>
</tr>
</tbody>
</table>

Subject Line: Request to participate in study: navigating a biomedical science career path

Request to Participate in Research

Dear ____________,

My name is Andrea McNeely Zimmerman, and I am a former program administrator for [training program name]. I am also a student in the Doctor of Education program at Northeastern University and am currently conducting a study for my dissertation and am seeking research participants.

I would like to invite you to participate in a web-based online survey. This survey is part of a resource study, the purpose of which is to understand the process by which biomedical PhD scientists are trained and supported for navigating a future career path. This survey should take about 12-15 minutes to complete.

I am asking you to participate in this study because you have been supported for some amount of time by the [training program name] while in training at the [university name].

The decision to participate in this research project is voluntary. You do not have to participate, and you can refuse to answer any question. Even if you begin the web-based online survey, you can stop at any time. At the end of the survey, you may elect to participate in a more in-depth phase of the study through either a focus group or an interview.

The possible risks or discomforts of the study are minimal; however, you may feel a little uncomfortable answering personal survey questions.

There are no direct benefits to you from participating in this study. However, your responses may help us learn more about and strengthen the career development support efforts and opportunities for biomedical scientists.
You will not be paid for your participation in this study.

Your part in this study will be handled in a confidential manner. Any reports or publications based on this research will use only group data and will not identify you or any individual as being affiliated with this project. Data will be stored in a double password protected server without identifying information.

If you have any questions regarding electronic privacy, please feel free to contact Mark Nardone, NU’s Director of Information Security via phone at 617-373-7901, or via email at privacy@neu.edu.

If you have any questions about this study, please feel free to contact Andrea Zimmerman, the person mainly responsible for the research, via phone at 434-214-0394 or email at zimmerman.an@husky.neu.edu. You can also contact Kelly Conn via email at k.conn@neu.edu.

If you have any questions regarding your rights as a research participant, please contact Nan C. Regina, Director, Human Subject Research Protection, 490 Renaissance Park, Northeastern University, Boston, MA 02115. Tel: 617.373.4588, Email: n.regina@neu.edu. You may call anonymously if you wish.

This study has been reviewed and approved by the Northeastern University Institutional Review Board (# xx-xx-xx). [protocol # will be provided to you by the HSRP office].

By clicking on the survey link below [Or the “accept” button below] you are indicating that you consent to participate in this study. Please print out a copy of this consent form for your records.

http://

Please fill out the survey by MM/DD/YYYY (2 weeks from send date).

Thank you for your time.
Andrea Zimmerman
Appendix D

Thank You Message Appearing After Survey Completion

Dear ___________________,

Thank you for completing the survey portion of the study. Your insight and input is greatly appreciated and will add significantly to this study. If you have agreed to participate in the next phase of the research study, you will receive an email or phone call to schedule your participation.

Thank you again for your willingness to participate in this study.

Sincerely,
Andrea Zimmerman
Appendix E

Reminder Email

Subject Line: Request to participate in study: navigating a biomedical science career path

Dear ____________, (will use SurveyMonkey option to automatically fill in names)

One week ago you received an email (below) about a research study that I am doing for my doctoral dissertation.

This is a reminder to complete the survey by MM/DD/YYYY, if you are interested in participating: http://_____________________________________________________

Thank you again for considering participation in the study.

Regards,
Andrea Zimmerman

*Note: This is a follow up email that will be sent to All Trainees that do not respond within seven days of the initial email. For the follow up email, the initial email will be forwarded to students so they can easily view the information included and respond appropriately.
Appendix F

Recruitment Email for Focus Group Phase

Subject: Thank you for participating. Scheduling request for next study phase.

Dear ___________________,

Thank you for completing the survey portion of the study. Your insight and input is greatly appreciated and will add significantly to this study. You are receiving this email as you have agreed to participate in the next phase of the research study.

You have been selected for the focus group phase. I would like to schedule a time at the convenience of participants. Please let me know whether a morning, afternoon, evening, or weekend time is best. We will meet in a neutral space in one of the library’s group meeting rooms. The focus group will last approximately one hour.

If you have any questions or concerns, please stop by my office (McKim G144), call 434-214-0394, or email Zimmerman.an@husky.neu.edu. Thank you again for your willingness to participate in this study. I look forward to speaking with you.

Sincerely,
Andrea Zimmerman
Appendix G

Recruitment Email for Trained Interviews

Subject: Thank you for participating. Scheduling request for next study phase.

Dear ___________________,

Thank you for completing the survey portion of the study. Your insight and input is greatly appreciated and will add significantly to this study. You are receiving this email as you have agreed to participate in the next phase of the research study.

You have been selected for the interview phase. I would like to schedule a time at your convenience. If you are within a day’s driving distance of Charlottesville, we could hold the interview in your town at a location convenient and comfortable for you. Regardless of location, the interview can be held over web conferencing or telephone. The interview will last approximately 45 minutes. Please let me know which option is most convenient and whether a morning, afternoon, evening, or weekend time is best.

If you have any questions or concerns, please call 434-214-0394 or email Zimmerman.an@husky.neu.edu. Thank you again for your willingness to participate in this study. I look forward to speaking with you.

Sincerely,
Andrea Zimmerman
Appendix H

The Unsigned Informed Consent Email for Interviews of Faculty Mentors

<table>
<thead>
<tr>
<th>Title of Project:</th>
<th>Navigating the Path to a Biomedical Science Career</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name of Investigators:</td>
<td>Andrea McNeely Zimmerman (Student Researcher)</td>
</tr>
<tr>
<td></td>
<td>Northeastern University, Department of Education—Higher Education Administration concentration</td>
</tr>
<tr>
<td>Study Contact:</td>
<td>434-214-0394 or <a href="mailto:zimmerman.an@husky.neu.edu">zimmerman.an@husky.neu.edu</a>.</td>
</tr>
<tr>
<td>Faculty Advisor:</td>
<td>Kelly Conn, PhD (<a href="mailto:k.conn@neu.edu">k.conn@neu.edu</a>)</td>
</tr>
</tbody>
</table>

Subject Line: Request to participate in study: Navigating a Biomedical Science Career Path

Request to Participate in Research

Dear ____________, (will use the mail merge function to automatically fill in names)

My name is Andrea McNeely Zimmerman, and I am a former program administrator for [training program name]. I am also a student in the Doctor of Education program at Northeastern University and am currently conducting a study for my dissertation and am seeking research participants. The purpose of this study is to understand the process by which biomedical PhD scientists are trained and supported for navigating a future career path. I am asking you to participate in this study because you are one of the mentors for the [training program name] at [university name].

I would like to invite you to participate through an in-person, web conferencing, or telephone interview. The interview will take approximately 30 minutes. If you decide to take part in this study, we will ask you to answer open-ended questions in a one-on-one interview about career development opportunities, perceptions, and preparation. You will be asked to also share documents, which may include graduate school personal statements, postdoctoral position cover letters, notes or slides from career development sessions, or other relevant documents.

The possible risks or discomforts of the study are minimal. You may feel a little uncomfortable answering personal questions.

There are no direct benefits to you from participating in this study. However, your responses may help us learn more about and strengthen the career development support efforts and opportunities for biomedical scientists.

Your part in this study will be handled in a confidential manner. Any reports or publications based on this research will use only group data and will not identify you or any individual as
being affiliated with this project. Data will be stored in a double password protected server without identifying information.

**The decision to participate in this research project is up to you.** You do not have to participate and you can refuse to answer any question. Even if you begin the interview, you can stop at any time. At the end, you will be offered an opportunity to review the interview transcript for clarifications and omissions.

**You will not be paid for your participation in this study.**

**If you have any questions about this study,** please feel free to contact Andrea Zimmerman, the person mainly responsible for the research, via phone at 434-214-0394 or email at zimmerman.an@husky.neu.edu. You can also contact Kelly Conn via email at k.conn@neu.edu.

**If you have any questions regarding your rights in this research,** please contact Nan C. Regina, Director, Human Subject Research Protection, 490 Renaissance Park, Northeastern University, Boston, MA 02115. Tel: 617.373.4588, Email: n.regina@neu.edu. You may call anonymously if you wish.

**If you are willing to participate in the interview phase of the study, please respond with three dates and times you are available during the next two weeks. Also, let me know whether you prefer an in person, telephone, or web conference setting for your interview.**

Thank you for your time.

Andrea Zimmerman
Appendix I

The Unsigned Informed Consent Email for Interviews of Administrators

<table>
<thead>
<tr>
<th>Title of Project:</th>
<th>Navigating the Path to a Biomedical Science Career</th>
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<td>434-214-0394 or <a href="mailto:zimmerman.an@husky.neu.edu">zimmerman.an@husky.neu.edu</a>.</td>
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</tbody>
</table>

Subject Line: Request to participate in study: Navigating a Biomedical Science Career Path

Request to Participate in Research

Dear ____________, (will use the mail merge function to automatically fill in names)

My name is Andrea McNeely Zimmerman, and I am a former program administrator for [training program name]. I am also a student in the Doctor of Education program at Northeastern University and am currently conducting a study for my dissertation and am seeking research participants. This purpose of this study is to understand the process by which biomedical PhD scientists are trained and supported for navigating a future career path. I am asking you to participate in this study because you are one of the administrators for programs at [university name].

I would like to invite you to participate through an in person, web conferencing, or telephone interview. The interview will take approximately 45 minutes. If you decide to take part in this study, we will ask you to answer open-ended questions in a one-on-one interview about career development opportunities, perceptions, and preparation.

The possible risks or discomforts of the study are minimal.

There are no direct benefits to you from participating in this study. However, your responses may help us learn more about and strengthen the career development support efforts and opportunities for biomedical scientists.

Your part in this study will be handled in a confidential manner. Any reports or publications based on this research will use only group data and will not identify you or any individual as being affiliated with this project. Data will be stored in a double password protected server without identifying information.
The decision to participate in this research project is up to you. You do not have to participate and you can refuse to answer any question. Even if you begin the study, you may withdraw at any time. You will also have the opportunity to review the interview transcript.

You will not be paid for your participation in this study.

If you have any questions about this study, please feel free to contact Andrea Zimmerman, the person mainly responsible for the research, via phone at 434-214-0394 or email at zimmerman.an@husky.neu.edu. You can also contact Kelly Conn via email at k.conn@neu.edu.

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If you are willing to participate in the interview phase of the study, please respond with three dates and times you are available during the next two weeks. Also, let me know whether you prefer an in person, telephone, or web conference setting for your interview.

Thank you for your time.

Andrea Zimmerman
Appendix J

Survey Instrument

Age (fill-in)

Gender

Years in training at [UNIVERSITY] (YYYY-YYYY) _________ - _________

Trained at [UNIVERSITY] as

  o  predoc
  o  postdoc

What is your current career sector?

  o  Academic
  o  Clinical/healthcare
  o  Government
  o  Industry
  o  Non-research (e.g. consulting, scientific writing, or unrelated area)

If you have worked in multiple career sectors, please mark those prior to your current sector.

  o  Academic
  o  Clinical/healthcare
  o  Government
  o  Industry
  o  Non-research (e.g. consulting, scientific writing, or unrelated area)

Which career sector were you interested in prior to graduate school?

  o  Academic
  o  Clinical/healthcare
  o  Government
  o  Industry
  o  Non-research (e.g. consulting, scientific writing, or unrelated area)

On a scale of 1-10, with 1 being not at all favorable and 10 being most favorable, please rate your mentor’s encouragement of the following career sectors:

  Academic  1  2  3  4  5  6  7  8  9  10
<table>
<thead>
<tr>
<th>Category</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinical/healthcare</td>
<td>1 2 3 4 5 6 7 8 9 10</td>
</tr>
<tr>
<td>Government</td>
<td>1 2 3 4 5 6 7 8 9 10</td>
</tr>
<tr>
<td>Industry</td>
<td>1 2 3 4 5 6 7 8 9 10</td>
</tr>
<tr>
<td>Non-research (e.g. consulting, scientific writing, or unrelated area)</td>
<td>1 2 3 4 5 6 7 8 9 10</td>
</tr>
</tbody>
</table>

On a scale of 1-10, with 1 being not at all favorable and 10 being most favorable, please rate the interactions with your mentor during training at [UNIVERSITY].

1 2 3 4 5 6 7 8 9 10

On a scale of 1-10, with 1 being not at all favorable and 10 being most favorable, please rate the interactions with your mentor after training at [UNIVERSITY].

1 2 3 4 5 6 7 8 9 10

On a scale of 1-10, with 1 being not at all favorable and 10 being most favorable, please rate the career development opportunities you had while in training at [UNIVERSITY].

1 2 3 4 5 6 7 8 9 10

On a scale of 1-10, with 1 being not at all prepared and 10 being most prepared, please rate how prepared you felt for your career search post-training.

1 2 3 4 5 6 7 8 9 10

On a scale of 1-10, with 1 being not at all favorable and 10 being most favorable, please rate how prepared you felt for your career(s) post-training.

1 2 3 4 5 6 7 8 9 10

Other than bench or technical skills, which skills are needed in your current position?

________________________________________________________
Did you receive these skills during training at [UNIVERSITY]? Yes

No

Would you be willing to participate in a focus group or interview? If so, please include your preferred contact information to use in scheduling further participation.

First name ________________________________________________________________

Telephone Number ________________________________________________________

Email Address ____________________________________________________________

Thank you for your time and willingness to participate in this survey. If you are selected to participate in one of the next phases of the study, you will be contacted within 2 months.
Appendix K
Focus Group Protocol

Good afternoon/evening. Thank you for taking the time to join our discussion of the training environment at [university name].

My name is Andrea Zimmerman, and this is __________________, who will act as an impartial assistant moderator. As stated in our previous communication, I am conducting research on how biomedical scientists navigate career paths. In particular, I hope to learn how PhD scientists could be better supported and trained for careers post-training.

We want to talk with you about your experiences as graduate students and postdoctoral fellows so we’ll be asking about what originally drew you to biomedical science and this program, and what it has been like for you here since you began.

Before we begin, let me suggest some things to make our discussion more productive. Because we will be recording for an accurate record, it is important that you speak up and that you only speak one at a time. We don’t want to miss any of your comments. We’ll only use first names here. No reports will link what you say to your name, department, or institution. In this way, we will maintain your confidentiality. In addition, we ask that you also respect the confidentiality of everyone here. Please do not repeat what others said when you leave this room.

During this time, I will ask you questions, and I will listen to what you have to say. I will not participate in the discussion so please feel free to respond to each other and to speak directly to others in the group.

We want to hear from all of you. We are interested in all viewpoints, common and uncommon experiences, so I may sometimes encourage someone who has been quiet to talk, or by asking someone to hold off for a few minutes.

If it is OK with you, we will turn on the recorder and start now.

This student focus group is being conducted for the Biomedical Science Career Path Study on MM/DD/YYYY by Andrea Zimmerman and assistant moderator.
Our start time is HH:MM.

I. Let’s begin with introductions.
   A. Please tell us your first name, what program or area of training you’re in, and whether you are a grad student or postdoc.

II. Now that we know a little about you, I would like you to think back to when you first decided you wanted to be a scientist.
   B. What was it that drew you to science and biomedical science in particular?
   C. What drew you to this particular program at [UNIVERSITY]?
SUMMARIZE: It looks like there were (quite a few/some) positive features of biomedical science and this program that motivated your initial choices. These features included: NAME CATEGORIES.

III. Now, we’d like to talk about what has happened since you entered grad school. What experiences have you had that encouraged you to continue or increased your initial enthusiasm for biomedical science?
   D. I’d like to list any experiences you have had that have discouraged you or reduced your initial enthusiasm.

IV. We are interested in your views of career sectors. We have identified four career sectors of academic, industry, government, and non-research (for example, consulting, scientific writing, or healthcare).
   E. What type of career did you intend to pursue when you were young?
   F. What about in college?
   G. How about now?
   H. What are pros and cons of an academic career?
   I. What are pros and cons of non-academic careers?
   J. How did you determine these? Who in particular has influenced your views on career paths?

V. How do you feel/what do you anticipate as you look ahead to your career?
   K. How prepared do you feel for the career search?
   L. How prepared do you feel for your desired career sector?
   M. What skills, other than bench or technical, do you anticipate needing for your career?
   N. How confident are you that you have the necessary skills for your career?
   O. Where did you receive training or support in these skills?
   P. What changes would you recommend for career development training at [UNIVERSITY]?

VI. To summarize what we discussed, you said…
SUMMARIZE THE POSITIVE AND NEGATIVE ASPECTS, ACKNOWLEDGING DIFFERENT POINTS OF VIEW.

VII. Does that capture the essence of what was said here? Are there any last comments?

VII. Finally, as I told you at the beginning, the purpose of this study is to get information about career paths and career development training and support in biomedical sciences at [UNIVERSITY]. As part of my analysis, I am collecting documents for review, such as personal statements for college and grad school discussing your interests and intentions, cover letters for postdoc positions, notes from career development seminars, emails from mentors, or other documents. If you have any documents you would be willing to share or if you have any thoughts after today’s focus group, please feel free to email me.

Thank you so much for your participation in the survey and focus group. Your input has been valuable for my study.
Appendix L

Trained Group Interview Protocol

Information on the signed consent form (Appendix B) will be reviewed by the researcher. The interviewee will sign the consent form before the researcher continues.

1. Tell me about what drew you to biomedical science.
   a. When did you first become interested in it?
2. Tell me about your graduate and post-graduate training experience.
   a. What was your relationship with your mentor/advisor and other faculty?
3. Tell me about the climate and conversations or perceptions about career paths or sectors.
4. Who has influenced your career choice or sector choice?
5. What was your job/career search experience like?
6. Tell me about the career development opportunities that were:
   a. Available to you.
   b. Taken by you.
7. Looking back, aside from technical skills, how well prepared were you for a career?
8. What skills or topics were missing in your career development opportunities or which should remain?
Appendix M

Faculty Interview Protocol

Information on the signed consent form (Appendix B) will be reviewed by the researcher. The interviewee will sign the consent form before the researcher continues.

1. Tell me about trainees’ interest prior to and during training.
2. Have there been shifts in career sector intention or focus?
3. What do you believe influences their career perceptions or trajectory?
4. What is your perception of each career sector? Are any favored or discouraged?
5. Which skills are needed for a career after training?
6. Which skills, other than technical, did/do you cultivate during their training?
   a. What type of career development opportunities do your trainees have (could be other programs, emails you forwarded of campus activities, workshops away, etc.)
7. Are the skills needed for different career sectors different?
8. Which skills and career development opportunities are missing and necessary for success?
Appendix N

Administrators Interview Protocol

Information on the signed consent form (Appendix B) will be reviewed by the researcher. The interviewee will sign the consent form before the researcher continues.

1. What is your perception of each career sector? Are any favored or discouraged?
2. Which skills are needed for a career after training?
3. Which skills, other than technical, did/do you cultivate during their training?
   a. What type of career development opportunities do your trainees have (could be other programs, emails you forwarded of campus activities, workshops away, etc.)
4. Are the skills needed for different career sectors different?
5. Which skills and career development opportunities are missing and necessary for success?
6. How are topics for career development determined?
7. What kind of feedback have you received from opportunities, or what kinds of opportunities have trainees asked for?
8. Who typically provides lectures or workshops in career development skills?
   a. Broader outside of academe?