HERE FOR MORE THAN JUST RESEARCH:
POSTDOCTORAL TRAINING AND TRANSITIONS IN STEM FIELDS

BY

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DISSERTATION

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ABSTRACT

The purpose of this research is to better understand how academic researchers in STEM fields identify and access postdoctoral positions, transition into postdoctoral roles, and access training, development opportunities, and networks once they are at their postdoctoral institution. Furthermore, this study aims to describe how aspects of identity influence any of these facets of postdoctoral training. There is relatively little research into the postdoctoral training stage. This qualitative, exploratory study is meant to describe how postdoctoral scholars view and understand their own experiences in the role, and how their identity may or may not impact this experience. Sixteen participants, most from backgrounds that are underrepresented in their disciplines, were recruited from research institutions across the country to participate in a 1-hour interview about their academic experiences, their postdoc experience, and their career goals. Findings include the importance of networks and support structures for understanding how to identify and transition into postdoctoral positions, the hidden curriculum related to the postdoctoral training experience, and the role of values and cultural identity in setting postdoc and career goals. These findings fill a gap in the literature by better representing current postdocs' expectations for this training period, specifically as it relates to potential transitions into a faculty role. The results can be used to design postdoc training programs that emphasize equity in STEM fields.

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Glossary of Terms

NIH   National Institutes of Health

NSF   National Science Foundation

NPA   National Postdoctoral Association

PI   Principal Investigator. This is usually a faculty member who secures grant funding and leads a research lab or team.

Postdoc   An individual holding a doctoral degree who is engaged in a temporary period of mentored research and/or scholarly training for the purpose of acquiring the professional skills needed to pursue a career path of their choosing.

R1   A category of university defined by the Carnegie Commission on Higher Education. The R1 category indicates that an institution has very high research activity, with at least 20 doctoral programs and $5 million in research expenditures.

STEM   Science, Technology, Engineering, and Mathematics disciplines, a commonly studied grouping of academic field.

URM   Underrepresented minority. For STEM, this includes racial and ethnic minority groups that are underrepresented in their discipline. The NIH and NSF categorizes underrepresented racial and ethnic groups as Black or African American, Hispanics or Latinos, American Indians or Alaska Natives, Native Hawaiians, and other Pacific Islanders.

Chapter One: Introduction

The goal of this study was to describe the unique processes that postdoctoral scholars describe and identify as they select advisors, transition into postdoctoral labs, and access institutionally provided professional development opportunities. Overlaying these three domains is the question of how aspects of identity, be that race or ethnicity, gender, or immigration status, may impact choice of advisor and experiences while in the postdoctoral role. The postdoc search and application process is akin to a "black box," and relatively little research has been done to explain exactly how the process of finding and securing a postdoctoral position occurs. This project sought to describe the postdoctoral selection, application, and transition process through the experiences of current postdoctoral scholars who are underrepresented in their respective disciplines.

I have spent the last decade and a half working with academic researchers in science, technology, engineering, and mathematics (STEM) disciplines, and have specifically worked with graduate and postdoctoral training programs, engaging with faculty directors and with students and postdocs in an advisory capacity. Through this work I have seen the unique search process for identifying postdoctoral opportunities and engaged with a variety of graduate students who have described access to the opportunities that are predicated on their graduate advisor's networks or other personal connections. I have further seen postdocs who have gotten "lost" in the system, and have heard firsthand of postdocs who feel as though they are being exploited for research production with little acknowledgement of their professional development needs.

I want to start by acknowledging that two of the conceptual frameworks on which this project is based are inherently problematic, and became more difficult to work within the further I moved into data analysis. First, STEM as a way of organizing a specific research domain is not particularly useful and the concept itself is predicated in large part on the potential of STEM fields to generate research dollars for academic institutions and the U.S. economy as a whole. Disciplines within STEM range from bench-based work on microbiomes to field work in environmental engineering, and each of these fields has their own peculiarities and patterns that are not always relevant to understanding career trajectories for trainees

in different STEM fields. The construct of STEM fields as ones that deserve special attention and resources also works to undervalue fields in social sciences, the humanities, and the arts, which should be recognized for their contributions to society and as worthwhile and valuable career paths.

The second problematic construct is that of "URM," or underrepresented minority. This categorization lumps together groups of people who come have distinct background, cultural identities, and experiences and identifies them based on their status as a member of a specific group rather than as individuals. Even within racial and ethnic groups defined by funding agencies like the NIH and NSF assumes commonality of experience where that is not necessarily useful – i.e., grouping together an individual from a Japanese-American cultural background with an individual from an Indian-American one based on their status as Asian-Americans. Additionally, who is underrepresented varies from field to field within STEM disciplines. For example, Asian-Americans are well-represented across STEM fields generally, but within specific subsets of STEM they are underrepresented. When I recruited for this study, I used language calling for postdoc URMs from STEM fields. The postdocs who I interviewed were aware of discrepancies in representation across fields, and self-selected for participation based on the specific environment within their own disciplines. One postdoc who would generally be considered well-represented moved through the education-system as a first-generation student, another from a Chinese-American background is underrepresented in her specific field, and a handful of non-domestic postdocs who we do not "count" as underrepresented but experience academic research as an "out group" all participated in this study and provided invaluable insights.

The postdocs in this study are all inhabiting a unique time and set of circumstances to be undertaking a postdoc and attempting to position themselves to move into faculty roles. All of the postdocs were forced out of their physical space due to the COVID-19 pandemic, stalling many of their research projects and forcing some to move to other methods and projects. Surely some of the alternative projects and approaches had a benefit in rounding out skillsets, but the pandemic made a subset of trainees that are inherently isolated even more so. Some started their postdocs during the pandemic, and at the point of the interview had yet to meet anyone, including their advisor, in person. The circumstantial

and societal impact of COVID-19 on postdoctoral experiences and career aspirations must be factored in when considering the data collected in this project.

Postdocs inhabit a particularly fraught position in the academic research ladder. They have obtained their PhD and commiserate skills, so are able to conduct technically difficult processes, ask more sophisticated questions, and function at a more independent level than graduate students. Yet they are not faculty, and are not granted the same freedom and resources that faculty are. This creates a situation where they are rendered "invisible," language that is used in the literature (National Research Council, 1969; Yadav et al., 2020) and by the postdocs themselves while being interviewed for this study. It is critical that more research be done about how postdocs choose the labs where they complete this stage of their training, and how they are being supported as they transition into labs. Coinciding with the particular vulnerabilities facing postdoc researchers is the ongoing lag in workforce representation of racial and ethnic minorities in the STEM disciplines, along with other ways that current university systems and processes fail to make room for complex identities. As individuals progress through their training and develop into scientists, they do not leave behind their identities, culture, or values. Academic research must acknowledge this and adapt training paradigms so that trainees are able to fully flourish and contribute to move research forward in new and more equitable ways. As one insightful postdoc stated during her interview:

> You know, if we pursue our research as rigorously as we pursue removing barriers to accessing STEM and science education broadly, we're going to do better, right? The reason we're not doing well right now is that we're acting like they're two opposing things, when really, they can work in synergy together.

Description of Research Environment

The postdoc is a particularly "leaky" spot on the academic career trajectory, and if academic research is to retain a diverse workforce throughout academic workforce, then it is critical that we address the issues within the postdoctoral training period and specifically how these issues impact underrepresented scholars and scholars who are otherwise in an "out" group based on different aspects of

their identity. The STEM workforce is persistently underrepresented from racial and ethnic minority groups in the United States; there are differences in representation from discipline to discipline, but overall the groups that are underrepresented include Black or African American, Hispanics or Latinos, American Indians or Alaska Natives, Native Hawaiians, and other Pacific Islanders. Data from national agencies like the National Science Foundation (NSF) and the National Institutes of Health (NIH) can help us understand the environment within which postdocs in academic research are functioning.

As one moves up the ranks in academic research into leadership positions, racial and ethnic underrepresentation increases and there is more disparity by gender. Since 1999, academic doctoral degrees awarded in STEM fields has begun to reach gender parity though is still not equitable. 26.4% of all STEM degrees awarded in 1999 went to women; this increased to 38.5% in 2019 (National Center for Science and Engineering Statistics, 2021). Men also receive tenure at higher rates than women, and white faculty at higher rates than URM or Asian faculty. Finally, as we look at individuals who progress into leadership positions, men are appointed at higher rates at every career juncture. 60% of presidents, provosts, or chancellors with STEM degrees are men, 64% of STEM deans, department chairs, and research faculty are men. Postdocs, the population of interest of this study, have higher gender parity. 57% of all postdocs and adjunct faculty in 2019 were men (2021); this is notable as you can see the proportion of men increases as one progresses into leadership positions.

Though numbers related to gender parity has become more equitable over the years, it is still not representative of the overall population. Increasing representation among racial and ethnic minorities has been an even more stubborn problem. In 1999, 6.4% of all STEM doctoral degrees were awarded to underrepresented minorities. In 2019, that number was 8.9%, and 7.5% of postdocs in 2019 were Hispanic or Latino, and 5.3% were Black or African American (National Center for Science and Engineering Statistics, 2021). This is despite more than a decade of research and training programs designed to increase representation based on race and ethnicity – the solutions that have been implemented to this point are simply not sufficient.

The NIH makes available demographic data for recipients of its grant funding. In addition to the NSF data related to representation in positions or degree conferral, grant funding data is illuminating to understand how individuals are able to acquire resources that are critical to their professional development. Notably, while the NSF collects data that is applicable to science fields across all domains, NIH data is only relevant to researchers working in the biomedical space. As of 2020, career development awards, which provide stable funding to trainees that are not reliant on an advisor's research funding, are awarded to women at a slightly higher rate than men, except for individual postdoctoral awards where it is 50% (Division of Statistical Analysis and Reporting, 2021). NIH research awards, the bread and butter of research funding in biomedical research, were awarded to women at 35% in 2020. This number has creeped up just under a percentage point every year every year since 1998, when it was 23%. Of those research grants that are awarded, the average dollar amount awarded to men is 20% larger than the dollar amount awarded to women. The success rate of funding applications, however, is about the same for men and women, which indicates that fewer women are submitting applications than men. NIH training awards are frequently used to fund PhD and postdoctoral trainees – 36% of the appointees to the awards in 2020 were women. 55% of individual fellowships, awarded directly to PhD and postdoctoral trainees are women (2021). This 55% of awards at the fellowship level makes the 36% of research awards to women PIs an even more illuminating figure that could indicate women leaving research at the transition from postdoc to faculty.

As shown above, the NIH provides numerous data points on gender and grant applications and funding. There is comparably little data provided by race or ethnicity. They do provide a breakdown of Principal Investigator, or PI, by race and ethnicity, which shows that 73% of all NIH research grants are awarded to white PIs, 2.6% to Black or African American PIs, 22% to Asian PIs, 1.5% to those who are more than one race, and less than 1% to American Indian or Alaskan Native and Hawaiian or other Pacific Islander. The numbers for fellowships are a bit higher in every category except Asian (including white PIs). For training grants, grants that are awarded to PIs who are seen as leaders in their field and are generally required to have research grants from the NIH, 85% of these are made to white PIs, 11% to

Asian PIs, 2.3% to Black PIs, and 1.5% to PIs who are more than one race (Native Hawaiian/Pacific Islander and Alaskan/American Indian values were too small to report in the dataset) (Division of Statistical Analysis and Reporting, 2021).

Statement of Problem

All of this data provides a fairly clear picture of the population within given career points, and how the picture changes throughout the academic trajectory. The data indicates that formal leaders at universities, those who are securing the most prestigious research awards, and those assuming leadership roles in training programs are disproportionately white and male. The postdoc, as a training ground for future faculty, is a critical point in professional development and one that is susceptible to attrition with a lack of centralized resources and reporting structures.

The postdoctoral training period is one that is highly individualized, meant to mold a trainee from a graduate student that needs direction to a researcher who can develop their own research questions and begin to form an idea about how they will carve out a "niche" for themselves in the research world. The issue is that without formalized programs or application processes, postdocs slip through the cracks in a number of ways. Some are lucky enough to enter into defined training programs, either through an NIH or NSF training award or institutionally funded, as some in this study did. Their experiences are the exception that proves the rule, and when compared to other trainees it is clear just how important the structured training was to their development. Without it, postdocs frequently are unable to access university resources, knowledge about university processes like benefits or grant applications, a network of peers, and training opportunities outside the parameters of their research. All of this contributes to a training paradigm that emphasizes research to the detriment of other elements of the academic faculty profession. As one interviewee stated: "If I cannot do anything other than research, then I don't want to be here anymore."

Research Questions

The guiding research questions for this study are:

1.   How do postdocs, especially women and those from URM groups, experience the decision-making process around selecting a lab for their postdoctoral training?

2.   How do postdocs think about their relationships with their mentors, and how does mentoring impact career choices and experiences of women and URM postdocs?

Significance

This study addresses a critical gap in the existing research literature. There has been scant research done investigating patterns of attrition and career movement for the postdoctoral stage, and this work seeds to address that with an exploratory investigation and an accounting of current postdoctoral experiences. It contributes to current understandings of career choices, stress points in postdoctoral STEM training, and provides evidence for the necessity of a well-rounded training program and standardized application processes. Many universities have begun to incorporate some of these approaches into their support structures with centralized offices dedicated to postdocs, but more week is needed to ensure equitable access to training and professional development programs.

Overview of Dissertation

This dissertation will provide context for the questions above, and evidence to contribute to the current understanding of career development in STEM, especially as it pertains to scholars from non-majority groups. I will begin with a review of the current literature in chapter two, including foundational work on diversity and equity on college campuses and in STEM disciplines. I will also review literature pertaining to graduate students as well as postdocs and current conceptions about training, career decisions, and mentoring. Chapter three will cover research methods and theoretical design. I will discuss cultural and social capital and reproduction, along with academic capitalism and production and how these concepts are applicable to understanding experiences of the postdoc participants. Chapter three also includes a narrative summary for all sixteen individuals who were interviewed as part of the study. Analysis and discussion of the data will be presented in chapter four, with main themes and key takeaways highlighted. In chapter five I will review these themes, and describe recommendations for future research and policy.

Chapter Two: Literature Review

Diversity, equity, and inclusion (DEI) in Science, Technology, Engineering, and Math (STEM) fields has received a great deal of attention in the world of academic research over the last two decades. Research has shown that undergraduate and graduate STEM degrees are awarded to minority racial and ethnic groups at a lower rate in comparison to their representation in the general population. Degrees awarded to women have begun to keep pace with the population, but that declines the further up one goes in academic roles. Much of this research has been driven in part by mandates from federal funders of STEM research, specifically the National Institutes of Health and the National Science Foundation. In STEM, underrepresented racial and ethnic groups include Black or African American, Hispanics or Latinos/as, American Indians or Alaskan Natives, Native Hawaiian or other Pacific Islander. The research literature in diversity in STEM frequently speaks about these groups as a monolith – "underrepresented minorities" or "URM" – though disparities differ among backgrounds and are discipline-specific. This essentialist approach to discussing all "URM" students can be seen in policy reports that frequently drive research agendas (Basile & Lopez, 2015). This literature review will describe many of these studies, providing a broad overview of the research and then describing as it correlates to the academic trajectory.

Interest Convergence and DEI Research in STEM Programs

Ensuring representation in STEM is critical for a number of reasons that are frequently cited in the research. One frequently cited rationale is to ensure that the United States can keep pace with other countries in research and innovation in terms of both size of workforce and pace of discovery. STEM innovation is an economic engine on a variety of fronts, and recruiting from previously untapped underrepresented minority groups is a way to meet workforce needs to drive discovery; this theme is especially apparent in early research on diversity in STEM undergraduate and graduate programs (Chang et al., 2011; Hurtado et al., 2009). Importantly, this rationale does not center the experiences, aspirations, or potential contributions of minority students, but rather situates diversity as a means of meeting economic goals. This is a similar approach to early research in diversity on undergraduate campuses, where diversity was touted as a way to enhance the educational experience of *all* students (Gurin et al.,

2002), even as that argument may have been made intentionally and strategically to move the conversation forward based on previous Supreme Court cases limiting the scope of affirmative action programs (Garces et al., 2018).

Several scholars have criticized this emphasis on DEI and STEM as an example of interest convergence. This is especially true of the rationale offered in many federal funding agencies that the United States is trending behind other countries in research and development, and increasing representation of racial and ethnic groups is one way to maximize the workforce and, in turn, our rate of innovation. Baber (2015) analyzed campus STEM DEI programs and found that the economic motivation translates to programs that focus on quantifiable outcomes but ignore broader issues of power dynamics, economic justice, and historical context. Basile and Lopez (2015) analyzed 31 policy briefs focusing on K-12 STEM education and found that authors frequently commodified Black students within the framework of white capitalism. The focus on STEM, and even the existence of this category of inquiry, works to devalue humanities, liberal arts, and social sciences disciplines where representation among minority groups and women is higher, and instead emphasizes pursuits that are more easily monetized in today's research environment. These shortcomings in the moral underpinnings for the movement to diversify the STEM workforce all contribute to its ongoing failure to truly disrupt the power and hierarchical structures that dominate these fields.

Recent literature has called for a more equity-driven approach to STEM diversity research, with an emphasis on interrogating power dynamics and cultural hierarchies, rather than a "diversity by the numbers" approach (Baber, 2015; Basile & Lopez, 2015). Equity requires that students and trainees from all backgrounds have tools they need to access lucrative, fulfilling positions in a competitive STEM job market; students and trainees are not served by joining a program that is active in recruiting from diverse backgrounds, but not in supporting them once they arrive (Slay et al., 2019) and giving them support structures needed to transition into the next career stage should they wish to. Of the top 20 professions from 2019-2020, the U.S. Bureau of Labor Statistics shows that all but 2 can be categorized as STEM professions (U.S. Department of Labor, 2021). A focus on retention of women and URM students in

STEM disciplines throughout the academic trajectory is an issue of economic and personal justice that has very real implications in individuals' lives.

The Academic STEM Career Trajectory

The DEI research in academic STEM fields has had a focus on undergraduate, graduate, and faculty populations. These are distinct educational and career stages, with finite start and end points, as well as programmatic structures that lend themselves to analysis. While this dissertation is focused on postdoctoral researchers and the specific impacts that structural and organizational dynamics have on their lived experiences, many of the themes explored in the more robust research centered on graduate students and faculty STEM researchers. While the specific experiences of postdocs are different, the themes in faculty and graduate student research are still relevant to interrogating diversity and equity in the postdoctoral career stage. Doctoral training programs typically house faculty with sufficient research funding to recruit postdocs, so postdocs end up working side-by-side with graduate students and are sometimes closely involved in the students' career development. Additionally, postdocs have all moved through graduate programs and are in theory training to move into faculty positions, so understanding how these touchpoints are conceptualizing, prioritizing, and pursuing DEI initiatives is also important to understanding the overall environment and trajectory within which postdocs have reached their current career stage.

STEM Undergraduate, Pipeline Programs, and Historically Black Colleges and Universities

As research began to reveal the disparities in academic STEM programs, research universities responded in part by establishing "pipeline" programs, programs designed to nurture scientific interest and talent among URM undergraduate and post-baccalaureate students. Many of these programs have experienced a great deal of success in graduating students who go on to enter doctoral programs. Historically Black Colleges and Universities (HBCUs) are also major contributors to the STEM workforce and provide training experiences that differ from those provided in large research universities, but have important similarities to many pipeline programs. As HBCUs and pipeline programs are such critical elements of STEM training for URM students, an analysis of these programs can provide a framework to compare

against more typical research university environments and can also contribute to the discussion of the postdoctoral application, hiring, and research climate.

The earliest research into STEM undergraduate programs found them to be plagued by racial climate issues that had a detrimental impact on URM trainees' adjustment and sense of belonging, a finding that has implications for development of science identity during a critical developmental point in their academic trajectory (Gurin et al., 2002; Hurtado et al., 2007). Participation in undergraduate research programs may keep students engaged in STEM majors that can be unwelcoming when they first enter them, as well as increase the likelihood of matriculating into STEM graduate programs (Eagan et al., 2013; Hurtado et al., 2008). Early STEM courses are known to be competitive with a large number of students, may be graded on a curve, value memorization, and in general are not ideal for the development of critical thinking skills (Hurtado et al., 2008). Involvement in scientific research can serve as an antidote to these classroom and racial climate pressures for URM undergraduate students by establishing a network of peers, labmates, and faculty. Research has also shown greater persistence among undergraduate STEM majors who had access to resources like study groups and student organizations, and the benefit is greater when it is structured, with a defined cohort, set meeting times, and stated goals, etc. (Chang et al., 2014). Pipeline programs provide these structured opportunities within the context of an R1 university, allowing URM students the space to learn the "hidden curriculum" of academic research while in a supportive environment.

One of the most successful pipeline programs is the Meyerhoff Scholars Program at the University of Maryland, Baltimore County. Success in this case, as defined by the program, is measured by the number of program graduates who go on to both enter *and* complete a STEM PhD program (Maton et al., 2016). The program provides advising, academic and social support, and knowledge/skill development through coursework requirements. Students are offered a spot in the program upon matriculation to the University of Maryland, and when compared to students who declined a spot, those who enrolled in the Meyerhoff Scholars Program were 5 times as likely to go on to complete a PhD program. One of the guiding principles in the Meyerhoff program is collaboration and the development of

strong peer groups; this is a contrast to ultra-competitive STEM undergrad programs at highly selective institutions, where competition is the norm.

Historically Black Colleges and Universities (HBCUs) have training programs that have likewise contributed to the STEM workforce. From 2000-2010, 40% of all Black or African-American STEM baccalaureate degree holders were HBCU graduates (Owens et al., 2012), and in 2015 HBCUs made up more than half of the top ten institutions producing URM STEM baccalaureate degree holders in the biological sciences, engineering, mathematics and statistics, and physical sciences (Adams et al., 2017). The environment at HBCUs almost certainly contributes to these graduation numbers. In one study, Black or African American students at HBCUs reported higher levels of tutoring other students, completing homework on time, and feeling engaged in class (Outcalt & Skewes-Cox, 2002). Another study finds that HBCUs institutionalize collaborative approaches that enhance student success, including small class sizes, the physical accessibility of faculty offices, a normalized culture of peer support and community, and faculty who believe and are invested in their students' attainment of their goals in STEM fields (Perna et al., 2009). HBCUs face different pressures than R1 institutions as their funding is frequently tied up in state budgets. Research is a resource heavy enterprise, and seeking alternate funding sources may be a way to compete with R1 institutions while developing "legitimacy" in STEM fields (Nguyen et al., 2019). We can expect then that students from HBCUs would be positively judged in the admission review process as it currently stands by attending a school that was able to secure additional external capital. HBCUs and undergraduate research programs are grounded in theories of student success and student involvement that posit that when students are involved they become more invested in their environment and so are more likely to succeed (Astin, 1985). This framework has implications for understanding postdoctoral attrition in an environment where postdoctoral trainees are decentralized, disconnected from each other and not often provided resources, protection, or guidance in comparison to every other category of STEM trainee or researcher, including undergraduate students, graduate students, and faculty.

Graduate Recruitment and Environment

The academic STEM training and career trajectory includes several transition points that are vulnerable to attrition of URM scientists. This includes transitions into undergraduate programs, graduate programs, postdoctoral training, faculty roles, and finally into faculty promotions and leadership positions. There is very little research documenting the process by which postdocs enter into postdoctoral roles and how that might impact training experiences and/or be influenced by different aspects around identity, including gender, race, and scientific identity. I was unable to find a single study documenting the postdoctoral search and hiring process in a cohesive way, so this review includes an analysis of literature focusing on both the graduate and faculty transition process, and the impact of each on the experiences of URM scientists. An analysis of the transition into graduate and faculty roles is beneficial to understanding the postdoctoral transition point due to the postdoc positioning on the academic trajectory as not quite students and not quite faculty. Understanding these processes also serves as a counterpoint to the postdoc transition as both are discrete, institutionalized, and well-documented.

Factors Contributing to Transition into Graduate Programs

Research into graduate application processes, trends, and admission standards has increased over the last 15 or so years, with a great deal of attention paid on factors that motivate URM applicants and admitted students to seek out and attend specific schools, and how faculty perceive their applications. Any number of individual priorities can factor into a prospective graduate students' decision to apply to or attend a specific institution, including residency, academic reputation, and work/life considerations (Kallio, 1995). For students from URM backgrounds, additional considerations may come into play. Research universities in states with affirmative action bans in admissions policies have experienced a decrease in the number of minority student applicants in years immediately preceding these bans, indicating that political mores and both campus and regional climate may be factors in application decisions (Garces, 2012). Science identity is another important element in the decision to apply to graduate school in STEM – that is, do students see themselves as scientists, feel confident in their scientific skills and ability, and, importantly, feel as though they are perceived as scientists by their

colleagues (Carlone & Johnson, 2007; Chang et al., 2011; Merolla & Serpe, 2013)? Stereotype threat is a consistent factor in URM students leaving STEM majors in selective institutions, and is an especially detrimental force for students attending highly-selective institutions (Beasley & Fischer, 2012; Chang et al., 2011). Undergraduate research opportunities are important for all science-inclined students, but especially critical for women and URM students in developing science identity and building a network, and as a tool for building resilience to counter stereotype threat. In fact, this element of undergraduate STEM education has been frequently shown to be a strong predictor for students who move into graduate programs (Hurtado et al., 2009; Melanie et al., 2010). Exposure to the academic research environment and the ability to build positive mentoring relationships has served as a pathway for URM students to move through barriers and enter into graduate programs.

Graduate Admission Process and Impact on Student Experience

The graduate admissions process is emblematic of how academic STEM research functions in a systematic yet idiosyncratic way. The decision process is typically committee-based, but varies from institution to institution, as do the application and admission requirements. In a qualitative study, Posselt et al. (2014) sought to describe some of these admissions processes at different universities across the country. Though the sample was multi-disciplinary, the study identified several common themes, including a process whereby faculty committees first apply an initial "cut" to candidate pools based on GRE scores and undergraduate institutions. After this first triaging of applications, diversity and equity comes into play in evaluating application materials. This represents a significant barrier and an institutionalized introduction of bias and assumption into the admissions process.

The application, interview, and admissions process represents the first interaction that students have with a training program, and they all have an impact on how students perceive the climate of a graduate program when they arrive. Two case studies by Posselt (2017) and Slay (2019) describe two graduate programs that have higher than average enrollment and graduation numbers for URM students in their respective disciplines. The two programs approach diversity, equity, and inclusion in fundamentally different ways; by comparing the experiences described by interviewees in these distinct programs, we

can see how approaches and policies advanced by training programs have an impact on student experiences and, potentially, career choices.

The first case study centers on an applied physics PhD program at the University of Michigan in the wake of a state ban on affirmative action policies in admissions decisions (Posselt et al., 2017). The "applied" aspect of the training program here is important, as it fundamentally shifts the way that research questions are asked, how projects are designed, and who "fits the mold" of a potential graduate student. The program additionally disrupted traditional power structures by enlisting its administrative staff to maintain close communication with students, particularly those from underrepresented backgrounds, and to ensure faculty leaders were aware of student needs and issues. This reflects leadership values that prioritize student experience and a willingness to listen to recommendations that may challenge their belief system.

The second case study describes a more traditional program at an elite institution (Slay et al., 2019). Similar to the first case study, this project collected data from students, faculty, staff and alumni within a psychology department that also graduated a high number of URM doctoral students. The study found widely variable perceptions between faculty and student interviewees about the campus climate, specifically as it related to initiatives around diversity, equity, and inclusion. The data reflected that while there was a top-down emphasis on DEI in recruitment, the environment that students found upon arrival did not value these initiatives as advertised. Student participants communicated this mismatch through anecdotes about faculty who were ill-equipped to mentor students from different backgrounds and peers who perceived URM students as "taking a spot" from a "more-deserving" student. Additionally, while the first study's interview data reflected a generally consistent perception of climate between faculty, student, and staff interviews, the data in the second study revealed that faculty and students had different ideas about the climate. A mismatch between faculty ideas about what students prioritize and what students actually prioritized has been documented in the literature and is consistent with admissions processes that result in students arriving at an institution with a climate that is not "as advertised" (Bersola et al., 2014).

This discrepancy upon arrival works as a disruption during a critical transition to graduate school that is already challenging.

A fixed vs. growth mindset theoretical approach can shed light on admissions processes that impact URM applicants in STEM graduate programs, with a "fixed" mindset that values "brilliance" and traditional markers of success (i.e., GPA, GRE, undergraduate institution), whereas a "growth" mindset assigns value to acquired knowledge, effort, resiliency, etc. (Scherr et al., 2017). Applied to these two case studies, we see the downstream impact on student experiences from admissions committees applying a fixed mindset (the psychology department) and a growth mindset (the applied physics department), and its implications for retention in STEM research and the environment necessary to continue development as a scientist. In the case of the applied physics program, the leadership fundamentally reconsidered what attributes made a "strong" scientist, and took seriously a holistic review of applicant materials. The program confronted the reality that their field was dominated by white males, and so rethought what the field should and could look like to attract burgeoning scientists from different backgrounds. The focus on the "applied" side of the field is notable as studies have shown that underrepresented scientists are more likely to pursue topics related to practical application rather than theoretical or bench approaches (Hoppe et al., 2019). The psychology program serves as a contrast to this deep programmatic shift – their program pursued more superficial approaches like appointing a faculty sub-committee to review all URM applications, revamping the website to highlight DEI initiatives and policies, creating a new curricular initiative, organizing a student-led organization for URM students, and hiring new staff members who value and support diversity issues. These are all significant and well-intentioned initiatives; even so, the interview data from this program reflect that students arrived at the program expecting an inclusive environment but instead found a space where diversity, and specifically race, were not discussed, students from URM backgrounds were resented because of their admission by fellow students, and faculty mentors were ill-equipped to serve as mentors. The program still functioned using a set of "meritorious" admission standards rather than challenging common ideas about what a scientist looked like, and the programmatic environment followed suit.

These two programs show different approaches to incorporating DEI initiatives into graduate admissions processes, and how these impact training experiences. The impact is felt especially by URM students, and the resulting culture has a major impact on retention. As programs assess their own efforts, it is important for program leadership to question their foundational assumptions about what the science pipeline looks like, who is generating the questions, how those questions are being asked, and how they wish to define success. At the graduate level, these all can have a significant impact on student transition to a postdoc position.

Historical Development of the Postdoctoral Scholar Role

Bookended by graduate programs and faculty, postdoctoral scholars (colloquially and in this dissertation referred to as "postdocs") exist in an in-between stage of the academic trajectory that is not quite trainee, but not quite independent scientist. The National Postdoctoral Association (NPA) defines a postdoc as "an individual holding a doctoral degree who is engaged in a temporary period of mentored research and/or scholarly training for the purpose of acquiring the professional skills needed to pursue a career path of his or her choosing" (National Postdoctoral Association, n.d.). The historical impetus for the position was to provide training for scientists who have acquired a set of specialized scientific skills through graduate study, and impart on them the skills necessary for pursuing a research agenda of their own. This is commonly referred to as "independence," and includes skills like acquiring research funding, building a lab, and developing research questions. Many postdoctoral trainees are able to hone these skills, but the reality is that postdoctoral training in R1 institutions is decentralized and unstructured, so training experiences are highly individualized and dependent on the mentoring they receive and/or their faculty advisor.

Postdoctoral training in academic STEM fields at US research institutions was first introduced in the 1870's at Johns Hopkins University where the training period largely functioned in an apprenticeship model – recent PhDs would work closely with a faculty advisor in their field to develop the skills needed to move into faculty positions (Cantwell & Taylor, 2015; Zumeta, 1985). The purpose of the role as a training vehicle for future independent researchers was explicit. Since that time, the position and number

of postdocs in research universities has reflected research trends in the institutions themselves. The National Research Council was created in 1916 as a subset of the National Academies of Science (NAS) in response to research and development needs brought about by the onset of World War I. The NAS then partnered with private foundations to fund research fellowship positions – a precursor to the modern postdoc (National Research Council, 1969). After World War II, research became even more intrinsic to the mission of universities, especially research funded by the federal government. Research began to grow exponentially in the second half of the 1900's, and with it the number of postdoctoral trainees carrying out this research. Numerous studies have documented the massive increases in postdoctoral researchers at universities from the 1950's through to the 2000's, though this population is admittedly difficult to track due to the decentralized and individualized nature of the postdoc (Bernard, 1962; Cantwell & Taylor, 2015; Geiger, 2017; Institute of Medicine, 2000).

With the increased flow of research dollars and the corresponding increase in number of postdocs, the characteristics of the postdoc experience also shifted. In the time period since World War II, there have been a handful of large studies that have interrogated these trends and experiences through quantitative and mixed methods approaches. The first of these was done in 1962 by Dr. Berelson Bernard (1962), with a goal to make an approximate estimate as to the number of postdocs at American Association of Universities institutions and to further describe different employment trends. An important trend he found at this time was that approximately 1/3 of all postdocs were foreign nationals – this trend will continue through current times and tells an important story about DEI in academic research, both in terms of who is being brought in to do the research, who is not, and how those who are brought in are assigned work and treated.

In 1969, the National Research Council published its report "The Invisible University: Postdoctoral Education in the United States" (1969). The title of this report illustrates the vulnerability inherent in the postdoc position, a condition that is still documented in research universities today. Through questionnaires and interviews, the NRC heard back from approximately 10,000 of an estimated 16,000 postdocs to assess number of postdocs, employment arrangements, pay, citizenship, and

motivations to pursue scientific research. Demographics of the postdoctoral population were reported in terms of discipline, gender, seniority, and institution. The data showed that postdocs were training at elite institutions disproportionately, with 80% of postdocs at only 25% of institutions with respondents – this likely maps onto research dollars flowing into elite institutions at higher rates. There was no mention of race and ethnicity, and minimal discussion of women except as to how the postdoctoral experience relates to married life:

> For married women, the postdoctoral position is an ideal one for working in their fields either while waiting for their husbands to finish graduate work or because their husbands are on the faculty and the nepotism rules do not permit them both to have a regular appointment. (National Research Council, 1969, p. 70)

The report does include an extensive discussion of the role of non-citizen postdoctoral researchers, and the data confirmed the trend described by Bernard (1962) of high numbers of non-citizen postdocs in research universities.

In 1984 and 1985, Dr. William Zumeta analyzed postdoctoral trends that showed an increase in numbers in the 1970's (Zumeta, 1984; Zumeta, 1985). Dr. Zumeta went further than these other reports, not just linking the growth in numbers to a growth in research dollars, but also identifying a decrease in postdocs who move on to faculty careers. Zumeta cites an increase in "reluctant postdocs," postdocs who were unable to secure employment elsewhere and so moved into this role due to market conditions; he also hypothesized that this has led to a decrease in "quality" of postdocs, with quality measured against the reputation of their PhD institution – a quality measure that also comes into play in graduate and postdoctoral admission processes and faculty hiring, and is shown to be inherently biased in discriminating against underrepresented groups (Posselt et al., 2012). Finally, Zumeta pinpoints a shift of postdoc funding moving from fellowships to research project sources in the 1970's, an important indicator of the shifting nature of the training mechanism. Instead of receiving funding for individual fellowships, postdocs had begun to receive salary support paid from their faculty advisor's research projects. This funding trend creates tension in balancing the postdoc's freedom to develop independent

research ideas and pursue professional development opportunities while being paid from funds tied to specific data production goals.

The most recent study into postdoctoral employment conditions and the workforce was completed by Sigma Xi, The Scientific Research Society, via a survey that was distributed to some 7,500 postdoctoral scholars throughout the country (Davis, 2005). Again the publication cited the difficulty of even getting the survey *to* postdocs because of the "diffuse" nature of postdocs both within and between institutions (Davis, 2005, p. 2). This theme is a fundamental problem that comes up again and again not just in studying the conditions of postdoctoral training, but in deploying resources meant to support them at the institutional level. Major findings of the survey included, for the first time in a nationwide study like this, those related to underrepresentation of minority scientists in the role. The findings also doubled down on Zumeta's identification of funding as a major contributor to the postdoc experience, with the commonly cited problem that postdocs can easily become just another "pair of skilled hands" in the lab (Davis, 2005, p. 11). The overview ends with a recommendation for the design of postdoctoral programs to more closely resemble graduate training – i.e., cohort-based, structured programs.

Entry into postdoctoral roles

The graduate student to postdoc transition is critical point in the STEM pipeline that is consistently leaky for URM and women PhDs. Studies have called into focus the importance of retaining URM graduate students in academic STEM research as they transition to their next career stage. A postdoc has become a requisite for obtaining a faculty position, and numbers of women and URM faculty are much lower than that at the graduate student and postdoc stage. One study showed that graduate students in the biomedical sciences make career decisions based primarily on their personal values and how well they align with specific opportunities (i.e., work/life balance, the mission of the institution or field, etc.), as well as "structural dynamics of the biomedical academic workforce" (Gibbs & Griffin, 2013, p. 720). Additionally, URM and women graduate students in the biomedical sciences lose interest in pursuing academic careers at completion of their PhD program at greater rates than their white male counterparts (Gibbs et al., 2014). These two studies may reveal that upon the point where PhD students

transition into the next step for pursuing a faculty position, more URM and women may be deciding that this career trajectory does not align with their values and is too difficult to pursue based on structural difficulties like saturation of PhDs on the academic career market, the ease of obtaining grant funding, etc.

Characteristics of the Postdoctoral Workforce and Global Academic Market Forces

Some graduate students enter into postdoctoral training without any intention of moving into faculty positions – they instead are essentially buying time until they make a decision about what comes next and/or finish up work related to their graduate training. This trend, for postdocs to enter into their roles as a stopgap until they determine what comes next, is a contributing factor to the enormous numbers of postdocs in the United States in STEM disciplines over the last 30 years. From 1973-2015, those working in academic fields who had a STEM PhD tripled, while those with a STEM PhD who had full-time faculty positions doubled. Additionally, the number of non-faculty PhDs in academic STEM research increased by 700% (National Science Foundation & National Science Board, 2018). This reveals that as faculty jobs decreased, the numbers of postdocs or contingent research faculty increased.

There are various causal factors leading to the disproportionate number of faculty positions in comparison to the flood of postdoc researchers working at R1 universities. Money is a major factor in the equation – as grant funds for research institutes increase, the pressure to hire specialized scientists also increases. Postdocs are relatively cheap labor and yet are highly skilled – PIs are not saddled with tuition expenses as they are with graduate students, and they are hiring individuals into the lab who they can be confident are able to do the work and produce quality data. On the institutional side, universities are able to access scientists with more flexible work terms than those that accompany tenured faculty positions. Postdocs typically work on a year-to-year contract basis, so they can simply be let go when and if the research funding runs out. The movement of universities towards "academic capitalism" and neoliberalism has been well documented as the institutions trend from a focus on knowledge production as a public good to production of technology and research products as profit generators (Slaughter, 2004).

This has led not only to the increase in postdoctoral researchers as a means of producing these products, but also to the presence of the university in global labor and technology marketplaces.

With the focus on profits and the increased globalization of universities, there has also been a considerable increase in the representation of non-citizens among postdocs. One study showed that from 1979 to 2008, the proportion of U.S. postdocs that were U.S. citizens went from 73% to 48% (Ghaffarzadegan et al., 2014), even as the representation of U.S. minority groups in STEM postdoc positions lagged behind the greater population. This is partly due to the degree to which countries in Europe and Asia are producing doctorates in STEM fields, and many of these scientists do end up returning to their home countries after completing their postdoctoral training in the U.S. Another study found that an increase in research and development costs at public universities was a significant predictor of an increase in international postdoc employment (Cantwell & Taylor, 2013). In effect, public universities that have research budgets largely funded through government agencies like the NIH and NSF are spending these budgets on the international labor market rather than investing in developing the domestic workforce. Funding agencies have attempted to address this exploitative trend through capping the number of years that a postdoc can serve in that role on federally funded research; Ghaffarzadegan et al. (2014) found in their modeling study that policies emphasizing capping postdoctoral training term limits and those impacting faculty hiring were not as effective in increasing U.S. postdocs as focusing policy efforts at K-graduate STEM training. Academic research and production of research output has been likened to a "pyramid scheme," whereby those on the "bottom" of the lab who produce the most data make up the bottom of the pyramid with the chances of moving to the next stage decreasing at each step of the ladder (Cantwell, 2015).

Non-citizen postdocs are vulnerable to an uncertain employment status – even more so than their citizen counterparts are. As international employees on temporary visas, their ability to stay in the country is entirely dependent on their employment relationship with the university. With the rise of project-based work and a lack of cohort style, institutionally-sponsored postdoctoral programs, this leaves the faculty advisor as the sole decider about whether their non-citizen postdocs will continue to have valid temporary

visas to remain in the United States. This is a great deal of power that is granted to the PIs, and leaves international postdocs in positions of being easily exploitable.

With PIs making individual determinations on who they bring into the lab with relatively little oversight, their own cultural assumptions come into play. Cantwell and Lee (2010) found that some PIs have reported a preference for hiring international postdocs over domestic, claiming that international postdocs have a stronger work ethic. At the same time, international postdocs report lab dynamics whereby the host culture is held up as superior, leading to feelings of isolation. Themes familiar to those found in studies on graduate admission processes also appear here, with PIs tending to recruit exclusively from countries that have a reputation of a being a major player in scientific research, even as those outside of the culture were recruited to produce data and publications. (Cantwell & Lee, 2010). Racism also plays out in other familiar ways in the context of globalization – in this same Cantwell and Lee study (2010), they found that PIs were making decisions about lab assignments – i.e., who gets assigned to specific tasks, who gets autonomy over research project development versus who gets more task-based, technical assignments – based in part on assumptions about scientific skillsets determined by national identity. For example, postdocs from China reported that they were assigned to more task-based work, while their counterparts from European countries were given freedom to contribute to the development of research ideas and project direction. This difference may play a major role in satisfaction with their postdoctoral training as postdocs have reported autonomy as a major contributor to satisfaction in the lab (Miller & Feldman, 2015). Little research exists about how assignments in the lab may play out among U.S.-born postdocs from different backgrounds, but it is perhaps safe to assume that these implicit biases are playing out in that context as well and very likely impact the decision to go on to pursue an academic career.

Postdoc Employment Conditions

Vulnerability in the postdoctoral role is not exclusive to those who are working on temporary visas. As postdocs are typically hired on annual, renewable contracts, the role is subject to termination based on grant funding. Since most other academic programs and employment relationships are considered "at-will" or contingent on satisfactory progress, there are typically safeguards in place should

these relationships be terminated that are housed within Human Resources or Student Affairs processes. Before terminating an employee for cause or laying employees off due to financial factors, for example, there are procedures and policies that need to be followed that are meant to ensure equitable treatment (and to protect the institution). For students who may be asked to leave a program due to unsatisfactory progress or academic dishonesty, there are similar processes. For postdocs, there are no such protections. Postdocs come and go because of the transient, project-based nature of the work without any real institutionalized recognition, in a way that is distinctly different from when students, faculty, or employees enter into or leave the institution. Research literature, institutions, and national and local postdoctoral associations have begun to recognize this disparity, and since 2013 there have been more centralized offices for postdocs formed at large universities as well as an increase in institutional policies related to postdocs, offices for international postdocs, and offices focusing on diversity, equity, and inclusion for postdocs (National Postdoctoral Association, 2021). This is not universal, however, and the purview of the offices is limited by the continued decentralized nature of postdoc hiring and appointments – the consistent barrier of identifying who postdocs are, and what lab they are working in makes awareness of and access to resources and policies an ongoing problem.

Collective action by graduate students and postdocs to obtain fair employment conditions has also become more prevalent in the last 10 years. While many graduate student programs at public universities have been organized since the student movements of the 1960's and 1970's, graduate programs at private institutions and postdocs have been slower to organize and be granted collective bargaining status by the National Labor Relations Board. In recent years, however, there has been a trend among these two groups towards unionization. Camacho and Rhoads (2015) documented the collective action campaign for postdocs in the University of California system as they worked to obtain representation from the United Automobile Workers of America organization. One of the most important themes contributing to this movement was the unchecked power yielded by the PIs. This power dynamic existed even after being granted bargaining status:

Your mentor will mentor you to the degree he feels like it….We now have the Individual

Development Plan [collective bargaining article] that we can insist on but PIs are senior in rank

and it's hard to teach an old dog new tricks. If the PI feels that you're not a priority, then there is

no way that you're going to convince him that it's his job to mentor you….The power dynamics

are not there in that regard. (Camacho & Rhoads, 2015, p. 309)

The power dynamics in a lab can be extremely hierarchical, and when those are unchecked by

institutional processes and norms, experiences may be dictated by the whims and characteristics of the PI.

This is a common theme in the literature in STEM training. Institutional norms in admissions and

classroom dynamics can have a meaningful impact on setting parameters and expectations around PI

behaviors in a way that contributes to the experience of the student or trainee. When the institutional

priority is research funding, this leads to PIs who are expected to generate research dollars as a criteria for

achieving promotion and/or tenure. The pressure is easily passed on to their lab members. Other reports

have documented the training environment and employment conditions that have led to the movement for

bargaining status, including inequitable salary and benefits package as compared to other university

employment statuses, difficulty of balancing lab expectations and family life, social isolation, and the lack

of standardized training expectations (Institute of Medicine, 2014). For URM trainees, these difficulties

may be mapped onto feelings of tokenism, lack of individual and institutional support, and experiences of

further isolation and/or microaggressions (Yadav et al., 2020).

Postdoctoral Hiring and Training Experience Characteristics

As described throughout this section, postdoctoral training is typically a highly individual

experience – postdocs identify PIs that they would like to work with based on research interests and

rounding out skillsets to make themselves marketable for their next career step. The hiring process varies

among STEM disciplines, but in most lab-based research programs it is individualized with prospective

postdocs reaching out to PIs via email, and then going through the interview and hiring process in a

decentralized, highly variable manner. This individualized approach continues into the training, where an

individual PI can have a disproportionate impact on the postdoctoral training experience. There are,

however, different models of postdoctoral training that have shown to be more successful in retention of postdocs in faculty careers, particularly for URM trainees.

The FIRST program is based at Emory University and has partnerships with several Atlanta-area HBCUs, including Clark Atlanta University, Spelman College, Morehouse College, and Morehouse School of Medicine. The program includes a formal application process, research and professional development mentors, a cohort-based curriculum, a teaching mentor, and a teaching assignment. The program attracts a higher rate of URM postdocs and women than are represented in the overall postdoc population, and the trainees go on to publish and move into faculty careers at high rates (Brommer & Eisen, 2006). The study by Brommer and Eisen (2006) includes qualitative feedback from past program participants, all of whom lauded the cohort model as well as the value derived from training in teaching methods. Another study described a similar program that showed that their postdocs' research productivity was not negatively impacted by participating in teacher training, and also had postdocs who went on to obtain faculty positions at three times the national average (Rybarczyk et al., 2011; Rybarczyk et al., 2016). This research is compelling evidence when combined with the experiences recounted by HBCU students and pipeline participants – even at the postdoctoral level, community, values, and a mission-driven program is necessary for retaining both URM academic scientists and early career scientists who are compelled to contribute to diversity and equity efforts.

These programs are not the norm and are both only possible because of federal funding – the postdoc's salary is covered by a grant, so their PI is essentially obligated to ensure that they have time available to participate in professional development opportunities. One quantitative study found that postdocs who did not interact with their PI at least once a week and/or did not have autonomy in shaping their own research project were highly predictive of dissatisfaction with the training experience (Miller & Feldman, 2015). From these findings we may be able to construe that those who participate in a fellowship program and have their own funding are more satisfied than those who are funded by a PI's research grant, as they will have more of a say in the shaping of their project. There also may be a story here about stage of career of the PI and how this may or may not contribute to postdoc satisfaction; I was

unable to find published research about this, but more established and successful PIs may be less available to postdocs to meet due to competing professional obligations, whereas a more junior PI would theoretically have more time available to serve as a mentor. The other side of this, though, is that a more junior PI may be focused on achieving tenure and building a reputation, and so may apply pressure on a postdoc to produce data to the detriment of her professional development in other areas.

Postdoctoral Transition to Faculty Roles

The transition from postdoctoral scholar into faculty positions is especially important in retaining URM scientists in academic research, with some indications that focusing on this transition point is the most effective approach for moving towards more equitable representation in academic STEM research (Gibbs et al., 2016). There are numerous barriers to moving into faculty positions that are present, including postdoctoral training conditions, the rise of contingent academic labor, the search for faculty positions, and perceptions about faculty job satisfaction. Retaining URM researchers in academia, particularly in highly visible faculty positions, is incredibly important to addressing retention throughout the STEM pipeline. For STEM trainees, being able to see their background represented in faculty role models is critical to retention.

The specific characteristics of postdoctoral training conditions discussed above contribute to postdocs leaving the academic workforce. Substantial disparities in self-efficacy, perceptions of mentoring for postdocs, and outcome expectations drive a disproportionate number of URM and female postdocs to leave academia during the postdoc period (Lambert et al., 2020). One model shows that stress, and specifically a high-effort, low-reward imbalance leads to female postdocs leaving the workforce much more frequently than their male counterparts (Dorenkamp & Weiß, 2018). During postdoctoral training, exposure to career paths outside of academia, including policy, government research, and industry become more attractive, particularly as these roles frequently offer better work-life balance and compensation along with a more applied approach to research (Gibbs et al., 2015). As described above, the number of URM postdocs transitioning into faculty roles can be positively impacted by cohort-based

training models that prioritize values, community, and teaching (Brommer & Eisen, 2006; Rybarczyk et al., 2016).

In addition to conditions of the postdoctoral training experience, the rise of contingent academic roles negatively impact postdocs hoping to transition into faculty positions. A contingent faculty position is an employment category where the university has not made a formal long-term commitment to the contingent faculty; appointments can be part-time and are usually on a year-to-year basis. Contingent faculty are not eligible for tenure, are typically not included in university governance structures, and are offered a different, less competitive compensation and set of benefits (American Association of University Professors, n.d.). More than half of faculty positions are categorized as contingent; this increase has coincided with the increase in postdoc researchers and a global, neoliberal research paradigm at large universities. When postdocs reach the limit of their postdoctoral training period, many end up transitioning into these contingent research faculty roles. In fact, with the increase of collaborative science between universities and private companies, faculty may have a specific financial interest in retaining postdoc scientists who already "know the ropes" and can continue to serve on collaborative teams (Lam & de Campos, 2015). Moving into a contingent faculty role enables many of the same vulnerabilities described above to continue, while also removing any expectation of mentoring and career development opportunity. Additionally, for the many postdocs who move into these roles if they are unsuccessful in obtaining a competitive faculty position, their time in a contingent position can work against them if they re-enter the faculty job market.

Finally, perceptions about faculty job conditions may contribute to a lack of interest in transitioning from postdoc to faculty. One study found that overall racial climate of a campus, the promotion and tenure process, and level of autonomy are key to retaining faculty of color and women faculty (Jayakumar et al., 2009). African American faculty in particular have reported barriers related to lack of mentors, lack of protected research time, difficulty of obtaining funding, and lack of grant support (Belgrave et al., 2019). In addition, structural inequities in grant review processes at federal funding agencies have been revealed based on research topics, with those topics that are more likely to be pursued

by URM scientists receiving lower priority scores (Hoppe et al., 2019). Additionally, the typical timing of a postdoc research position – mid-to-late-20's to early-30's – coincides with a point in life when many young adults are thinking about starting a family. R1 academic careers have a reputation for being difficult to balance with raising a family, and indeed research has found that postdocs who are married with children are less likely to transition to a PI role than their counterparts without children. Within the group of postdocs who are married with children, the women were shown to be even less likely than the men to pursue a PI position (Martinez et al., 2007). Gibbs et al. (2016) have called for universities to intentionally make work environments attractive and supportive in terms of mentoring, grant support, and protected research time if we are to increase the number of URM and women postdocs who are retained in faculty research positions.

Summary

The literature included in this review describes academic STEM research and its decades-long quest for improving diversity, equity, and inclusion. Some of these approaches are band-aids without the required foundational shifts in perceptions of what scientists look like and how research should be approached. Graduate programs admissions processes and training programs are included in the analysis as their structures have been shown to directly impact the student experience and retention. In light of this, it is clear that a more in-depth understanding of how the postdoc job market functions from a process perspective is necessary to better understand how to retain URM postdocs in academic STEM research and to increase the number who ultimately transition into faculty positions within universities that are more equitable and humane in their treatment of scientists from URM backgrounds.

Chapter Three: Research Methods

This chapter will explain approaches used to conduct exploratory, qualitative research to understand how 16 current postdocs from a variety of backgrounds made the transition from graduate student to postdoc. Previous studies have collected quantitative data as a means of identifying patterns in decision-making about career choices, but few have explored in depth this critical transition point and how postdocs make sense of their experiences as they move through the postdoctoral career stage. I additionally sought to understand how postdocs explain their own role within a university, and their relationship to that university and colleagues both within their lab and in other facets of the university. By nature, the postdoctoral experience is highly individualized and specifically designed for the trainee; as such, a semi-structured interview process seemed the most appropriate for this study to enable the participants to tell their own individual stories in a way that made sense to them. My questions were guideposts, but the narratives and understandings varied greatly from individual to individual in a way that required a flexible interview style. The theoretical framework and tools of analysis became apparent as I collected and worked through the interview data.

Purpose of Study

The purpose of this study is to supplement existing literature about postdoctoral hiring practices and mentoring support structures within institutions using narrative accounts from postdocs themselves. It provides an opportunity to hear directly from postdocs, and accounts for experiences within these specifically defined domains of hiring, lab selection, mentoring, and how postdocs might see these domains overlapping and impacting each other. The study also interrogates the role that the current regime of extramural research funding plays in career trajectory and decision-making processes for postdocs in career transition points.

Research Questions

The guiding research questions for this study are:

1. How do postdocs, especially women and those from URM groups, experience the decision-making process around selecting a lab for their postdoctoral training?

2. How do postdocs think about their relationships with their mentors, and how does mentoring impact career choices and experiences of women and URM postdocs?

Research Methods

In this study, I used a narrative inquiry approach to elicit individual experiences and interpretations of relationships, processes, and environments. Narrative inquiry lends itself to educational research, including in the world of higher education and academia and especially for postdocs as their experiences are highly tailored and usually exclusive to them. Connelly and Clandinin (1990) define narrative inquiry as "the study of the ways humans experience the world" (p. 2). They further describe the term as relating both to the phenomena of study (i.e., the story) as well as the method by which that phenomenon is studied (i.e., narrative inquiry). Interviews are an especially useful tool for narrative inquiry for studies that have "strong temporal dimensions" (Beal, 2013, p. 1) but are still analyzed as a whole. This concept is relevant to the current study, which was conducted in the context of two important, temporally defined phenomena: 1) the postdoc is, by definition, a set period of transition between obtaining the PhD and moving on to an independent investigator role, and 2) the interviews were conducted in January-March of 2021, in the midst of the COVID-19 pandemic. They provide a snapshot of postdoctoral experience during a defined time of intense change that required adaptation and flexibility. Aspects of each of these contexts can be found in the specific stories as recounted by the participant postdocs, while also coloring the holistic understanding of each interview.

Data Collection Procedures

My intention when I began this project was to record and make meaning of narratives of postdocs who are in STEM research labs at higher education institutions, and was particularly interested in the impact of identity on transition points as experienced by URM and women postdocs. The narrative approach was selected to allow for postdocs to provide individual interpretations of their experience of the transition to the postdoc, how they moved through their decision process, how their identities impacted that decision process, and how they interacted with mentors in making this decision. The study utilized a recruitment email, selection survey, and interviews as data collection instruments.

Research Sites and Participant Selection

Scientific research at universities requires a great deal of resources, therefore postdocs are largely employed at large, R1 universities. I started with a list of all R1 universities as defined by The Carnegie Classification of Institutions of Higher Education (Carnegie Commission on Higher Education, 2018). This classification in a given year is based on the number of doctoral degrees granted at each institution, combined with the total research expenditures. The list yielded a total of 131 universities within the United States.

From this list, I attempted to reach out to all institutions who had a listed office for postdoctoral affairs or a named administrator who oversaw postdocs, either for the university as a whole or for STEM specific fields. Of these 131 R1 designated institutions, I was able to identify 103 offices of postdoctoral affairs and/or a contact for postdoctoral administrative matters on a website. These 103 universities received a recruitment email that explained the study and included a link to a short eligibility survey. A total of 71 individuals completed the eligibility survey that included a summary of the project, participant expectations, and a link to a data collection form that included demographic information, including race, ethnicity, gender, citizenship status, institution, and discipline. This demographic information was used to prioritize interviews in three ways: 1) I prioritized interviews with postdocs who were from underrepresented racial or ethnic groups and were US citizens, 2) I attempted to maintain relative parity in gender representation, and 3) I also attempted maintain a balance in representation from different STEM-specific disciplines and universities. I did have to balance my priorities with interviewing those who volunteered and/or responded to my follow-up message with a signed informed consent form. In doing so, I ended up with 16 participants from 12 distinct universities. Interestingly, all of the universities were located in the Southeast, Midwest, or New England areas of the United States – no respondents were from any universities in the Great Plains, Northwest, or Southwest. This may reflect regional inequities in research funding among universities in some of these areas and a corresponding lower amount of postdocs, or may be attributed to other factors.

In order to collect data from a sufficient number of postdocs, I ended up interviewing postdocs who were from Asian-American and White American backgrounds, two groups that are not traditionally underrepresented in STEM fields. Interviewees from these groups were mostly women, and in all cases included postdocs who were thoughtful and active in addressing issues of diversity, equity, inclusion, and anti-racism at their institution and throughout their academic career. There were also a handful of respondents who identified as US citizens but I discovered over the course of the interviews that they were in the country on temporary work visas while completing their postdoc. Their insights were invaluable and provide important context for the postdoc experience, especially as the proportion of academic researchers who are international is so significant. As discussed in the literature review, international postdocs have been shown to experience identity-related assumptions and differential treatment from PIs and other lab members (Cantwell & Lee, 2010). As such, their inclusion, though not initially intentional, provides a richer and more thorough understanding of the lived experiences of postdoctoral researchers who are vulnerable to exploitation and also must navigate power structures while adjusting to new cultural and social environments.

One of the unique attributes of this study is the number of distinct interviews that were completed. I wanted to be sure that I cast a wide net to reach as many postdocs as I could so that I could reach a critical number of interviews and theme saturation. The authoritative work on theme saturation in qualitative interview analysis comes from Guest et al. (2006) who found that in a series of 60 interviews with women from two West African countries, they reached data saturation after 12 interviews. I wanted to ensure that all who submitted a survey and met eligibility requirements were able to participate in the study so followed up with all those who fell in this category with the informed consent form. Of these follow ups, 16 ultimately completed this form and participated in the 1-hour long interview. This number of interviews allows for comparison of narratives from a rich data set that includes similarities and important differences in experiences, backgrounds, disciplines, and goals. In the discussion section, each participant is given a pseudonym. Each participant with relevant demographic information is included in Table 1.

Table 1

Participant Alias', Demographics, Disciplines, and Citizenship

Alias	Gender	Race	Ethnicity	Discipline	Citizenship
Alicia	F	Black or African American	Not Hispanic or Latino	Pathology	US Citizen
Christopher	M	Asian, Black or African American	Not Hispanic or Latino	Molecular Biosciences	US Citizen
Daniela	F	Asian	Not Hispanic or Latino	Entymology	US Citizen
David	M	Did not provide	Hispanic or Latino	Plant Pathology	US Citizen
Elena	F	Did not provide	Hispanic or Latino	Mathematics	US Citizen
Grace	F	Asian, White	Not Hispanic or Latino	Environmental Engineering	US Citizen
Henry	M	White	Not Hispanic or Latino	Engineering	US Citizen
Jaime	M	White	Hispanic or Latino	Molecular Biosciences	US Citizen
Kevin	M	Did not provide	Hispanic or Latino	Plant Pathology	Non-US Citizen
Laurie	F	Did not provide	Not Hispanic or Latino	Human Development	US Citizen
Marisa	F	Did not provide	Hispanic or Latino	Molecular Biosciences	Non-US Citizen
Nadia	F	White	Hispanic or Latino	Molecular Biosciences	US Citizen
Octavia	F	Black or African American, Mixed Race	Hispanic or Latino	Geology	US Citizen
Paulina	F	Did not provide	Hispanic or Latino	Entymology	US Citizen
Ruth	F	White	Not Hispanic or Latino	Interdisciplinary Sciences	US Citizen
Vicki	F	Did not provide	Hispanic or Latino	Engineering	Non-US Citizen

Interview Process

Once the informed consent form was received, I moved forward with scheduling each one-on-one, 60-minute interview. These interviews were all conducted over the University of Illinois Urbana-Champaign's instance of Zoom in February and March of 2021. At the beginning of each interview I

summarized the project one more time and stated that while I had a list of questions, the interview was meant to be tailored to their specific experience and so we would see where the conversation took us. This allowed for each interview to encapsulate the specific experiences of individual postdocs, with an opportunity to ask follow-up questions based on their perceptions of what was the most important in their academic development.

I asked all participants to begin in a similar way, with an overview of how they became interested in science and/or research, and an "academic biography" including brief descriptions of their undergraduate and graduate experiences; these accounts sometimes went further back to high school experiences and childhood depending on the individual. This "grand tour" of research and academic experience as an entry point for qualitative data collection was described by Malone and Barabino (2009) as an organizational approach for conducting focus groups with URM graduate students in STEM. This provided a good opportunity for the participants to reflect and become more comfortable speaking with me about their experiences and perceptions. I was specifically interested in when they began perceiving themselves as scientists, i.e. forming an identity as a scientist and gaining confidence in their ability to contribute to and succeed in academic research. The development of identity as a scientist has been shown to be incredibly important to the retention of students in STEM fields from early stages of the career trajectory (Carlone & Johnson, 2007; Chang et al., 2011; Hurtado et al., 2009), and I was eager to understand how this identity formation may or may not come into play in later decisions around transitioning to a postdoc role. This question also provided the opportunity for them to discuss familial and/or community influences, the role of values in their pursuit of scientific inquiry, and how other aspects of their identity (gender, race, class, etc.) may have contributed to their educational experience to this point. Values and community are known to be critical domains as URM scientists make decisions about their career trajectory (Gibbs & Griffin, 2013), and the loosely-designed interview style allowed participants to address these areas where it naturally made sense to them. That is to say, I did not ask explicitly about how their culture, belief system, or other aspects of their identity came into play, instead

wanting these insights to spring naturally from their own reflection on their past experiences where it made sense to them.

From there, I moved into questions specifically pertaining to their experience as graduate students, including their decision to pursue a PhD, their relationship with their advisor and lab dynamics, the characteristics of the programmatic student body, and any specific information related to how faculty and students interacted. These questions were designed to capture the degree to which each individual established a network during graduate school, and how they established mentoring relationships. Previous work has interrogated graduate student experiences related to gender, race, and ethnicity identities related to programmatic outcomes, and delving into the experiences of the interview participants allowed for mapping these experiences onto previously described patterns.

I then asked questions pertaining to their decision to pursue a postdoc, how they ended up with their current postdoctoral advisor, and what the transition into their current lab was like. The previous interview questions provide important context and nuance to the participants' experience, while these next questions get at the essence of the gap in knowledge that this study is seeking to address – that is, specifically how postdocs pursue positions with specific advisors, how these employment relationships are discussed and negotiated, the ease (or unease) with which they transition into their postdoctoral career stage, and how these may or may not be related to their long-term career objectives. The responses to these questions also provide important context in understanding how mentors shape and influence this critical transition point.

The last set of questions in the interview focused around how they defined the goals for their postdoc period, what their current postdoc community looks like, what their post-postdoc goals were, and what their idea of a "perfect" postdoctoral training experience would look like. Like the earlier subset of questions focused on their graduate experience, these questions provided context for understanding how they approach decision-making around staying in academic STEM research, the influence of community and mentors, and the degree to which their current experience met their expectations and/or prepared them for their next professional steps. Finally, I provided an opportunity for feedback based on items that

stood out to them that they didn't discuss by asking if there was anything I hadn't asked that they thought I would have. This question yielded rich responses, including that one postdoc wouldn't have found her current position without her advisor's network, that the study of inequitable systems in STEM had been a useful tool to build resiliency, and a discussion around the differences in values and structure of a small community or teaching university vs. a large research university.

Each interview was recorded with consent of the participant. The Zoom audio file was then uploaded to an online transcription service, from which I was sent a full transcript of each interview. I edited each of these transcripts for accuracy, and then uploaded into Taguette, a qualitative research coding cloud program. This program allows for an organized way to develop a cohesive codebook while moving between multiple documents. In addition to the transcript, I took notes on different points of discussion in each interview to serve as additional documentation in the research process, which contributed to my overall analysis.

First Cycle Coding

For the initial coding, I used an inductive approach to identify themes and codes as they arose organically in the data. I coded each interview transcript as soon as possible after the completion of the interview so that my memory of the discussion was still fresh. For this exploratory study, I used a holistic coding approach to better understand the full dataset. Saldaña (2016) describes holistic coding as applying a "single code to each large unit of data in the corpus to capture a sense of the overall contents and the possible categories that may develop" (p. 165). Little has been written about the specific area of inquiry of lab selection and mentoring related to women and URM postdocs, so it was important to use this holistic approach so that categories were able to develop organically. I did assume that specific themes and categories would be present (i.e., mentoring for professional development, publication, time management); not all of these panned out, some were not as important as I had initially perceived, and some did receive a great deal of discussion. After all interviews were coded, I exported the full codebook with correlated coded data and did a detailed review to address and reconcile instances of similar codes.

This process also allowed me to ensure that my understanding of each code was consistent throughout the different interviews.

Member Checks

At the conclusion of the initial round of coding, I completed member checks with each participant. Member checks are a commonly used strategy in qualitative research to ensure internal consistency of the data, and to ensure that my interpretation after the initial analysis "feels" true to the participants' understanding of their experiences (Merriam & Tisdell, 2016, p. 246). I had confirmed with each participant at the conclusion of the interview that I would be sending a summary of our conversation with them to ensure accuracy of my conclusions, so all 16 were expecting to receive this. As each transcript was approximately 10 pages long, I provided a summary of approximately 10 bullet points to each participant over email rather than the full transcript, and asked each to let me know if anything was missing or incorrect. Importantly, the summary was in my words, so was my interpretation of statements and experiences they described to me, and it was this interpretation that I was asking them to validate. All interviewees responded, some with a simple confirmation that it all looked accurate, some with minor changes to my interpretation, and others with updates (including one who had secured a faculty position at a university starting in the fall).

Analytic Memo

The member checks, along with the narrative summaries provided at the end of this chapter, were an essential quality check element for myself, as well as aiding substantially in systematically thinking through the data I had collected. After writing the summaries for each participant, I developed one overall, analytic memo. This writing process allowed me the opportunity to more fully develop hunches and/or identify of patterns I had picked up on as I was collecting the data, draw connections or contrasts between participant experiences, as well as find connections to existing literature. As Saldaña (2016) states: "Your private and personal written musings before, during, and about the entire enterprise are a question-raising, puzzle-piecing, connection-making, strategy-building, problem-solving, answer-generating, rising-above-the-data heuristic" (p. 44). This writing exercise allowed me hone in on an

appropriate coding approach for my second cycle of analysis. I was able to better identify the emergent themes and categories from my initial approach of, what Saldaña coins, "pragmatic eclecticism" (p. 44). In summary, I started coding the data utilizing a constant comparative method and holistic coding, refined these initial codes, conducted a writing exercise to elucidate themes and better understand the data, and then advanced to my second and final coding cycle.

Second Cycle Coding

After my initial coding of the data, developing an analytic memo, and returning again and again to my two research questions, I then refined the data categories and themes with my second cycle of coding. My questions are based on experiences, on participants' perceptions of their decision-making processes and how their identity may impact decisions and outcomes. I also took into consideration the theoretical framework for analyzing this dataset – that of Bourdieu's cultural and social capital and habitus. With this in mind, I observed that repeated instances of power dynamics, tensions, and dichotomous struggle frequently appeared in the data: the pressure to produce academic products vs. campus activism and community work, selecting a postdoc advisor based on personal factors vs. consideration of long-term career goals, advocating for young Hispanic students to participate in scientific research vs. being mindful of traditional Hispanic family values. These struggles helped to guide me to specific instances of where social capital was used, and where cultural capital served as an advantage or a barrier.

In this second cycle of coding, I assigned codes with this thematic framework in mind. This allowed me to identify datapoints that were more or less relevant to the research questions at hand, and narrowly focus my analysis. Some of the coding overlapped, and some of the codes in the second cycle were new – though the theme of the "hidden curriculum" emerged in the first cycle, in the second cycle is where I was truly able to identify and elicit examples of this in the experiences of the postdocs. After the second cycle of coding, I compared the codes of corresponding datapoints and ultimately assigned one, or a new code, as the "reconciled" code. The reconciled code frequently expanded inclusivity of the entire corpus of data, as I became more accustomed to the themes and how the specific datapoints fit within the

broader categories. As an example, item 4 in Table 2 shows how one datapoint moved from being specifically about gender to fitting within a broader category of networks based on identity – be that gender, race, nationality, etc. Table 2 shows how 5 illustrative datapoints were assigned initial codes in the first cycle of coding, their codes in the second cycle of coding, and how they were ultimately coded in the final and reconciled coding cycle.

Table 2

Datapoints and Assigned Codes by Cycle

Data	First Cycle Code	Second Cycle Code	Reconciled Code
And yeah, there were, there were some, I would say some cultural [factors], because he was Dutch. And there's, there's a slightly different way that postdocs and graduate students interact typically, there. So there's an element of that, and probably an element of sexism as well.	Community – lab	Lab - power structure	Identity – power structure
Like in academia, you can do much more like it's you can do whatever you want. In industry, they sort of, to some extent, tell you what to do. But at least you feel like, hey, we're, we're testing this out, we'll see if we can get a product or not. Right? In academia, we're just sort of like you have complete flexibility. But you might not get something at the end.	Industry-science	Career exploration – industry	Career exploration – industry
So then I decided to do agronomy as a bachelor degree, but at that time, I think my parents influenced me more to study, because I was pretty comfortable in my hometown. With the school, working in the farm, I had some work options. So I wanted to study in my hometown, and my parents kind of pushed me out and said, you need to go to stay somewhere else, you you're not going to stay here.	Family	Leaving home	Leaving home

Table 2 (cont.)

Data	First Cycle Code	Second Cycle Code	Reconciled Code
So I became connected with peers of mine, who were, who were women. And, again, I took an approach of kind of like, I would like to normalize this conversation. So I would often talk about what it's like to be a woman. And it was helpful, I think, for me, because I was coming at it from not having been brought up within this system, I was an outsider coming in and being like, Whoa, what do you guys think about this?	Gender – community support	Network - identity	Network – identity
I also felt that there was so much more resources that I had available for me as a student than I do a postdoc.	Postdoc – valued	Access to resources	Access to resources

Validity and Reliability

This study utilizes several methods to ensure both validity and trustworthiness. First, to ensure validity, the coding was done in two distinct stages with sub-stages/clean-up cycles for each. This ensured that codes were applied consistently throughout and within interviews. The Taguette program assisted in maintaining internal validity by providing an organizational structure to code the interview transcripts. I maintained primary sources in the form of interview transcripts, interview recordings, and my notes from each recording. Secondary sources include my written analysis and the codebook, which includes both initial and second coding cycles. This codebook also provides an audit trail for claims made in the discussion/analysis section of this dissertation. The member checks described earlier in this chapter ensured that my interpretation of the participants' experience was consistent with their understanding, further ensuring the validity of the study. Finally, staying aware of my positionality, described in the next section, further supports the validity of the analysis.

Researcher Positionality

I bring to this research a long history of working with graduate students and postdoctoral researchers at large universities with well-funded research programs. I have overseen training programs

and specifically recruitment, student/employee affairs, and career development programs that have a consistent focus on enrolling or hiring URM scientists. I was motivated to complete this project because of consistent issues I have seen play out at both universities I have worked for concerning postdocs, power structures around gender and race, and resources available to them. As I was completing the interviews, I noticed these biases creeping in from time to time early on in the interviews (for example, asking one early participant if she thought gender impacted a specific decision process – she did not) and made an effort to 1) share my background with participants at the onset of each interview and 2) ask participants to clarify their experiences using their own perception of reality. While I have personally witnessed troubling situations and systems related to postdoctoral researchers, the participants came to the interviews with a wide array of experiences and understandings of these experiences, and respecting the integrity of their individual perceptions during the course of the interview was essential for maintaining the validity of the data.

Additionally, my professional roles have called upon me to mentor and advise both graduate students and postdocs in issues including relationships with their advisors, degree progress, identifying institutional resources and/or processes, and career exploration. Throughout the course of these interviews I found myself having to resist the urge to suggest or discuss potential ways forward and commiserate with issues I had seen before. That said, the interviews themselves were an opportunity for postdocs to discuss experiences in a way that they are not usually called upon to do. A number of them thanked me for pursuing this line of research, expressed that they have frequently felt invisible, ignored, and undervalued in their roles, and that the interviews themselves were an opportunity for self-reflection and had a therapeutic effect.

Finally, I was aware of systemic dynamics at play during the interviews. I am a white woman who has been working in higher education administration for over a decade. I am not a scientist, so though I have worked closely with scientists, my perceptions of things like lab interactions and relationships with advisors are not first-hand. That said, and as discussed above, I do bring with me perceptions about STEM research culture in academia. I specifically sought to interview postdocs from

underrepresented backgrounds, but as a white administrator I do not have lived experience of this population. My interactions with "gatekeepers" – PIs, faculty program leaders, senior administrators, etc. – are markedly different than how postdocs interact with them. All of these factors contributed to my desire to undertake this project and shed light on opaque systems, but are also important to explicitly identify as I collected and analyzed the data.

Theoretical Foundations

This study analyzes a critical transition point in the trajectory of STEM researchers in academia. As such, a theoretical approach with foundations in education is appropriate to understand the power structures, decision-making process, and systems in place. I initially proposed using Bourdieu's theory of cultural and social capital and habitus as an analytic tool; however, as I began analyzing the data I was struck that I should let the data develop and select an analytic tool based on how it unfolded to me. After completing two rounds of coding, the patterns that presented themselves ultimately are appropriate for an analysis that utilizes Bourdieu's theories.

As discussed in the literature review, this study will use academic capitalism as a theoretical framework against which the narratives of these postdoc scholars unfold. Academic capitalism is the idea that in both teaching and research, universities are "focusing on generation of external resources from market activities that turn on the selling of products, processes, and services" (Slaughter, 2004, p. 8). This theoretical framework is particularly appropriate as the STEM research environment in which postdocs function has experienced both an increase in the number of postdocs as well as an increase in research and development budgets. Much of the research that has focused on postdocs portrays them as the unseen labor in the academic capital market, and this invisibility contributes to inequities experienced by underrepresented postdocs as they strive to develop independent research programs and/or develop skills to make them more attractive on the academic job market (Cantwell, 2011; Cantwell & Taylor, 2015).

This framework is further appropriate when juxtaposed to the role of values and the ability of postdocs to function as individuals, embracing all aspects of their identity and lived experiences. Of the postdocs interviewed, many expressed a desire to teach as a way to contribute to their community. Others

were eager to contribute to mentoring and to "lift as they climb." Still others wanted to be active in the campus community, engaging with the Postdoctoral Association and other community groups. All of these pursuits require time, and are not on their face activities that will further the research goals of the Principal Investigator. When research is prioritized with an emphasis on research dollars, other values that have traditionally been important in academic careers lose their relevancy. This framework is all the more important when interrogating how identity impacts a job category that has evolved in a way that some PIs see it as existing primarily to contribute to data production. In this context, the ability of postdocs to hold values that are not in line with the commodification of research is jeopardized. The values that support research are the cultural capital that postdocs should "have" (efficiency, time spent in the lab, data production, moving into a faculty position at an R1 institution, etc.), and held values that may detract from academic production are oppositional.

As academic capitalism will provide the guiding framework for understanding the context within which postdoctoral researchers are functioning, theories of cultural and social capital and reproduction of inequities will guide the data analysis. The guiding question in the analysis will be how the identity of postdocs, particularly women and those from URM backgrounds, navigate the waters of academic capitalism, and how these structures influence experiences and perceptions of postdoctoral researchers, their decision-making processes, and the systems within which they function. Bourdieu explained cultural capital as having three states: a) as an embodied and long-lasting imprint on mind and body (also known as *habitus*), b) as an objectified state, including cultural goods like books, music, etc., and c) as an institutionalized state, taking the form of objectification and conferring special qualities (Bourdieu, 2011, p. 79). Bourdieu also states that social capital is understood as "the aggregate of the actual or potential resources that are linked to possession of a durable network of more or less institutionalized relationships of mutual acquaintance and recognition—or in other words, to membership in a group" (p. 84). The understanding of cultural capital in the context of higher education has been advanced through work that critiques traditional conceptions of whose culture has capital, and underscores the cultural wealth that students of color bring to their undergraduate institution (Yosso, 2005). This approach to cultural wealth

may be useful in understanding divergent values based on program, institution, faculty mentor, and decisions about career direction. This theory can account for a number of patterns that will be highlighted in the discussion section, including the utilization of social networks for identifying postdoc positions, the importance of student-invited seminar speakers, the role of values in community formation, and even the mechanics of the job search process.

An analysis based on social and cultural capital is especially appropriate for postdoctoral training within academic research. Because nearly all aspects of postdoctoral training are informal, from the identification of potential mentors to the application, hiring, and onboarding process, through professional development and transitioning to the next career step, social connections and access to networks facilitate transition points. Postdocs are in vulnerable employment categories, many are on year-to-year contracts with an advisor who holds sole discretion over whether they will be asked to stay on. Depending on the advisor, displaying the cultural capital that is most in line with power structures at their university may be an implicit (or explicit) prerequisite to maintaining their employment. As the research machinery in the United States has by and large kept white men in positions of power, this can create difficulties from those with different cultural backgrounds, approaches, and ideas about what a scientist can and "should" look like.

Limitations

This qualitative, exploratory study provides an analysis of distinct experiences of postdocs in STEM disciplines and how they identified and selected their specific postdoc lab. This question of how postdocs decide where they will complete this training has not been fully explored in the literature, so an exploratory study is an appropriate device to better understand this particular transition point. However, the study does have a handful of limitations. One of these is the issue of self-selection, which occurred on two distinct fronts. First, the universities that I sent the initial recruitment email to all had a published contact or office on their website that offered some kind of administrative support for postdocs; I infer from this that postdocs at these universities are already receiving some kind of structured support and resources outside of their lab, however limited it may be. Postdocs at one of the 28 R1 universities where

I was unable to locate a centralized office for postdocs, representing just over 20% of all R1 universities, did not receive an invitation to participate and their experiences are not incorporated in this study. Second, the postdocs I interviewed all volunteered an hour of their time and conceivably are people who have opinions about postdoctoral training. It is not the case that all of their opinions and experiences were negative, but most did express a level of frustration with, at the least, convoluted processes.

Another limitation that came to light as I was conducting the interviews is the impact of academic discipline. While STEM is a discrete category of a type of academic research, it is also broad and encapsulates a number of disciplines with specific practices. A mathematics postdoc, for example, would have a particular process for identifying a postdoc that is very different from that of a molecular biologist, which is also very different from that of a physical sciences researcher. Their experiences are useful to explore in comparison with each other, however, as they provide a chance to understand different ways of moving through the job search and interview process. Additionally, the STEM paradigm is somewhat arbitrary and built upon the idea that research is an economic engine; the economic contributions confer upon it a status of "valuable." This paradigm is morphing and has begun to be more widely questioned, with many programs instead adopting the "STEAM" acronym to acknowledge the valuable contribution that artistic disciplines make to society.

Finally, these interviews represent a very small subset of postdoctoral researchers. As discussed in the literature review, the number of postdocs employed at universities is quite large and continues to grow year over year. Drawing conclusions from such a limited sample is problematic, but their experiences are important to share and shed light on a difficult to navigate process during an especially vulnerable and important stage of their careers.

Summary

In this chapter, I have described specific approaches for the methodology of a qualitative, narrative inquiry of postdoctoral researchers, their decision-making process of pursuing a postdoc, and their mentoring experience. A narrative approach was selected appropriate for this exploratory study, and a loosely-formed, semi-structured interview protocol was implemented to allow postdocs to tell their

unique stories. 16 interviews were conducted in total, with each being recorded, transcribed, and coded in two rounds using a cloud-based tagging program. Each participant received a summary of their interview for confirmation of my interpretation. Limitations of the study include self-selection bias, a relatively small n, and the variability of academic disciplines within STEM.

Chapter Four: Participant Narratives

As part of the member check and analysis process, I summarized each interview into one narrative paragraph. This paragraph was meant to capture the "essence" of each interview, highlighting main points, circumstances, or situations raised by the individual postdocs. These summaries are provided here, organized alphabetically by first alias name. Providing the summaries will help readers to better understand the analysis and findings based on the participant interviews.

Alicia

Alicia had the most non-traditional route of all of the postdocs interviewed in this project. After graduating from undergrad, she attended veterinarian school at an HBCU in the south. She decided to pursue a residency and a PhD after completing veterinary school to move away from clinical practice, which she found to be emotionally difficult. She then pursued her residency and PhD, and subsequently a research postdoc, at a large southern public university (the same one where both Nadia and Octavia are postdocs, each to be summarized later in the chapter). She is a mother with a young child and her overall description of all of her academic communities were positive with substantial support systems and committed mentors. She will be moving into a faculty position where she can pursue pathology and research at another large, southern university.

Christopher

Christopher's experience has been marked by difficult transitions that ultimately led to positive research experiences, a drive for advocacy, and strong mentorship. He transferred from a community college to a 4-year college, where he developed relationships with biology instructors and was encouraged to pursue his passion in science. He then moved into a master's program where he had a strong bond with other students; after graduating he pursued a PhD in biology at a large, public university in the south. The beginning of his PhD was difficult due to an experience where he misunderstood how to analyze data and was accused of falsification. This led to a direct conversation with his advisor where they both clarified expectations of the other. This strengthened their relationship, though he described additional instances of vocalizing his opinions that put him at odds with his PhD program leadership.

After graduating, he moved to a large, R1 institution in the Midwest. Christopher described this as another difficult transition as a Black man moving to a predominantly white institution and white town in the summer of 2020 amidst racial justice protests and a pandemic. He unfortunately experienced racism in the lab where he had started and was ready to leave the institution, but was able to leverage connections he had made to find a lab that was a better fit for him and now feels that he is thriving, supported, and productive. He has become involved in the campus Postdoc Association and other minority student organizations. He hopes to move into a faculty position at an R1 institution.

Daniela

Daniela's transition from her graduate program to postdoc was also unique. She is the child of two Taiwanese parents. They both attended college in Taiwain, and as such she described feeling similarly to first-generation college students as she had to learn many aspects of the US academic system from her peers or through her own research. She had a sometimes difficult relationship with her graduate school advisor, but was active in student government and had a strong community of support in her peers. She did not receive support or network connections from her advisor or committee members when she began looking for a postdoc, and ended up responding to an advertisement for a teaching position at a small university in a field that was quite different from the one where she completed her PhD. She took the job partly out of anxiety about the future, and after one year of teaching began applying to postdoctoral positions in response to ads she found primarily on Twitter. She secured a position at a large research university in the south (the same university where Grace, described later, is also completing a postdoc). She intends to move into a faculty role and has a strong relationship with her current advisor and is developing her skill set as an independent scientist.

David

David's interest in science and research as a career has been based on pragmatism as well as an inherent interest in research, and he characterized his progression through the academic trajectory as relying heavily on his network and "soft skills." When he was growing up, his father gave him the option of being a lawyer, doctor, or engineer. He liked working with people so decided to pursue the doctor path,

but described getting below average grades in undergrad. He attended a community college and transferred to a four-year institution after completing his associate's degree. While there he developed an interest in research, and decided that plant pathology was a stable research option as humans will likely continue eating food in the foreseeable future. As he was completing his undergraduate program, he attended a SACNAS conference and struck up a conversation with a recruiter from a rural, satellite campus of a large public university in the Midwest that was running a summer research experience program. He leveraged this connection to then move into that same institution's master's program and from there was invited by his master's advisor to stay in the lab, write two more chapters of this thesis, and complete a PhD. He did this, and has now stayed in the lab for his postdoc position. His job search after completing his PhD was especially impacted by COVID, and he ultimately stayed in the lab partly out of a need to maintain secure employment. He describes being happy to be there for the time being, but his ultimate goal is to move into a role with industry.

Elena

Elena moved from one coast to the other to attend undergrad at a small, elite, research university in the mid-Atlantic. She developed an interest in mathematics, and was encouraged to pursue this by mentors and advisors who believed in her potential. She went on to pursue a PhD in mathematics, and emphasized that it was important to her to be able to use mathematics to benefit society in some way, which led to an interest in the biomedical field. She was connected to a strong student community in undergrad, and specifically received mentoring from a women in STEM mentoring group. When she finished her PhD she used a national website to apply to mathematics postdoc positions, and ultimately opted to enroll in a one-year postdoc training program at a small research university in the Northeast. She was persuaded to enroll in this program because each month there was a mini-conference, with leaders in mathematics around the world who came in to present lectures based on a theme. She described the ability to tap into this network, as well as the network she established with the other postdocs in the program, as being the most beneficial aspects of that program though it was difficult to have to find another postdoc after only a year. She ended up moving to a large research university in the Midwest to complete a second

postdoc, and after completing this interview with me has secured a faculty position that will start in the Fall of 2021.

Grace

Grace is completing her postdoctoral training in environmental engineering at a large, southern university. She became interested in the field based on family experiences growing up, and pursued an undergrad degree before moving into a consulting role at a large firm. She decided that the work she was doing at the firm was not as academic as she wanted, and realized that pursuing a PhD was ultimately how she was going to be able to obtain the intellectual freedom that she wanted. Grace's discipline is characterized by physical work in the field. She is a Chinese-American woman and described as not fitting with her field's cohort. Based on her background she is underrepresented in her discipline, and frequently felt like an outsider while enrolled in her graduate program. She values teamwork and careful planning and attributes this in large part to her Chinese upbringing, and often felt that these values were undervalued in the field whereas things like physical strength and spontaneity were valued. She is now completing a fellowship with a team of three mentors and has made substantial progress in academic productivity despite a slow start due to COVID.

Henry

Henry signed up to participate in this study from a different perspective than most of the other interviewees. He is one of the two participants who are white, non-Latino or Hispanic, and not an international trainee. He is active in his campus postdoctoral association, and is specifically active in the association's work around DEI related to postdocs. Henry is a postdoc at an elite research institution in New England, and became interested in the hiring process for postdocs after he went through the process and witnessed friends and colleagues have challenging times finding roles. He spearheaded an initiative at the institution to track hiring of postdocs in which he reached out to research leaders and administrators; work began in the area but was derailed after the pandemic began. He was thus interested in this project, and our conversation centered not only on his experience in his training, but also what he has seen as a campus leader in postdoctoral policies. His training role is with a senior, established researcher and he

describes his progress as being difficult because of the pandemic and is uncertain about his future career path.

Jaime

Jaime is a postdoc researcher in molecular biology, and has moved through his academic training making valuable connections. He became interested in science as an undergrad, where he initially declared as a pre-med major but became interested in scientific inquiry after an interesting class and a strong connection to his professor in the class. He participated in a summer internship program for URM trainees at an elite institution and at that point decided to apply for graduate school at this same school. He was not granted an interview in his first program choice at the institution, but based on a connection he had made during his internship was granted an informal interview while he was on campus for another program and was admitted after impressing the faculty he met. He struggled in graduate school with understanding the processes and policies as a first-generation student; while he achieved academically he stated always feeling insecure about being in the program until he had actually graduated. He is now in a postdoc training position at another private, elite institution in the South, but is moving onto a postdoc role at the NIH to try out a different environment. As a Hispanic man, he stated that he has struggled with feeling a lack of support compared to other URM students and a general lack of role models who can identify with his background.

Kevin

Kevin is a postdoc who is pursuing research in agriculture and plant pathology. He grew up in a rural community in Argentina, and was influenced to study agriculture based on family connections with farmers while he was a child. He was not eager to leave home for college, but his parents pushed him to leave his small town, and he developed a close relationship with an instructor of one of his biology courses. This instructor had research connections with a professor at a large, public university in the Midwest in the United States, and Kevin was persuaded to apply to graduate school at this institution for his PhD. He was again not eager to leave home, but was convinced this would be the best route for him to continue studying this topic that was important to him. He states that he spoke almost no English when he

moved to the states, but taught himself through social and lab interactions and is now fluent. His relationship with his graduate advisor was a bit rocky as he was completing his PhD based on non-aligned expectations, but he ultimately decided to stay in the same lab for his postdoc so he could continue his current lines of inquiry. He is unsure of whether he will stay in the states when his postdoc training is complete and what type of role he will move into.

Laurie

Laurie's background is a bit different than others in the study based on her academic area of research. She is in education researcher with an interest in delivering services to families of students from underserved communities. She completed her PhD at a large public institution, and is now in a postdoc program at an urban research institution in the Midwest. She is Hispanic, and has struggled in her academic pursuits with leaving her home and community, and is unsure of how she may or may not fit into an R1 institution based on uncertainty around time commitments and how that balances with prioritizing her family. Despite experiencing relative isolation due to starting her postdoc during COVID, she has forged a strong community of peers at her institution and has a committed advisor who is supportive of her research project and helps give feedback about her larger questions regarding career path.

Marisa

Marisa is another postdoc who had an untraditional path based on her experiences of first coming to a US institution as a postdoc and with a young child. Marisa's PhD is in Molecular Biosciences. She began this degree in Colombia, where she grew up, and later moved to Chile. Obtaining this PhD was difficult based almost entirely on lab relationships; her PI and labmates were not supportive of her when she was pregnant during her doctoral program. She had to go on bedrest due to the stressful environment, and her mother actually took her phone away because her PI continued to contact her while on bedrest. After having her child, she decided she wanted to complete her PhD and did so, but was then ready to walk away from research and science altogether. This changed because her partner was in a postdoc position in a large US city; she came to visit and a colleague of his mentioned a researcher at another

university in the same city that was looking for the specific skillset that Marisa had. This contact connected the investigator with Marisa, and Marisa immediately began arrangements to move to the US with her child. The transition was bureaucratically and culturally difficult, and compounded by COVID, but her current advisor is supportive and encouraging. She has experienced some pushback due to what she thinks may be assumptions about Colombia and its research strength in her field, but overall she described her postdoc experience as positive and one where she has grown professionally.

Nadia

Nadia was a first-generation college student who completed her bachelor's at a small liberal arts college in California and became interested in research after being encouraged by instructors and her work-study supervisor. She participated in a research internship program for underrepresented students and then transitioned to a research tech role. It was in this role that she fully decided to pursue a PhD in biomedical sciences so that she could pursue questions that interested her. She applied at the Midwestern research university where she participated in the internship program and was accepted. During her graduate program she was involved in student activities, including at the departmental level and programs for Hispanic and Latino students. She described a program that was supportive, tight-knit, and responsive to student needs and requests, and an advisor that was supportive. She knew she was interested in a postdoc position but was very interested in teaching; her graduate program approached her as she was completing her PhD about a course that needed an instructor, and she was able to design and deliver a graduate-level course. She then pursued postdoc opportunities that would allow her to prioritize teaching, and moved to a large southern university where she was able to continue in the classroom. She has now been in the role for two years and is hoping to obtain a position at a small teaching university. Nadia is passionate about bringing science to Hispanic and Latino communities and hopes that this can be a touchpoint in her career.

Octavia

Octavia's experience in scientific research has been influenced by role models, instructors, and mentors who have believed in her and with whom she identified and forged connections. She valued

maintaining her identity as a musician, an athlete, and a woman of color, and was able to do this while in undergrad at an elite institution and pursuing a bachelor's degree in geography. She was active in student activism while in undergrad and organized a journal club with other science students who were Black or Brown and moving onto PhD programs so they could learn more about diversity, equity, and inclusion work in STEM fields and how they might work to build communities of support while in graduate programs. She attended graduate school at a large institution in New England and continued her student activism, working to develop policies around faculty/student relationships and engaging with a mentor/mentee group for Black women. She did not have a close relationship with her advisor, but did receive strong support from connections she forged in the mentoring group, which aided her in a difficult decision process for choosing a postdoctoral program. She is now a postdoc at a large southern university, and has felt isolated and mislead by what was advertised as a "new" postdoctoral experience, but where she has not been able to access resources she has requested, including connections to other women of color conducting research in STEM fields. She reported feeling unsure if she belongs or can be accepted in R1 institutions.

Paulina

Paulina is a postdoc in etymology in a large, public university in the South. She attended a selective, prestigious high school in her hometown in the Midwest before attending undergrad in the same region. She was initially interested in attending medical school, but was able to join a lab during undergrad and developed an interest in research. She stayed at the same school for her graduate program and pursued her PhD in the same lab as where she worked as an undergrad. Because of this she achieved seniority in the lab relatively quickly and became responsible for mentoring undergrads and other graduate students who were newer to the team. She was not particularly close with other students in her program, but because she stayed in her hometown she had a built-in community. She always knew she wanted to do a postdoc and applied for a number of positions that she found by searching an online job posting site. She interviewed at one location, and they offered her a job with the requirement that she move and start within a very short time period. She stated that she was able to make this transition

because she didn't have children, so had relative freedom to move her life on short notice. Paulina's postdoc is funded by institutional funds that her advisor, who is in a research leadership position. She fills the role of a lab manager as her PI is stretched thin with administrative responsibilities. She likes this role, and also has had positive experiences working with the postdoc association and minority student groups. She hopes to move her family to her current city, obtain a faculty position, and eventually move into a university leadership role so she can address issues of equity and disparity.

Ruth

Ruth's path was also forged by connections she made in developing a unique research niche at the intersection of the fields of engineering, ethics, and education. Ruth is white, but volunteered to participate based on her research interests in career development and exposure to the field of engineering. She was interested in pursuing an engineering degree but was a D1 athlete and so was not able to commit the time to the program. She instead focused on organizational psychology and attended graduate school in the Midwest based on advice from an undergrad mentor who was active in ethics education. While in graduate school she was active in coaching programs, and described various instances of sexism and/or gendered assumptions that male faculty members made about her and other female students. She was unsure about pursuing a postdoc, but based on a recommendation from a collaborator at a different institution she pursued an opportunity in an integrated science program. She has a difficult relationship with her current advisor, but has established a community with other postdocs and students in the program.

Vicki

Vicki is an engineer from Chile who began her graduate degree in Germany and finished in France. She described becoming interested in the world of science and research because she always was driven to ask and answer questions about how and why things work the way they do. Her graduate experiences were positive but working within various international systems was a difficult learning curve. She moved from Germany to France because her partner is also an academic and moved; they have two children and addressing child care needs was a responsibility that fell largely on her to figure out. Vicki

knew she wanted to do a postdoc in biomedical engineering so that she could pursue scientific questions that would benefit society. She met a researcher at a conference who was developing medical devices, and he invited her to be a postdoc in his lab in a southern US research institution. She accepted, and moved with her daughter in March of 2020. Her partner had planned on moving but was then forced to stay in France for an additional six months because of COVID. Vicki described this as being difficult but also a time when she was able to be productive in the lab due to limited distractions and necessarily structured worktimes. She wants to stay in research but is unsure if she would like to be a PI. She described experiences of sexism, and described frustration with an academic system that does not make allowances for families and specifically people raising children.

Chapter Five: Results and Discussion

In this chapter, I will discuss the results of the data collected in the interviews in comparison to the current research literature about postdoctoral and STEM training. I will address milestones in the process of searching for a postdoc position, specifically how postdocs 1) decided to pursue a postdoc, 2) conducted searches and applications, 3) engaged (or did not engage) in interviews 4) experienced the transition into their new training environment, and 5) have acclimated in their postdoc position. Common themes will be explored through all of these stages, including themes around mentoring, gender and race identities, the research environment, academic communities, and values.

The discussion in this chapter is centered on two theoretical devices. The analytic tool used to understand and make sense of the data collected from the interviews is that of social and cultural capital and reproduction. These theories, coined by Bourdieu (2011; 1977), are useful in understanding interactions, growth, and social dynamics in educational settings. Cultural capital is understood as an individual's shared values and touchpoints within specific groups which grant access by knowing and understanding a common vernacular; social capital focuses on connections that an individual can use to obtain access to networks and opportunities. Reproduction is the idea that within settings with shared cultural capital and interrelated social capital, values and power dynamics will be copied over time. The framework for understanding the environment that postdocs are functioning within is that of academic capitalism, which is closely aligned with academic production. Academic capitalism is the theory that higher education institutions have moved towards market-based approaches and values and operate with a goal of wealth-generation (Slaughter, 2004). Academic production focuses instead on how researchers participate in wealth-generating activities, rather than the overall research environment in which they exist (Cantwell, 2015).

The guiding research questions for this study are restated here:

1. How do postdocs, especially women and those from URM groups, experience the decision-making process around selecting a lab for their postdoctoral training?

2. How do postdocs think about their relationships with their mentors, and how does mentoring impact career choices and experiences of women and URM postdocs?

Within the context of postdoctoral training, lab selection and lab environment are critical to a better understanding of experience. The lab as a space of learning for graduate and postdoctoral trainees is comparable to the classroom in K-12 education research, or campus climate in undergraduate education research. Research labs, or in some cases research teams, are microcosms of academic life, and these small organizational units have begun to receive more attention in STEM training research. Participants repeatedly brought up lab dynamics – not limited just to relationships with their advisor, but also with other students and/or postdocs. Selecting an environment that suits their personality, research interests, and learning and work style is critical to their career development and transition to independence. As described in the interviews, research labs are the site of academic production and where cultural capital and social capital can be used to understand career growth and lab dynamics that impact career decisions.

The Decision to Pursue Postdoctoral Training

There is a great deal of literature that explores how graduating STEM PhDs navigate career choices. I will briefly review that literature here to ground the decision-making processes of participants in this study, but most of the focus will be on the process *after* a decision is made to pursue a postdoc and stay in academic research -- i.e., where exactly to pursue a postdoc, and with whom as an advisor, though these two decisions are sometimes closely related.

Of the 16 postdocs interviewed here, 12 pursued postdocs because they felt relatively confident that they wanted to stay in academic research. Some in this group were relatively certain that an academic career path was not just for the-short-term, but also the long-term - many stated that they never really considered another option because a postdoc is the next step one takes when on an academic career path. Some were a bit less committed about the future beyond the postdoc, but were still interested in pursuing an academic career for the moment, though they did not go so far as to commit to pursuing a faculty position.

One postdoc, David, moved into a postdoc position because he was not able to secure an industry position immediately after graduating. The COVID pandemic had just begun at the point of his job search, and he felt pressure to secure employment. His graduate advisor extended an offer, and as he enjoyed his experience in the lab while getting his PhD, David chose to accept this offer. In this example, David was able to use social capital to essentially bide time until he is able to secure a job that is more appealing to him and aligns with his career goals. Similarly, three of the interviewed postdocs needed to do *something*, the clock was ticking, and they needed a job. This group is still very much in an exploratory career stage, open to a faculty position without fully committing to that as a desired outcome of completing the postdoc. Others stated that they never considered other options and only applied to postdoc positions with an intention to either move into a faculty role, or to further explore research and an academic career.

The Application Process

The nuts and bolts of the application process are nebulous – calling it a "process" is even a bit of a misnomer as it implies a set way of doing things and standardization. The experiences of the postdocs were vastly different from each other, and interview experiences for the same postdocs were also sometimes vastly different depending on the lab, PI, or institution with which they were interacting. This is reflected in the limited literature on the topic, as well. This is emblematic of the postdoc role as a whole, which is widely variable from postdoc to postdoc, even within the same lab.

One of the most striking differences in the process was the involvement of the PhD advisor. Unsurprisingly, the postdocs who described a relatively strong and positive relationship with their PhD advisor also described a search process that involved the advisor. Usually this came in the form of putting the postdoc in contact with established connections of the advisor, with a limited few receiving strategic direction on how to select an advisor for their postdoc, how to reach out about potential jobs, what questions to ask, etc. In fact, the most impactful guidance that PhD advisors were able to provide to the postdocs came in the form of connections with their collaborators or colleagues. As Laurie stated at the end of her interview:

And it's, it's like a black box. It's kind of sad to say, but a lot of it is word of mouth. And who ultimately, like I wouldn't have gotten this position. If my mentor didn't know [my postdoc advisor] and worked with her. I honestly believe that. I don't think I would have gotten it. Yeah, they say that honestly, like, it's the truth. I applied to other postdocs didn't get anything at all. But I also feel like my mentor didn't have close connections with them.

Through this example, we can see explicitly the role that social capital - Laurie's relationship with her PhD advisor, and her PhD advisor's relationship with Laurie's postdoc advisor - plays in garnering academic and financial capital - a job for Laurie and a next step in her career trajectory towards a potential faculty position. Laurie states that the postdoc application process is like a "black box," and uses the phrase "word of mouth." This illustrates not only the uncertainty around how postdocs identify opportunities, but how those opportunities turn into real positions. Laurie has a PhD in a lucrative field from a well-known institution, but it was her access to social capital that was pivotal to her securing the postdoc.

Jaime described a similar process in identifying potential postdoc advisors:

….I went into my network again, as I tend to do, and I spoke to my advisor. Most of the postdocs I've encountered, they don't get their postdoc from, like an application. They don't always apply. In fact, actually, I think in the United States, as I was, as I was considering my second postdoc in the United States, it doesn't seem to be a common practice, at least among laboratory sciences to get your postdoc through an application that you can apply. But it's not going to mean as much it seems as if you went to somebody else. So I went through my advisor, my graduate school advisor. And I said, you know, I'm interested in a postdoc, do you know of anybody? And he said, No, but why don't you go down the list and think about who you want to postdoc with? And we'll reach out to them, because I know because he knew a lot of people, his former advisor, who will actually be my future advisor for my second postdoc.

Jaime represents a few different processes and ideas in this passage. First, he references how frequently he goes "into his network" when it is time to think through next career steps. Jaime did this to

get into his graduate program, and again to establish a connection to his second postdoc advisor. He also stated that of the postdocs he has met, most of whom are in lab sciences in the United States, nearly all of them have identified their postdoc positions through "going into their network." This reflects not only that postdocs are discussing with each other their experiences of finding positions, but also that ultimately in many situations, and specifically in the two reflected above, the importance of using relationships with their graduate advisor and their recognition in the field. Jaime stated that his advisor didn't "know anyone" who was looking for a postdoc, but asked Jaime to make a list and they would reach out anyway. The advisor knew that, due to their reputation in the field, their name could likely garner Jaime opportunities to interview and consider postdocs in a variety of labs. Jaime's initial postdoc lab was not a close collaborator or acquaintance of his graduate advisor, but he was still able to use his network to make a connection. In this example, the social capital used by the graduate advisor was instrumental to ensuring opportunities for trainees. This process also contributes to reproduction in the sciences – when postdocs are secured through informal networks, trainees from known labs or programs may get farther from an unsolicited email than someone from a lesser known program.

Both Laurie and Jaime described a mostly positive relationship with their PhD advisors and were comfortable going to their advisors for help in identifying and applying to postdocs. Not all postdocs had this experience, and many who were not comfortable using their advisor and their network had a difficult time finding a postdoc. One prime example of this is Daniela, who described a difficult relationship with her graduate advisor, including an incident where a prospective graduate student interviewing with lab members asked her how it felt to be a less-favored lab member. Daniela's advisor was less involved in mentorship and career development, and when Daniela approached her to ask for assistance in identifying potential postdoc labs, her advisor didn't seem to understand how to help. Daniela was left to look for postdoc positions on her own, without introductions: "And then kind of very randomly, I spent like six years in [my graduate school] program, I started applying for jobs in my last year. And then I didn't get any."

With her advisor not there to make immediate connections, she ended up in a teaching position that was not intentionally in service of a long-term career goal, career trajectory, or even in her immediate discipline. Importantly, Daniela also approached members of her committee to request help in making connections at a conference that would hopefully result in postdoc opportunities, and these faculty members also seemed to not understand the role that she was asking them to play. Daniela later found a postdoc position through a job posting on Twitter, which she had been told was being used more frequently in recruiting postdocs for specific projects. In Daniela's situation, she was not able to access traditional social capital to use in obtaining a postdoc position, but was able to utilize new modes of communication and connection to make a career step and secure a training opportunity.

Through another narrative, we see dynamics of social capital and power that played out in in the process of selecting a lab in which to complete postdoctoral studies. Octavia described being introduced to a potential postdoc advisor at a conference and had an impactful scientific experience putting together a research fellowship proposal with this faculty member. Upon discussing the potential move to her PhD advisor and committee members at her graduate institution, however, she was persuaded not to pursue a postdoc with this advisor based on rumors about a difficult working style. This potential advisor, who is a Black woman and a leader in the field, has had this reputation of being "difficult" since she herself was a graduate student. After consulting with several mentors beyond her advisor and committee, Octavia decided that she did not have the bandwidth to "stand shoulder to shoulder" with this potential faculty advisor. She was still a trainee and would have enough on her plate without worrying about how this relationship would potentially negatively impact her career growth and her own reputation in the field.

> And I mean, the unfortunate part is, I feel like I had to make my decision to not be a trainee under her to protect my own career as another woman of color, if I become her trainee, will all of that just transfer to me? Like, will people ever be able to disentangle me from her? I don't think they will, especially just seeing what they're doing to her now. Right? That might taint me in some people's eyes. And as messed up as that is, I didn't want to start my current academic career on

that foot, right? Like I would rather become a professor one day and collaborate with her, rather than be a postdoc under her. That was a really big part of my decision to not do that postdoc.

Octavia saw race and gender, and specifically the intersection of the two, at the heart of this situation. Not only had this Black woman been unfairly disparaged in the field in Octavia's opinion, but now because of this Octavia ultimately gave up an opportunity to train under her based entirely on this fact. Octavia felt her reputation would suffer – that she would be known as difficult and this could harm her ability to collaborate with others in the future. This speaks to an implicit recognition of the importance of social capital in scientific careers, and her understanding that this PI perhaps did not have capital Octavia felt she needed for her career growth. Additionally, this potential advisor was denied the opportunity to further train and mentor Octavia and ultimately further her own research and career by growing her network of trainees. Again, reproduction is visible here, where a Black woman is left out of social networks, with a direct impact on her ability to build a team and produce research – both of which present barriers to career growth.

The process of identifying potential mentors through advisor networks and/or a bit of luck is not one that all postdocs undertook. Elena, a postdoc in mathematics, had a different experience based on specifics in her discipline. There is a central website – mathjobs.com – where all potential postdocs are able to submit application materials, and where those seeking postdocs can post job descriptions. Elena found her postdoc position posted on this site, applied, went through a standard interview process, and was selected into a postdoc program. Though cultural and social capital surely aided in the process through her CV, elite graduate institution, and potentially the name of her graduate advisor, she was still able to submit materials without solely relying on connections brokered through her network.

Other postdocs attempted to superimpose their own standardized process for finding a postdoc. Henry, a postdoc at an Ivy League institution, developed an excel spreadsheet that included PIs of labs in which he was interested in working. He did not work with is graduate advisor on this, but instead was guided by perceptions he had about the value of completing a postdoc at a prestigious institution. Henry had served on faculty search committees as a graduate student, and had learned through this process the

importance that postdoc institutions played in the faculty selection process. Other metrics in Henry's spreadsheet included the specific skillset he would learn in the lab and whether that would help him in a faculty job search, and reputation of the potential advisor in terms of mentoring and interpersonal relationships. Henry reached out to potential advisors one-by-one starting with his top choice, giving each a chance to respond before moving onto contacting the next. Again, this was not based on any specific strategy described to him by an advisor or mentor, but instead the result of informal discussions between him and other graduate students and postdocs who had already gone through the process.

This example shows the importance that networks play in obtaining a postdoctoral position, even if the network is not directly responsible for connecting the postdoc with potential advisor. In this case, Henry didn't use social capital to forge connections. Instead, he made use of the cultural capital he accumulated while in graduate school. The knowledge he gathered while sitting on faculty search committees about the importance of postdoc institutions, and the knowledge from other graduate students and postdocs about the academic research system helped Henry to proceed in his postdoc search in a deliberate manner. Only one other person, Nadia, reported the experience of sitting on a search committee, and included a similar standardized approach with insights garnered about what her postdoc should look like to better position her in the faculty job search.

In retrospect Henry communicated frustration with this process that he largely had to tailor himself due to its opacity. That said, both he and Nadia were able to put together systematic approaches based on input from other people who had moved through the process and their selection to serve on faculty search committees as graduate students. They did not specify how they were selected to sit on the committees, but it is worth noting that these are typically "invite-only" seats, and resulted in intimate knowledge of the faculty search process that ultimately aided both as they moved into their postdoc search. Henry noted that anecdotally, others in his graduate program opted to leave academia rather than move through this process that was opaque, ill-defined, and "emblematic" of the worst traits of academia.

The Interview Process and Transition to Postdoctoral Training

As postdocs moved from sending inquiries to potential advisors and/or submitting more formal applications, the next step was typically some kind of interview or interaction with the potential PI. Again, the experience for a postdoc varies from postdoc to postdoc and is markedly different from any other subset of the academic career trajectory. Faculty searches, for example, are extremely formalized with specific protocols for how ads are written, where they are posted, the selection process, and multi-day interviews. In STEM programs graduate students are also typically brought to campus for formal interviews with program faculty and other students, and to get a feel for the social environment at the school. Employee hiring at universities is governed by a Human Resources department, which maintains oversight over the posting, interview, selection, and hiring process. Amid all of these bureaucratic processes at universities, postdocs and other non-faculty academic appointments receive little attention, which allows them to utilize non-standard interview processes. This includes some postdocs who start a role after limited communication with their new advisor, up to postdocs who are granted faculty-like interviews, including delivering a research talk and meeting with various lab members and potential collaborators. In the following section, we can see repercussions of postdocs who joined labs with less intensive interview processes.

Additionally, some participants reported not really understanding what to look for once they got to the interview stage of the job search process. If trainees aren't able to tap their graduate advisors for input on what to seek out in a research mentor, and don't have an obvious other mentor to fill this void, they may be left trying to assess whether the match is a good fit on their own or with input only from peers and/or near-peers. Ruth, who worked in career development coaching for STEM trainees while in her graduate program, reported that in retrospect she didn't "know what questions mattered" when going through the interview process with her new advisor. She raised concerns about her postdoc advisor with her graduate advisor as she was interviewing, but received advice that she would be lucky to work under this person as they are prestigious in the field.

Another postdoc who had a difficult transition into his postdoc lab similarly missed crucial information that could have been ascertained from a different interview process. Christopher is a Black man who moved from the mid-Atlantic to a very white state and city in the Midwest to complete his postdoc at a large R1 institution. He had never lived in the Midwest before and moved to this lab based solely on his interactions with his advisor – he had not met other lab members who would be his close colleagues prior to accepting the role. Christopher moved to this new state in the summer of 2020, in the midst of protests after George Floyd's murder in a neighboring state as well as the COVID pandemic. These two factors made participating in social or networking activities difficult, if they were possible at all. Christopher reported feeling isolated and having difficult interactions with his labmates. His postdoc advisor did not communicate an ability or interest in understanding the complicated transition and social dynamics that Christopher was dealing with. This all came to a head when a lab member made a comment about Christopher's hairstyle. Christopher had decided to leave the institution, but met with his training grant program director, who recommended other labs and PIs and encouraged Christopher to consider transferring labs. Christopher interviewed with one of the recommended PIs and all members of that lab, and decided that this was a place where he could feel supported and a part of the team. He transferred labs and described thriving in this new environment.

Interviews are a fundamental part of understanding a workplace or training environment that one is thinking about joining. Neither Christopher (when selecting his first lab) nor Ruth were able to engage in a thorough, reflective interview process, and both struggled with the transition into their current research environment. There is no certainty that had they done full research team interviews with guidance on the types of questions to ask and things to watch out for that their situations would have evolved differently, but it certainly could have revealed important information to them both. The postdoc job search process has similarities to a "hidden curriculum," defined as how "particular assumptions, beliefs, values, or attitudes manifests themselves implicitly and inadvertently in schooling, learning, and professional environments" (Villanueva et al., 2018, p. 158). The concept of hidden curriculum first appeared in educational research in 1968 (Jackson), and has been applied largely in classroom settings to

explain ways that children are able (or unable) to read unspoken rules, and how cultural capital is reproduced in ways that mirror existing social hierarchies.

The concept has not been widely applied to professional development in STEM, but it is helpful in understanding how trainees interact with the postdoctoral search and hiring process. A hidden curriculum is applicable in many areas of STEM training and career development. One participant previously mentioned, Daniela, worked briefly as a teacher after completing her PhD and spoke of undergraduate students who she hardly knew approaching her on the last day of class to request a letter of recommendation for graduate school. She started the next semester by intentionally stating that if students were interested in graduate school and might want a letter from her, they should make use of her office hours so that she could get to know them better. Daniela had a unique perspective as a student whose parents did not participate in the American education system and so was left to learn about various processes from her peers, which may have made her uniquely sensitive to this issue. Christopher also noted that he had always been told that unless you were the top of your class, undergraduate professors weren't interested in interacting with students. He had an innate interest in science and so sought his professors out despite what he described as a lackluster performance as an undergraduate student. The connections he made with his professors and the social capital he was able to accumulate through the unwritten rule of asking questions of faculty after their classes served Christopher well as he moved on to graduate school.

The concept of the hidden curriculum in this context is even more apparent in comparison with the experiences of Nadia and Henry. Both served on faculty search committees to give a student perceptive on candidates, but were able to use the opportunity as an informal educational and career exploration opportunity. The knowledge they acquired helped them fill in the gaps about the postdoc application process and focused their approach to identifying potential advisors. Nadia, a first-generation student, also discussed taking every opportunity she could to educate herself about career opportunities and how to contribute to her professional development through availing herself of resources and networks during graduate school. At the graduate career stage the resources exist for learning about what different

career options are, but the details about what is valued in a postdoc from the perspective of a faculty search committee were most apparent from access to the committee itself.

The opaqueness of securing a postdoc position stands in contrast to the graduate school application process, which is knowable because of a formal process that is relatively consistent from school to school. Questions about the process can be quickly answered from an internet search. The details – i.e., *how* or *who* to ask for a letter of recommendation, are where the hidden curriculum becomes relevant. In a search for a postdoc position, there is no knowable process beyond the information that individuals are able to glean from their peers, mentors, advisors, or other resources. The hidden curriculum pertains to all aspects of the process – from how to identify potential advisors, how to reach out to them, what to expect and/or ask for in interviews, how to successfully transition into a lab, how to determine and set goals for the postdoc training period, and how to set themselves up for success in whatever step is coming after the postdoc. Graduate programs are doing more to prepare students to make these kinds of determinations, as well as the more centralized offices for postdoctoral support, but the students still must frequently be proactive to seek this information out if they don't already have insights to the process from their peers or advisors.

Onboarding and Administrative Processes

The mechanics of moving and onboarding in a lab and university are also complicated for postdocs. Of the 16 postdocs that I interviewed, only four stated that they had a relatively smooth onboarding process. 2 of those were individuals involved in structured programs, which as we will discuss later provides the benefit of access to institutional resources and streamlined processes. The other postdocs experienced administrative issues, including difficulty with getting an actual academic appointment processed at all, as Grace did:

> It took about two weeks or so for….the department I'm in to even realize that like there was such a thing as a postdoc fellow. You'd think there had never been one at a gigantic University. So I eventually, I had to go to the postdoc office….I had met the head of that, the director during orientation, and she had mentioned this thing where they were like, associates and postdoc

fellows, and you get to pay health insurance. And finally, in desperation, I went to her. And I was like, Can you give me an example of like, when this happens, because they're telling me that this doesn't exist, and I need health insurance.

This example shows the benefit of an organized process like orientation, and the social capital it can afford to someone like Grace, who was able to use it to ensure that she received a paycheck and health insurance. Another postdoc, Nadia, described an experience of putting together a grant application only to find out that she needed to involve the sponsored research office two days before it was due. Both of these negative administrative experiences could have been alleviated with a more centralized approach to postdoctoral onboarding and oversight. Offices of Postdoctoral Affairs are relatively new resources in universities over the last two decades, and their involvement with the postdoc community differs between institutions. Of the postdocs interviewed, several had access to orientation with a centralized office like this, and others were held through their local Postdoctoral Association. In no cases were the orientations mandatory, as they are with most employees (including faculty) starting at an institution, and for graduate students. These orientations were usually offered on a monthly or quarterly basis – sometimes less frequently – and became more difficult to access for the postdocs who began during COVID. Those who attended these orientations stated that the engagement was minimal, and that they forgot most of the information but remembered the individuals who were running the session.

The issues illuminated by a lack of orientations highlights the importance of dedicated personnel to act on behalf of postdocs, and ensuring that postdocs know who they are so that they can use this social capital to advocate for themselves. In addition to Grace's self-advocacy through availing herself of the knowledge from the Office of Postdoc Affairs, Christopher also had experiences that highlight the importance of connections to the administrative support staff. Both as a graduate student and as a postdoc, Christopher was aided by informal conversations and check-ins with his graduate department's administrative assistant and the administrative assistant for his postdoc training program. Posselt et al. (2017) demonstrated that in a graduate program with demonstrable commitment to diversifying their

STEM field, access to informal support through administrative assistants was crucial for graduate students and for faculty to understand how to support students from different backgrounds.

Organized Training Programs

Postdocs training experiences differ, and one variable that has a significant impact is that of whether they are participating in an organized training program or if they are hired in an ad hoc basis to work on ongoing research projects. When Christopher began his postdoc training, he was appointed to a training grant that spans departments and provides resources to him. He did not know what these resources were until he began discussing leaving the institution and the program director reached out to him – in fact, he stated that he didn't know that the training program director was available to him as an advisor until the director contacted him. This is another example of the hidden curriculum and how it can make social capital invisible – students who completed graduate programs at institutions with more robust research programs and training grants may have understood that the training grant director was available to them as a resource. But this example also illuminates the importance of a structured training program – even if the structure is not well communicated or organized, Christopher had a program director to go to for help when he needed it. This additional support system provides built-in advisors and mentors that the many postdocs funded through their advisor's research grants do not have. Based on Christopher's recounting of identifying a subsequent postdoc lab, had he not had a training grant director to go to he would have been more likely to leave his institution.

Christopher also benefitted from an additional connection he made early on in his postdoctoral training program. He was attending a mandated "Responsible Conduct of Research" training, or RCR, where a university leader for research programs was also in attendance. Christopher asked a question about how a new Black postdoc, particularly in the midst of a pandemic and ongoing racial societal unrest, would be able to find a community at the institution. Christopher stated that he was blown away by the positive reaction he received not just from the university administrator who was on the call, but also from others who responded to his comment. The administrator reached out to Christopher after the session and the two developed a relationship; when Christopher was going to leave, this administrator put

him in contact with a Black professor in a different STEM discipline college in the university. This contact provided additional mentorship to Christopher in navigating how to function in a field where he was a minority and felt isolated, and how to build a supportive community. In a sense, these mentors un-hid strategies for Christopher by 1) making themselves available and 2) explicitly describing their experiences and resources. Finally, Christopher's involvement in the training program put him in contact with university administrators and aided him in developing the social capital that he was able to use when he was thinking about leaving the institution. Postdocs who experience similar issues in their labs but who do not have access to the social capital that Christopher had may instead end up leaving the institution, and perhaps academic research altogether.

Elena, a postdoc in mathematics, was similarly part of a structured training program. When it came time for her to apply for postdoctoral training, she used a popular online tool called "mathjobs.com" that allowed her to submit one application to a variety of positions. She ended up applying and being accepted to a postdoctoral training program at a prestigious institution. Her impetus for enrolling in this program was the exposure to frequent renowned scholars in her field through the program-hosted seminar series, but Elena stated that the connections she made with her fellow postdocs ended up being the most important feature of the program. The program was only a year-long so she ended up having to search and apply for postdoc positions very soon afterwards, but she stated that her experience participating in the one-year program made it worthwhile. She received guidance from her specific professional development mentor on her next postdoc, including where to apply, what to look for in an advisor, and how to design a postdoc that would be in service to her career goal of serving in a faculty position. Elena has since secured a faculty position in mathematics.

Another interviewee in a structured program was also the one with the most unique training experience of the sample. Alicia attended veterinary school at an HBCU directly after completing undergrad, then went onto a joint residency and PhD program at a large R1 institution before completing a postdoc in the same lab where she did her PhD work. In both her veterinary and residency programs, Alicia had access to structured curriculum and trainings, as well as a defined cohort. Her experiences

were largely positive and included both supportive mentors and a network of peers. This network of peers

provided not only a group to talk to and share experiences with as Alicia moved into the faculty job

market, but was also a community that shared onsite childcare responsibilities. Her transition into her

PhD/postdoc lab was positively impacted by these various sources of built-in support. Alicia has also

secured a faculty position for the Fall of 2021.

We can see from these defined training programs the commonality of access to resources in the

form of individuals, be those program directors, potential collaborators, experts in the field, domain

mentors, or a structured cohort. The networks made social capital accessible for the postdoctoral scholars

as they moved throughout and beyond their postdocs. For Christopher, the social capital of a connection

with his program director provided access to a more supportive advisor and lab, the connection with the

research leader who then connected Christopher with the Black professor with whom he could share

experiences. This social capital is what kept Christopher in his postdoc position at the university. Elena

benefitted directly from her training program; when it was time for her to identify a subsequent

postdoctoral role, she sought out input from her cohort and her professional development domain mentor.

The potential to accumulate social capital influenced her decision to participate in the program in the first

place. Alicia was also able to put her social capital to use in similar ways through navigating the faculty

job search, as well as to meet basic needs such as swapping childcare duties while she was at work.

A final example of a postdoctoral training program is that of Octavia, who enrolled in a postdoc

training program that was advertised as a "new kind of postdoc training." Octavia has been an activist

throughout her academic career; her descriptions of her undergraduate and graduate experiences were

largely defined by her activism and connections she forged with campus leaders and networks. While she

was a graduate student she participated in a mentoring group for women of color, and developed a

network that went beyond her academic discipline in a way that encapsulated her full identity. She asked

for access to this type of network in her postdoctoral program, which was advertised as valuing social

activism in her field and providing mentoring that recognized different perspectives. The program is a

new one and there is only one other postdoc in it, and Octavia was told that perhaps in future years they

would have these resources available. Octavia is completing the first year of the two-year program, and reports that she feels isolated and does not have any friends at her institution, and that she is doubting whether there is space for her and if she belongs in an R1 research institution. In Octavia's case, she does not have access to the social capital that was so beneficial to her in graduate school. Importantly, she has asked for a network with other women of color with whom she can use and provide social capital for academic advancement. She has not been provided this, and she now feels isolated and is rethinking whether she wants to stay in an R1 institution.

Postdoctoral Mentoring and Faculty Seniority

Mentoring has received a great deal of attention in the STEM research literature, especially as it relates to URM trainees. One theme that was frequently highlighted by numerous participants in this project was the distinction between an advisor and a mentor. A mentoring relationship "one that ideally consists of a reciprocal, dynamic relationship between mentor (or mentoring team) and mentee that promotes the satisfaction and/or development of both" (McGee, 2016, p. 3). In the context of most STEM graduate programs and postdoctoral training, an advisor is the key faculty member to whom the trainee reports. The trainee works in their lab or on a research project that is guided by the faculty member. In the case of postdocs, who are functioning more independently than graduate students, the research is likely closely related to the research portfolio of the advisor who can provide input and suggestions. The crux here is that while many times advisors serve as mentors and the implicit assumption is that this is the case, it is not always true in practice. As an example, half of the interviewees who participated in this project did not seek advice from their advisors in their search for a postdoc. Some tried, but reported that the interactions were not fruitful. As the participants moved into postdoctoral roles, many had advisors who were busy with other responsibilities in the institution, so the postdoc is serving in a lab manager capacity and the advisor relies on them for data production and smooth operations in the lab space.

A factor that contributed to trainee-advisor relationship in the eyes of many of the study participants was the seniority of the advisor. As described above, where postdocs were serving as an ad hoc lab manager, in several instances this was because the PI of the lab was in a senior role and fulfilling

administrative responsibilities at the institution. This impacted the relationship in a number of ways.

Pressures on the advisor's time resulted in a need to delegate responsibilities that typically fall to a lab PI,

including mentoring of graduate and undergraduate students and overseeing basic workflows in the lab.

This type of lab structure isn't always a negative thing. Paulina, a postdoc in a lab in a large public

institution in the South, has an advisor who oversees all research operations and strategy at the university.

As such, she is left with many of the responsibilities described above and stated that "he [her advisor] isn't

able to provide much mentorship, he tries, he provides praise and professional development opportunities.

And he is very encouraging. I really appreciate what he's doing." Nadia, a postdoc in a different large

public institution in the South, has an advisor who is not serving in an administrative capacity but is an

established leader in the field and is called upon to deliver talks around the world. Both Nadia and Paulina

were able to use the opportunity to develop leadership skills – an area that numerous postdocs noted was

lacking in their postdoctoral training, but sorely needed as the training period is intended to be a stepping

stone to a faculty position.

Another aspect of seniority is the tenure status of the faculty advisor. A number of the postdocs

had advisors who were on a tenure track and building a case for promotion and/or tenure, so these

advisors were feeling a very real pressure to produce data, publications, grant funding, and other

academic products. As a senior member of research teams, various postdocs reported that this pressure

had an impact on their relationship with their advisor and/or their stated goals for the postdoc in one way

or another. Three of the postdocs interviewed for this study stated directly that they were confident that

their advisor's goal for them in their postdoc was to produce data that could lead to publications and grant

funding. As Kyle stated:

> "I think his [advisor's] goals are for me to produce as much data as I can. And I honestly think
>
> that's, from the year and a half that I spent here, I feel like that pretty much sums up exactly what
>
> he was wanting. Just produce as much data as you possibly can."

This example highlights the role that academic capitalism and production plays in the

postdoctoral experience. Kyle is in a role that purportedly exists to serve as a training vehicle for him to

transition to a faculty position, but the focus is on the data generation rather than on professional development. Another postdoc, David, was in a lab of an advisor who had not yet achieved tenure and felt that the singular goal for the entire lab was to produce data so that the advisor could achieve tenure. Whether the PIs feel the pressure of achieving tenure or simply the pressure to produce grants and publications as a tenured faculty, this stems from the focus of R1 institutions on garnering grant funding and achieving research eminence. Postdocs are called upon to contribute data, and as scientists who have already completed their doctorate, PIs can easily look over the training aspect of the role in the effort to produce.

A tenured advisor who has stable funding may be more encouraging of professional development experiences. They also provide social capital through reputation and influence, as well as a well-resourced lab, which directly benefits the postdocs. Nadia and Paulina both stated that their PIs were able to get them whatever they needed for their various projects, and that money was rarely an issue. They also were able to gain mentoring and leadership experience that would not be so easily accessible if they were in labs of less established mentors. In contrast, four of the participants specifically sought out postdoc advisors who were closer to them in career stage – Assistant Professors who had more recently been in postdoc roles. Daniela had experienced a difficult relationship with her graduate advisor who was near retirement and a luminary in her discipline, but who was unable to provide career guidance that was relevant to the current postdoc job market process. For her postdoc role, she specifically targeted more junior faculty who she felt could understand her perspective and experiences better. Similarly, Octavia sought out an advisor who was not as far removed from the questions around next career steps after completing the postdoc period. The down side is that these more junior labs have smaller teams, are likely to have fewer resources, and advisors are likely to have a smaller network of collaborators for the postdocs to connect with for potential faculty jobs. In this way, the postdocs are giving up social capital for a mentoring relationship that is more similar to a near-peer relationship. The decisions about postdoc advisor seniority was one that participants made based on their perceptions, advice from mentors, and

advice from peers, and is another example of unwritten rules that can have a major impact on training experience.

Postdocs, Values, and Non-Research Activities

The role of values came up regularly in these interviews – how they motivated postdocs to pursue a scientific research career, how they shaped their career goals, and how they formulated opinions about how best to develop a lab-based team. From the 16 postdocs interviewed, only three did not explicitly bring up values as playing an important role in their academic experience. Values were discussed in terms of power dynamics in the lab, contributing to society, maintaining a balance with family life, honoring the culture in which they were raised, maintaining other facets of their identity beyond being a scientist, paving the way for future generations of URM trainees, and advocating for student and postdoc voices to be heard on campus. In many of these situations, postdocs specifically reiterated that it was important for them to maintain involvement in activism around some of these sets of values, and that balancing that with research expectations could be difficult in terms of both time and advisor expectations about what received their attention.

Values and Power Dynamics

In this study, I am addressing power dynamics in three ways: 1) power dynamics in a specific lab or research group, including between students and/or advisors, 2) power dynamics related to a specific cohort or body of trainees, including graduate students or postdocs in a particular training program, or 3) power dynamics related to broader institutional policies or processes. Many participants were involved in various student groups or activism while in graduate school, so while the focus is on postdoctoral experiences this section includes experiences from their time in graduate school.

Power dynamics in a specific lab or research group appeared as inter-student/inter-postdoc conflict, or conflict between a PI and trainee that brought into focus the trainee's values in comparison to what they were currently observing. Where postdocs discussed these experiences related to a graduate program, it many times had direct impact on how they chose a lab for their postdoc. Grace, who as an Asian-American is well-represented in STEM fields globally, is underrepresented in her particular field

based on the most recent NSF data (National Science Foundation & National Center for Science and Engineering Statistics, 2019). Grace spoke to this tension, and how values of teamwork that were important to her and deeply held in her Chinese-American upbringing were undervalued in her experience in research.

> I have felt highly underrepresented in my field specifically, but, you know, in STEM, you know, Asians are probably massively over represented, I would say in some places, and I do know, that it's very discipline specific. So I would say I was raised in my, most of my living family is Chinese. And so most of my family experiences when I was growing up, were with them. And the overarching sort of cultural focus is on kind of harmony, like you just don't do stupid things. So the primary reason why I chose [my graduate advisor] over a couple of other labs was because he is a very good team maker. So he, even if I, when I was feeling like I didn't fit in, and that, like, he didn't understand me, and I him, and there's, you know, all sorts of emotional trauma, but I never felt like I wasn't part of the team. And that's always been very important to me.

Grace's difficulties with her graduate advisor were complex, rooted in identity, representation, and how this related to team building in the lab. Grace saw her advisor as very much of the majority in her specific discipline – an active, adventurous white guy who befriended other students and postdocs in the lab that were similar to him. She felt at odds with many of his values, but still felt like a valued member of the team despite not fitting the "mold" of this discipline. Grace was able to gain experience hiring and running teams of undergrads and found that this was one aspect of research that really appealed to her, so when it was time to find a postdoc she looked for an advisor who would support this kind of environment. Even so, Grace spoke of one of her mentors who advised that she should play down her mentoring and team building experiences and focus only on data production – the backbone of academic capitalism and production, of which postdocs are the workhorse. Grace was advised to "reproduce" traditional academic values, namely productivity, to the detriment of values like teambuilding. Grace believed strongly in values of teambuilding and harmony, and had to reject advice from a mentor to stay true to her cultural values that she brought to the research environment.

Values also came up in a more pronounced way related to how postdocs chose to spend their time and be involved in activism on campus. Four of the postdocs in this study were active or planned to become active in their local Postdoctoral Association. Of these four, two were motivated after moving into a postdoc position and seeing the lack of resources and organization around postdocs on their respective campuses. The other two were motivated by similar reasons, but also were seeking out leadership roles and experiences. They all hoped to make an impact on the postdoc community by providing more professional development resources, making the hiring process less transparent, and, as one postdoc stated, provide a voice to this community that feels voiceless.

One postdoc specifically noted that he was still negotiating with his advisor around his involvement with the Postdoctoral Association as it was time that was taking him away from his research activities. This again presents the issue of postdocs working in labs where the goal of the PI is to produce data, and depending on the PI, the professional development for the postdocs is secondary. This also is a consideration for postdocs who value teaching as a professional value and want the opportunity to hone this skill before they move into a faculty position and are assigned courses to teach. An emphasis on teaching has been shown to be an important aspect to postdoctoral training programs that emphasize DEI work (Eisen & Eaton, 2017), and many of the postdocs interviewed in this study communicated an interest in teaching and mentoring while they were in postdoc roles. As Octavia stated: "It is important to kind of lift as I climb." To do so, though, requires a PI who is on board with achieving those goals in the absence of an institutional priority that postdocs be given time to teach.

This dynamic is important in considering the role that faculty are expected to play, and especially in thinking about expectations for URM faculty. Since the social movements of the summer of 2020 shined a light on inequities across a multitude of social structures in the United States, universities have placed a renewed emphasis on diversity, equity, and inclusion through institutional policies and communities. This work is done disproportionately by women and faculty of color and puts a strain on their time, making meeting more traditional requirements for promotion and tenure more difficult (i.e. publications, grant funding, teaching, etc.) (Jimenez et al., 2019). In recent years there have been calls for

valuing diversity work as promotion criteria, with at least one university taking steps to implement formal criteria (Flaherty, 2021). Further complicating this is the need for external reviewers for promotion cases – how to identify reviewers, how to ask them to assess achievements, etc. If this shift in values is truly taking place and universities will recognize involvement in DEI initiatives as a basis for promotion and tenure, then it is imperative that 1) faculty have exposure to this field as part of their training period during their postdoc, and 2) the value of the work is truly put on equal footing with other promotable criteria on the basis of time and effort allocated to it. If the postdoc is truly a training for a faculty role, and faculty will have the opportunity and/or expectation of involvement in DEI work, then it is essential that this be incorporated into training programs. Postdocs interviewed as part of this project expressed a desire to contribute to building a more equitable community, and in fact stated that they needed to be able to do this to continue as a researcher.

Science as Community Activism

Values were also introduced into the conversation when the postdocs were asked to give an overview of their academic history, including how they became interested in research. Several noted that they while they had an innate interest in their field, they also wanted to leverage their role in research as a way to give back to society. One postdoc noted that with an interest in mathematics, she needed to find a way to contribute to society and so became interested in how mathematics could be applied in the medical field. Another postdoc, an engineer, had a similar desire to put her skills to use to develop biomedical devices that would better people's lives. A third postdoc noted that while she was interested in scientific research, she did not feel comfortable working for industry – specifically industry in the agricultural field – because it did not align with her values. The desire to contribute to society closely aligns with the concept of applied science – research that can be used to solve real-world problems. Previous research has shown that in biomedical fields, URM researchers are more likely to be involved in applied research than in theoretical research. However, NIH funding is more frequently awarded to projects that are more theoretical in biomedical fields (Hoppe et al., 2019). This again is a relic of cultural capital – in scientific research, research that is done at the "bench" has been more highly valued than research that is interested

in delivering solutions to communities. Those who pursue aims outside of what is valued culturally have a more difficult time obtaining grant funding.

Values and Leaving Home

A third theme that came up under the category of "values" was that of family and work-life balance. Like families, this looked different from individual to individual, and came up in different ways. Some brought up gender and the difficulty of raising children while in an academic career, but also around race and ethnicity and cultural norms around leaving home and family roles. Leaving home and adjusting to a new environment and support structures came up repeatedly, but was strongly emphasized by those who were from Hispanic or Latino backgrounds. Laurie enrolled in a graduate program that was also in the Midwest and far away from her family on the West coast. She described being quite homesick while she started graduate school and was away from her family for the first time, and at the time of the interview was applying for faculty positions in western states to try to move closer to family. Laurie also described grappling with the amount of work required in an R1 faculty position, and whether the job requirements would allow for the work/life balance that she hopes to have. Finally, Laurie relayed the difficulties that she has had in conveying to her parents the amount of work that was required of her in an academic research position. Paulina, who also grew up in a Hispanic family, first left home for her postdoc position, moving from the Midwest to a university in the South. Her mother moved with her, and she plans to move her entire family in the coming years.

Nadia discussed similar issues as Paulina and Laurie, but with a bit of a different perspective as it related to her professional goals. Nadia is a Hispanic woman who grew up in the western US, and moved to the Midwest and South for graduate school and her postdoc, respectively. She did not specifically recount issues of homesickness with either move, though she does hope to move back to be near her family as she seeks out a faculty position. Nadia cares a great deal about teaching and hopes to find a faculty position where she can focus on this, and she is specifically passionate about bringing science to the Hispanic community near where she grew up but describes the academic career trajectory as being fundamentally at odds with some of her cultural values:

And I also have this continuous, some thought that if I'm successful, I will educate the youth and send them away from their family, which is like anti…anti what they would want, they would prefer that their families stay close by. And I have seen the struggle in my own family as well as in the families of other students where you know, they leave and parents are constantly asking, when are you coming back? Why are you leaving? You know, when will you be done, so you can come back and be where we are. And the point is that at some point, they often don't go back because the academic track takes them somewhere else forever. And so, so it's appealing, but it's also like, I'm not sure if the original thought I had is what I want to do, or it was what I will do.

In many STEM disciplines, the general consensus is that career development is best served if graduate school, postdoc training, and the first faculty appointment are all completed at different institutions. In faculty hiring committees, for example, a postdoc that stayed at the same institution as graduate school may be looked at with skepticism compared to a postdoc who went to a new institution. This necessarily makes it more complicated to stay near family and so is more difficult for individuals who hold staying near parents and extended family as an important value. This again contributes to the reproduction of current values apparent in R1 institutions, and works against those who may be eager to be involved in scientific research and have great potential, but who are not willing to relocate away from their families and are viewed with skepticism by hiring committees or PIs.

Resources for Postdocs

The issue of postdoc access to campus resources came up repeatedly in this set of interviews as 1) discussions of impactful professional development, and 2) frustration about the lack of resources or muddled processes for accessing them. In one specific example showing the real-life impact that professional development sessions can have, Marisa described how her approach to presenting changed after attending a session on imposter syndrome:

There is another one that I loved that was about imposter syndrome, that I feel that I suffer from it all the time. So it was very good to see a lot of people feeling the same. That is something that really was helpful….My advisor asked me if I could do a talk for a meeting in his country,

because first I'm a female working here, and I'm from a country of South America. And third,

because it's a very, very difficult, like a very difficult skill, you know? So he asked, and I said,

No, but after the [imposter syndrome] seminar, I agreed.

It is critical that postdocs be given the freedom to develop their professional skills. To restate

what Henry, one of the interviewees expressed: the postdoc is supposed to be training for faculty roles,

actual training for what you'll be doing as a faculty member should be included in the approach. Nadia

gave another example of how important training and access to campus resources are for postdocs. Nadia

was writing a grant, but had not been told that there was a central university office to work with to submit

it. She was still able to submit the grant after a fellow postdoc told her two days before it was due that she

needed to contact the central research office, but the story shows how removed from standardized

processes postdocs can be, though these processes are expressly communicated to faculty. Similar to

Grace's experience in advocating for her own postdoc appointment being processed, Nadia was forced

and able to use social capital to get her grant submitted and learn the hidden rules of research.

Gender, Postdocs, and Academic Production

Questions of identity contribute to how postdocs see themselves in their role, within their lab, and

within their institution as a whole. I did not ask questions specifically around race, gender, ethnicity,

sexual orientation, ability, etc. as I intentionally wanted these issues to be brought to the discussion

organically by the postdocs as they experienced them. Of the postdocs interviewed, none of those

identifying as men brought up gender in any way, including as it relates to family and work/life balance.

Of those who identified as women, ten of eleven discussed ways that gender specifically impacted their

experiences in research in terms of power differentials, differential treatment, and managing complex

situations related to pregnancy and child-raising.

The first category that was evident in coding of the interview data related to gender was that of

power differentials. This relates to experiences and access that the postdocs thought were denied to them

or unique to them based on being a woman in scientific academic research. Grace, who worked in a field

that emphasized field work, stated that she was denied assignments in lucrative locations because she was

a woman; her PI felt that as a person of smaller stature, she would not be able to keep up with the physical work that the location demanded. Importantly, Grace was never invited to contribute to these expeditions, the work was simply assigned to male counterparts. Ruth also discussed a number of power differentials based on gender in the engineering field. She recounted an experience at a conference where she and another woman presented on their area of expertise. The crowd was made up of mostly men, and during the discussion a few of the men informally took over leadership of the discussion and physically excluded Ruth and her co-presenter (also a woman) by forming a circle in which they were not included.

Postdocs also recounted instances of direct differential treatment that they identified as being related to their gender. In addition to Grace's experience of being left out of projects, she also experienced difficulties interacting with a postdoc in the lab of a collaborator who she felt, upon reflection, discounted her experience and knowledge because she is a woman. Paulina also had similar experiences with male collaborators and colleagues, as did Marisa and Vicki. Some of these interactions were in labs that were diverse in terms of international representation and the interviewees attributed the interactions in part to cultural differences. Some of the women who discussed these instances were international scholars themselves, interacting with men from a variety of backgrounds, and some were U.S. born. In a time where science is increasingly collaborative and global, researchers find themselves entering into complex teams where they may be interacting with others who are accustomed to societal and gender hierarchies that are not the norm in a U.S. R1 institution.

Other postdocs had to navigate interactions with their advisors or other male faculty members who treated them differently. Ruth, in her work as an advisor, discussed numerous interactions when the male faculty in the room would seemingly excuse themselves from providing guidance to a female student because they claimed to "not understand" how things were for women in the field. STEM is becoming more diverse in terms of gender representation at the trainee and junior faculty level – in fact women are starting to surpass men in many STEM PhD programs – but the leadership positions in many STEM departments are still dominated by men. This results in older, white men serving as mentors to

younger, more diverse women, and in Ruth's example these mentors were not able to appropriately provide guidance for their trainees.

Nadia also navigated differential treatment with her postdoc advisor. Nadia and her advisor fall into the scenario described above – Nadia is a Hispanic woman, and her advisor is an older white man who is very influential in the field. He came to her to discuss fears related to the "Me Too" movement, for advice relating to social turmoil in the lab, and for help with administrative tasks. Her advisor did not approach other postdocs in the lab with these topics, and Nadia also stated that he treated her a bit nicer than he treated others in the lab in a similar position. She did not assume that the way he treated her was entirely based on her identity or gender, but left room for the possibility.

Several of the participants discussed the difficulties of having and raising children as a woman in academia. The postdoc typically occurs at a time in life when many are starting families, making the discussion around work-life balance especially important. Elena described an experience where she was working with collaborators and struggling with whether to tell them that she was pregnant as they were planning out a project and she didn't want to seem like she was asking for special treatment. She discussed with her advisor and received the advice that if the response from collaborators was anything other than a "congratulations," then those were collaborators with whom she did not need to continue working. Marisa had a very difficult time with her pregnancy; she was on bedrest and had an advisor who continued to text and call when she was out of the lab. She switched advisors when she returned to complete her PhD after having her child, and her new advisor told her that she shouldn't have had a child while in the program. Vicki discussed the difficulty of attending conferences as a parent of a small child living separately from her partner, and how attending these important events felt like an impossibility. She also noted that when speaking with other women in a similar role, the conversation frequently veers towards balancing childcare and research, and that this topic rarely comes up for her when speaking with men. That theme bears out in this study, where many of the women brought up childcare and none of the men did. This was a small sample and none of the men had children. One woman who did not have

children, Paulina, noted that if she did have children, starting her postdoc position with the turn-around time that was required would have been impossible.

Networks

Networks were an incredibly important theme in this research, not only in finding postdoc roles but also in the role they played to establish communities. Many of the women who discussed childcare turned to their networks of women in research to identify childcare resources that were accessible to them. One of the participants, Alicia, even relied on her labmates to trade childcare duties. Networks established by the women interviewed in this project were also described as sounding boards to go to when they encountered situations that they perceived as sexist. Again, their social capital was the mechanism they used to make sense of their experiences and give voice to power differentials. The Postdoctoral Association, or NPA, is another important resource for postdocs to access a network of peers. Christopher stated that the NPA at his university has provided an incredible network after his difficulties in his first lab, and that he has made fast friends through this association that has served as a critical source of support. In contrast, Octavia had a difficult time accessing the NPA and stated that she didn't really have postdoc friends. Nadia, who is at the same university as Octavia, noted that their NPA was very top down in that its priorities seemed to be set by university administrators rather than by the postdocs themselves. This type of tepid response was typical of the participants when asked about the postdoc association, with many of them providing a response along the lines of "they're trying but….". COVID has made socializing and connecting for postdocs who are already disparate even more difficult.

Identities factored into these networks in a multitude of ways. Many of the women who were interviewed for this study expressed a deep need to connect with other women in the field. As described previously, Octavia expressly requested to be connected with other women of color researchers; this was not done, and she expressed a sense of loss because of this. Kyle, a Hispanic postdoc working at a private university in the South, also stated that he did not have a postdoc community and further stated that most of the postdocs he saw did not interact with each other. He also noted that he has met very few researchers in his field with a background similar to his, and that he has felt a disparity compared with

other URM trainees in resources and support offered to him. Kyle, similar to Octavia, is questioning whether he wants to stay in an R1 research environment. Elena noted that much of her support while she was a graduate student came from the women in STEM peer mentoring group, of which she was a part. When Christopher was struggling with the decision of whether or not to leave his postdoc and university, he was connected with a group for URM graduate students in STEM. Even though they are students, Christopher communicated being bolstered by having a group who can listen to and understand his experiences. Kevin, a postdoc who grew up in a South American country but came to the US for his graduate program and postdoc, made meaningful connections within the international community at his university. These identity-based groups provide critical support to postdocs who are in a stage of training that can be extremely isolating. In this chapter I previously explored the themes associated with an organized training program, which in addition to connecting postdocs with mentors and resources, also connects them to a cohort. Recent research has supported hiring and developing cohorts of faculty who are underrepresented in STEM fields, and funding agencies like the NIH have developed grant programs based on the model (J. Mervis, 2020). If this is shown to be effective at the faculty level, and already implemented at the undergraduate and graduate level, there is reason to believe that it would also have impact in retaining URM scientists at the postdoctoral level.

Summary

In conclusion, themes and categories that were apparent in the data included a general opaqueness around the postdoctoral hiring process, similar to the "hidden curriculum" paradigm that is often used to understand classroom education. The "hidden curriculum" is also relevant in how postdocs are able to access resources once they have started at the university from foundational things like security in the university's employment process and securing child care, to areas of importance in career development like how to submit a grant. Postdocs relied on their network of peers, their "social capital," to fill in gaps where they were not supplied with information. Other themes included the ability of postdocs to be released from research responsibilities by their PIs, understanding that research is the major impetus for the postdoc role but with a need to balance this with professional development opportunities given its

status as a training period before moving into a faculty position. This applies not only to professional skills like presenting research, but also to allowing time away from research to engage in activities related to DEI initiatives and teaching. Allowing postdocs to explore other facets of academic employment allows them to contribute to the research environment in a way that is true to their full identity.

Chapter Six: Conclusion

Diversity, equity, and inclusion in STEM is a well-researched line of inquiry in the world of education. However, most of this research is focused on K-12 or undergraduate students, rather than on the conditions at the graduate and post-graduate level. Even so, over the last decade more attention has been paid to understanding how processes within graduate education and faculty hiring and retention may reproduce inequities in STEM fields. Less attention has been paid to postdocs, which is likely due in part to their transient nature, the less-than-formal application and hiring process, and their inconsistent appointments. This research projects takes a critical eye to elements of the postdoctoral training period, and particularly how elements of identity do or do not influence experiences, access, and transitions.

In the literature review, I described the research that has been completed around STEM research and its key findings. In undergraduate education, we have seen that access to research opportunities, strong mentorship, and an opportunity to develop a science identity are key developmental opportunities in retaining students, and especially URM students, in STEM fields throughout undergrad and beyond. Programs that emphasize community building, small class sizes, and access to faculty are all steps that institutions can take to provide support structures. We see strong examples of this in programs like the University of Maryland Baltimore County's Meyerhoff Program, as well as in how many HBCU's approach course structure and institutional priorities.

In graduate programs, DEI research has focused on the application process, as well as to retention strategies. Research has shown that the application process to PhD STEM programs leaves a large amount of discretion to the faculty admissions committee, and places faith in their ability to assess a student's potential based on application materials and processes that introduce built-in biases. For example, many graduate admissions committees implement a triage system where applications are not closely reviewed unless they meet a certain threshold, defined in part by GPA, GRE scores, and undergraduate institution. All three of these measures are known to be biased against URM students. Additionally, admissions committees function with preconceived ideas about what features make strong scientists, based in part on

their experiences. While many of these traditional characteristics are well-founded, it also creates an environment that is difficult for students with different backgrounds to enter and thrive in.

Once students matriculate into graduate school, there are additional barriers to retention in the graduate program. As one study found, programs may recruit with diversity goals in mind, striving to achieve diverse race and ethnicity representation on paper. This does not always translate to an environment that is truly welcoming to different backgrounds, nor one that is supportive to students from non-majority backgrounds. Changes that will fundamentally impact and build a more equitable STEM research environment requires graduate programs to question about how they define success for both admitted and graduated students.

For approaches to postdoctoral training and hiring processes, the research is much less robust, especially as it relates to women and URM trainees, yet it paints a similar picture. Postdoc programs that are well-defined with structured cohorts have been shown to have a stronger impact in terms of graduates who move into faculty positions than postdocs who are hired and complete work on a project basis. Research has also shown that an emphasis on teaching can be a factor in successful transitions to faculty roles (Rybarczyk et al., 2011; 2016). The number of URM graduate students who transition into postdocs is not keeping up with the proportion of URM trainees in graduate school, though women are starting to catch up here and in those who transition to faculty roles. However, when looking at leadership positions in STEM academic research, both groups are significantly underrepresented. Given the vulnerability of this particular transition – from graduate student to postdoc – and the high degree of URM students that the STEM workforce loses here, I sought to design a research project that would shed light on these processes and better understand how postdocs experience this transition and what factors are important to it.

Methods

Given the relatively unexplored nature of the transition from graduate school to postdoc training, I developed a research protocol that would allow me to explore experiences of individuals. This

qualitative study is exploratory in nature, using a narrative analysis to understand how identity impacted postdocs at this transition point. The guiding questions for the study were:

1. How do postdocs, especially women and those from URM groups, experience the decision-making process around selecting a lab for their postdoctoral training?

2. How do postdocs think about their relationships with their mentors, and how does mentoring impact career choices and experiences of women and URM postdocs?

For this study, I recruited 16 postdocs from 12 R1 institutions. Of the sample, 11 were women and 12 were URMs. Though I initially intended to interview only those from groups who met URM criteria as defined by funding agencies like NIH, I ended up expanding my participation criteria based on responses. Many were still underrepresented in their discipline (for example, a Chinese-American woman in a discipline that does not have proportional representation of Asians or Asian Americans). I also included three international postdocs, who though they were not domestic racial minorities, were still minorities in their respective fields. I also included two participants who were from well-represented groups in their disciplines, but who were active in postdoctoral associations and mentoring, and have given thought, time, and effort to DEI in their disciplines and at their institutions. A table listing all participants with demographic information like race, ethnicity, gender, and postdoc university characteristics can be found in the Research Methods chapter.

Each interview lasted approximately one hour, and was semi-structured in design. Participants were asked about their academic trajectories and how they became interested in science and research, their decision to pursue graduate school, how they decided to do a postdoc, what the application process was like, and about their mentoring networks both in graduate school and in postdoctoral training. After each interview, I uploaded the audio to a transcription service and was then able to code each transcript in a cloud-based qualitative coding program. I used the constant comparative method in the first round of coding, going back to revise previous codes based on new data and themes. After the first round of coding was complete, I sent each participant a summary of their interview as a member check to better ensure

validity of the study. I then embarked on a second round of coding and was left with approximately 200 codes within 11 larger themes.

The analysis of data collected centered around two theories: academic capitalism and production, and social capital and reproduction. Several of the postdocs I spoke to noted that they felt "invisible" at their universities. The language of invisibility has been used in the research literature dating back to the 1960's with the National Research Council's report on postdocs at universities (National Research Council, 1969). The feeling persists and is a lived experience of postdocs who participated in the study. The insights of the participants who used this language were that they existed in a gray area between student and faculty; they are a trainee but expected to function with minimal oversight. They are in a role designed to feed into a faculty position, but offered little institutional recognition and organized resources. They are largely left to find a postdoc based on their own contacts or those of their advisors, and move through the application and onboarding process with varying degrees of formality and procedure. Networks play a critical role in their career advancement – as one postdoc stated, "research is all about who you know." The use of social capital and reproduction helped to make sense of how postdocs made decisions, how they advanced, and where they may have felt barriers existed.

Similarly, academic capitalism and academic production provide a framework for understanding the context within which postdocs function and are asked to contribute to a larger enterprise. At R1 institutions, research is a priority. This is a reasonable expectation, but the accumulation of research dollars can detract from other goals that have traditionally been held by universities, like teaching and mentoring. Postdocs, as the invisible contributor to academic production, are pivotal in generation of research dollars. Academic production as a backdrop helps to understand the context within which postdocs must use their social capital to access professional development resources and networks that may be under-resourced or less visible.

Findings

The postdocs interviewed for this project had a variety of experiences and outlooks on their educational history, academic research as a discipline, the role of a mentor, and a potential career in

research. Their goals for doing a postdoc, and motivation for moving into a postdoc role, are just as widely variable. Postdocs are inherently individual training mechanisms; when the role was first conceived the point was to provide room for newly minted PhD scientists to develop into an independent scientist, with their own research portfolio and directions. As a whole, this concept rings true when applied to the participants of this study. Though not all postdocs who participated see themselves necessarily moving into a role of a faculty researcher, their training and goals are distinct and individually crafted, sometimes with the input of a mentor or advisor.

Hidden Curriculum and Postdoc Careers

The concept of a hidden curriculum is applicable to postdocs and their particular position within the academic career trajectory. For graduate students, there is a defined, knowable process for applying to and interviewing with graduate programs. That process may differ between disciplines, schools, and programs, but it is usually information that is publicized for recruitment purposes. Compared to graduate programs and faculty positions that have a thorough, organized approach to recruitment, there is little recruitment for postdocs. As such the application process is based on word of mouth – what PIs need a postdoc, who has funding, etc. This requires that potential postdocs have adequate social capital to access this information and to make the necessary connections. Additionally, graduate programs have defined milestones, including prelims, qualifying exams, courses, and teaching requirements. Because a postdoc is meant to be a period of individual development and training, with the exception of limited postdoctoral training programs there is not a blueprint. Postdocs may again rely on social capital to understand what kind of training and professional development they need to make themselves an attractive candidate on the faculty job market. This may come in the form of a faculty mentor or mentors, peer mentors, near peer mentors, or from organized offices committed to postdoctoral development. Mentoring is a skill that is not intuitive for all faculty, and not all faculty are required or motivated to develop mentoring skills. As a result, the guidance that postdocs receive from advisors is largely dependent on the individual PI. Any other mentors, be that faculty or otherwise, will be dependent on the postdoc again utilizing social capital to access.

The Importance of Networks

Again building on previous research (Scaffidi & Berman, 2011), networks played a critical role in the professional development and career choices and direction for postdocs. The postdocs in this study tapped into their network for all kinds of different needs. Many tapped into networks at early stages for their path to becoming a scientist, including identifying and matriculating into graduate programs. Most used their networks or those of their advisors to identify and apply for postdoctoral positions. Peer networks were critical to retention in the STEM workforce as we saw with Christopher when he was considering leaving his postdoc role, and in Octavia as she struggles to acclimate with an absence of a meaningful network of peers. Aspects of identity play an important role in the development of networks, as both Christopher and Octavia (and numerous others) have relied at various points in their training on networks based on identity, including a women of color group for Octavia and a graduate student minority group for Christopher. In the relatively isolated position of postdoc with the added complexities of identity, the ability to interact with a network of people who can share in the postdoctoral experience was a meaningful aspect of training.

Taken in conjunction with access to meaningful, supportive networks, the hidden curriculum of the move to a postdoctoral position and professional development is influenced by identity. Access to networks opened doors for postdocs, especially for those who were able receive peer and faculty mentoring from people with shared identities in groups for women in science, women of color in academia, and graduate student minority groups. Access to these groups increases the social capital of all involved by expanding their networking reach, and in doing so contributes to making visible aspects of postdoctoral training that are traditionally word of mouth.

The Role of Values

Previous research has established that values play a critical role in the decisions of graduate students as they choose career paths (Gibbs & Griffin, 2013). The importance of values to career decision-making was evident in this study as well. One postdoc stated that her personal values would preclude her from working in private industry in her field, which she felt had ethical problems. She also

saw government as having its own set of structural issues making it a difficult career path, which left academia as the obvious choice. Another postdoc differentiated between R1 institutions and smaller universities that emphasize teaching rather than research. Others questioned their role at R1 institutions based on their personal values; I discussed in the previous chapter that Grace saw tension between the values of harmony and teamwork that she was raised with in her Chinese-American upbringing and those of data collection that are emphasized in R1 institutions. Octavia questioned whether she had a place in the world of R1 research universities at all based on her postdoc experience not aligning with the values that it advertised and that she cares about.

Future Directions for Research

A few areas of future directions for research became apparent as I moved through the data collection and processes. These are focused on diversity, equity, and inclusion activities, the study of research teams and labs as organizational units, the seniority of an advisor as a mediating factor in a postdoc training experience, and further work in understanding different types of mentorship and advisement.

Diversity, Equity, and Inclusion Activities

A common theme that came up with the postdocs I spoke to was a desire to be engaged in activities to better the STEM workforce from a holistic perspective. This includes things like teaching, mentoring, ensuring that trainees have a voice in department decisions and strategy, team building, and contribution to groups like the Society for Advancement of Chicanos/Hispanics and Native Americans in Science (SACNAS), and postdoctoral associations. One postdoc alluded to this type of activity as honoring her identity as a whole, rather than just identifying as a scientist in a vacuum, and this perspective coincides with current thinking about how science identity develops and is experienced. One does not function as a scientist devoid of personal experiences, positionality, and social context – any aspect of an individual's background may serve as a valid reference point, source of knowledge, and motivation, and participating in activities that recognize this is a reasonable expectation. Postdocs viewed this stage of their training as just that – training. They didn't see themselves solely as producers of data,

but as members of a dynamic and complex academic body that requires more attention to be truly equitable. More work needs to be done to understand how faculty advisors view postdocs in their lab, and how advisors can best be partners in postdoc professional development.

Additionally, postdocs are conceivably in a training period as preparation for a faculty position. More schools are calling upon faculty to engage with DEI efforts, and all ask faculty to serve on committees, teach, and take leadership over projects or programs. When faculty are starting out they have had little training related to these domains, yet are expected to carry out essential responsibilities in DEI, which are oftentimes formalized in departmental, college/school, and/or university mission statements and strategic goals. If they are untrained or unmotivated to do so, students or trainees will bear the brunt of subpar teaching, mentoring, and DEI leadership. Finally, as more universities are acknowledging DEI activities as critical and including them as promotion criteria, more work will need to be done to understand how to evaluate contributions. This includes how promotion committees will assess impact on students and trainees, how to assess impact on the institution and broader community, and how they will select and instruct external reviewers to assess contributions.

Research Teams and Labs as Organizational Units

Research has established the importance of mentors in career development, including the importance of a variety of mentors based on individual needs and the impact of peer mentors. In addition to mentoring, the interviews completed for this study indicated that the lab environment is another critical factor in a postdoctoral experience. Several of the postdocs had difficult interactions with other members of the research team – so much so that more than one considered leaving research altogether and others questioned whether their place was in a lab at an R1 institution. Postdocs encountered lab members and collaborators who made inappropriate comments about race, about having children, and about their basic competence in their field. A number also recounted the opposite experience, having had training experiences in close-knit, collaborative groups. Those who had positive experiences also indicated that these relationships were important to their success. Still others assumed leadership roles in the lab, and gained experience mentoring and overseeing research operations. Research trainees spend forty or more

hours a week working in small groups in research labs, and understanding how different factors like PI rank, funding, and size of the lab may influence dynamics is important to aid postdocs in choosing a lab. Some studies have begun to look at this (Cantwell, 2015), but given the outsized influence lab dynamics has on training experience, it is an area that warrants further investigation.

Seniority of Advisor

The relationship between the postdoc and advisor varies and depends on things like personal mentoring styles, needs of the postdoc, career goals, size of the research lab, and research and data production expectations. The last two points are in many ways features of academic capitalism and production, where research products like publications and grants weigh heavily on faculty who look to postdocs to contribute to projects based on their technical expertise and skills. It is fair to expect that faculty at R1 institutions are there because they enjoy contributing to research and are motivated to do so, but it is also fair to say that faculty longevity at a given R1 institution is based on that faculty's ability to secure extramural funding. Junior faculty who have not yet achieved tenure may have promotion cases that hinge on this metric and so to them, securing funding is pivotal to their own careers. Some faculty may be able to manage this pressure, but on the face of it one could reasonably foresee a situation where a junior faculty member who needs to secure tenure may set research productivity expectations on their postdocs that are at odds with the postdocs need to engage in other professional development activities, like mentoring, teaching, or leadership activities as mentioned above. It may also create a situation where the postdoc is asked to contribute to research that is not necessarily in service to developing their own research portfolio in a way that will strategically serve them when/if they go on the faculty job market. That said, some postdocs in this study intentionally sought out junior faculty as advisors because of their close proximity in career stage – they wanted an advisor who could remember what it was like to be a postdoc.

There is much to consider when postdocs are selecting an advisor and a lab, and many factors that contribute to these decisions. Seniority of the postdoc's advisor, including whether or not they have tenure, needs further investigation to better understand if there is a relationship to how the postdoc will be

mentored, data production expectations, and retention in the STEM academic research workforce. Understanding potential patterns could be useful to future postdocs as they embark on the important task of selecting a postdoctoral lab and advisor.

Recommendations for Policy and Practice

Over the last decade, different policies have been put into place to increase equitable treatment of postdocs across institutions and disciplines. These include an increase in offices of postdoctoral affairs, implementation of required supplemental funding for postdocs on fellowships who do not have access to employee benefits like retirement, and a cap on the number of years that postdocs can remain in their training role. While these policies are well-intentioned, their impact may be undermined by the organizational structure of universities that keep postdocs relatively isolated. In the case of offices of postdoctoral affairs, postdocs are best aided by this office if they 1) know that it exists as a resource and 2) offers relevant programming. Through the interviews conducted as a part of this study, many postdocs stated that the sessions they attended were minimally useful and did not garner large attendance, which also undermines the offices' contributions to network development. In the case of supplemental funding, not all universities require this, leaving it up to PIs to supplement fellowships on a case-by-case basis. Finally, a policy like a cap on the number of years that one can postdoc has essentially created what is commonly known as a "super postdoc." This is an individual who moves from a postdoc role into a research faculty position – a career track that in some ways is even more vulnerable than postdocs for its lack of oversight, professional development opportunities, and funding that goes along with a typical faculty position.

The policies and practices discussed above have had some positive impact to be sure, but their overall usefulness to the experiences of postdocs is lessened as they do not get to some of the structural issues that define the isolated postdoctoral experience, and especially the experiences for women postdocs and postdocs of color. The recommendations below are supported by the data collected in this study and build upon existing research literature. A shift towards these approaches to postdoctoral training will help to address the larger environmental issues that impact the training experience.

Postdoc Cohorts

One of the most common themes that came out of these interviews and is addressed in the literature is that of isolation and "invisibility" of postdocs in the larger research and university environment. Graduate programs are based almost entirely on cohorts, with students applying and matriculating on a set timeline. This is likely a product of the requirement of coursework at the beginning of graduate degrees. As a counterexample, however, most institutions in Europe and Australia do not require graduate students to complete coursework – they instead go directly into their research work in a PI lab. These students still matriculate as cohorts and have access to the networks that are built as a result of this. Faculty also begin at set times of the year and frequently know other faculty who begin at the same time. Funding institutions are beginning to understand the importance of cohorts for faculty, especially as it relates to groups traditionally underrepresented in STEM fields. The NIH has recently developed funding opportunities for "cluster hiring," where institutions secure grant funding and hire cohorts of faculty with a demonstrable history of working to improve campus culture for scientists from underrepresented groups. This focused approach is untested in STEM fields, but other disciplines have used the method and seen significant increases in representation across racial and ethnic minorities (Jeffrey Mervis, 2020). The grants include access to professional development opportunities, mentoring plans, and activities around community building and support. While the approach is untested for faculty in STEM fields, based on the findings in this study and others about the importance of peer mentoring and networks, cluster hiring is a promising avenue for faculty and one that could reasonably be emulated for postdocs.

Organized Application, Onboarding, and Orientation Process

Implementing cohort-based postdoc training programs would also provide a way to streamline onboarding and reduce some of the bureaucratic difficulties postdocs experience when joining a lab and a university. I heard from several postdocs that they had to advocate for themselves and chase down information in routine things like getting their postdoc appointment set up, enrolling in health insurance, and identifying university offices to work with when submitting grant applications. This last point is

especially important in the context of academic capitalism. Postdocs are the engine of the research production at large institutions, and if universities want them there, they should provide the tools necessary for the postdocs to secure funding for research projects. This knowledge will also help the postdocs as they transition to faculty roles. A basic, required orientation that provides this information to postdocs, modeled on graduate student or employee orientations, would be beneficial to the postdocs, their advisors, and the university.

Professional Development Opportunities

As discussed throughout this study, the postdoc position was originally conceived as a stopping point in between a graduate program and a faculty role and meant to develop skills that junior scientists need to develop into independent investigators. As R1 universities became focused on generating research dollars, postdocs became critical to producing the data that supported grant applications and publications. As postdocs moved into a role of highly-skilled, specialized scientist, the emphasis from the institutional perspective also shifted away from professional development training that would benefit postdocs as they transitioned into faculty roles. Postdocs in this study voiced a desire to teach and mentor, hone leadership skills, and engage in collaborative projects. They know that a faculty position consists of more than just producing data and are seeking opportunities to develop other skills. Ultimately, training postdocs results in faculty who are ready to engage in complex projects that will further enrich the climate in STEM fields for scientists at all career and academic levels, and investing in this training will benefit not only the postdocs, but also the universities on a larger scale.

Summary

This exploratory narrative analysis sought to explore how postdocs made career decisions, and particularly how they chose a postdoc advisor. It further explored how different aspects of identity, including race, ethnicity, gender, first-generation student status, and citizenship further impacted their decision-making about an advisor and their subsequent experience in their postdoc lab. The data collected showed that lab choices are very much impacted by identity, along with values about community and research that may not overlap with the dominant values at large R1 institutions. The individual interviews

provided postdocs an opportunity to talk about their academic experiences in the context of their identity as it made sense to them, and to reflect on university processes. Through their reflections, the data also shows that on a broader scale, the disconnected nature of postdoctoral training may impede their ability to develop networks and access future career opportunities. In line with previous literature, this study provides additional evidence that the postdoctoral training experience could be improved by utilizing a cohort-based approach, providing professional development opportunities, and the implementation of a standard application and onboarding process.

References

Adams, T., Robinson, D., Covington, A., & Talley-Matthews, S. (2017). Fueling the STEMM pipeline: How Historically Black Colleges and Universities improve the presence of African American scholars in STEMM. *Journal of Urban Learning, Teaching, and Research, 13*, 9-25. https://eric.ed.gov/?id=EJ1150035

American Association of University Professors. (n.d.). *Background facts on contingent faculty positions*. Retrieved May 15, 2021 from https://www.aaup.org/issues/contingency/background-facts#:~:text=%22Contingent%E2%80%9D%20faculty%20positions%20include%20both,to%20faculty%20holding%20these%20positions

Astin, A. W. (1985). *Achieving educational excellence* (1st ed.). Jossey-Bass. https://catalog.hathitrust.org/Record/000417451?

Baber, L. D. (2015). Considering the interest-convergence dilemma in STEM education. *Review of Higher Education, 38*(2), 251-270. http://dx.doi.org/10.1353/rhe.2015.0004

Basile, V., & Lopez, E. (2015). And still i see no changes: Enduring views of students of color in science and mathematics education policy reports. *Science Education, 99*(3), 519-548. https://doi.org/10.1002/sce.21156

Beal, C. C. (2013). Keeping the story together: A holistic approach to narrative analysis. *Journal of Research in Nursing, 18*(8), 692-704. https://doi.org/10.1177/1744987113481781

Beasley, M. A., & Fischer, M. J. (2012). Why they leave: The impact of stereotype threat on the attrition of women and minorities from science, math and engineering majors. *Social Psychology of Education: An International Journal, 15*(4), 427-448. http://dx.doi.org/10.1007/s11218-012-9185-3

Belgrave, F. Z., Moore, M. P., & Douglas-Glenn, N. E. (2019). Barriers and assets to external funding for African American faculty. *International Journal of Qualitative Studies in Education (QSE), 32*(10), 1250-1269. https://doi.org/10.1080/09518398.2019.1659443

Bernard, B. (1962). Postdoctoral work in American universities: A recent survey. *The Journal of Higher Education, 33*(3), 119-130. https://doi.org/10.2307/1979365

Bersola, S. H., Stolzenberg, E. B., Fosnacht, K., & Love, J. (2014). Understanding admitted doctoral students' institutional choices: Student experiences versus faculty and staff perceptions. *American Journal of Education, 120*(4), 515-543. http://dx.doi.org/10.1086/676923

Bourdieu, P. (2011). The forms of capital. In M. Granovetter (Ed.), *The sociology of economic life* (3rd ed., pp. 78-92). Routledge. https://doi.org/https://doi.org/10.4324/9780429494338

Bourdieu, P., & Passeron, J.C. (1977). *Reproduction in education, society and culture*. Sage Publications. https://catalog.hathitrust.org/Record/000379850?

Brommer, C. L., & Eisen, A. (2006). FIRST: A model for increasing quality minority participation in the sciences from the undergraduate to the professoriate level. *Journal of Women and Minorities in Science and Engineering, 12*(1), 35-46. https://doi.org/10.1615/JWomenMinorScienEng.v12.i1.30

Camacho, S., & Rhoads, R. A. (2015). Breaking the silence: The unionization of postdoctoral workers at the University of California. *Journal of Higher Education, 86*(2), 295-325. https://doi.org/10.1353/jhe.2015.0010

Cantwell, B. (2011). Academic in-sourcing: International postdoctoral employment and new modes of academic production. *Journal of Higher Education Policy & Management, 33*(2), 101-114. https://doi.org/10.1080/1360080X.2011.550032

Cantwell, B. (2015). Laboratory management, academic production, and the building blocks of academic capitalism. *Higher Education, 70*, 487-502. http://www.jstor.org/stable/43648883

Cantwell, B., & Lee, J. (2010). Unseen workers in the academic factory: Perceptions of neoracism among international postdocs in the United States and the United Kingdom. *Harvard Educational Review, 80*, 490-517. https://doi.org/10.17763/haer.80.4.w54750105q78p451

Cantwell, B., & Taylor, B. J. (2013). Internationalization of the postdoctorate in the United States: Analyzing the demand for international postdoc labor. *Higher Education, 66*(5), 551-567. https://doi.org/10.1007/s10734-013-9621-0

Cantwell, B., & Taylor, B. J. (2015). Rise of the science and engineering postdoctorate and the restructuring of academic research. *Journal of Higher Education, 86*(5), 667-696. https://doi.org/10.1353/jhe.2015.0028

Carlone, H. B., & Johnson, A. (2007). Understanding the science experiences of successful women of color: Science identity as an analytic lens. *Journal of Research in Science Teaching, 44*(8), 1187-1218. https://doi.org/10.1002/tea.20237

Carnegie Commission on Higher Education. (2018). *Doctoral universities: Very high research activity*. https://carnegieclassifications.iu.edu/lookup/srp.php?clq=%7B%22basic2005_ids%22%3A%2215%22%7D&start_page=standard.php&backurl=standard.php&limit=0,50

Chang, M. J., Eagan, M. K., Lin, M. H., & Hurtado, S. (2011). Considering the impact of racial stigmas and science identity: Persistence among biomedical and behavioral science aspirants. *Journal of Higher Education, 82*(5), 564-596. http://dx.doi.org/10.1353/jhe.2011.0030

Chang, M. J., Sharkness, J., Hurtado, S., & Newman, C. B. (2014). What matters in college for retaining aspiring scientists and engineers from underrepresented racial groups. *Journal of Research in Science Teaching, 51*(5), 555-580. http://dx.doi.org/10.1002/tea.21146

Connelly, F. M., & Clandinin, D. J. (1990). Stories of experience and narrative inquiry. *Educational Researcher, 19*(5), 2-14. https://doi.org/10.3102/0013189X019005002

Davis, G. (2005). Doctors without orders. *American Scientist, 93*(3), 1-13. https://www.sigmaxi.org/docs/default-source/Publications-Documents/postdoc-survey-highlights.pdf?sfvrsn=2

Division of Statistical Analysis and Reporting. (2021). *NIH data book: The NIH funded research workforce*. N. I. o. H. Office of Extramural Research https://report.nih.gov/nihdatabook/category/14

Dorenkamp, I., & Weiß, E.-E. (2018). What makes them leave? A path model of postdocs' intentions to leave academia. *Higher Education (00181560), 75*(5), 747-767. https://doi.org/10.1007/s10734-017-0164-7

Eagan, M. K., Hurtado, S., Chang, M. J., Garcia, G. A., Herrera, F. A., & Garibay, J. C. (2013). Making a difference in science education: The impact of undergraduate research programs. *American Educational Research Journal, 50*(4), 683-713. https://doi.org/10.3102/0002831213482038

Eisen, A., & Eaton, D. C. (2017). A model for postdoctoral education that promotes minority and majority success in the biomedical sciences. *CBE Life Sci Educ, 16*(4), Article ar65. https://doi.org/10.1187/cbe.17-03-0051

Flaherty, C. (2021). The dei pathway to promotion. *Inside Higher Ed*. Retrieved September 4, 2021, from https://www.insidehighered.com/news/2021/05/14/iupui-creates-path-promotion-and-tenure-based-dei-work#.YTPnNw_4gKs.link

Garces, L. M. (2012). Racial diversity, legitimacy, and the citizenry: The impact of affirmative action bans on graduate school enrollment. *Review of Higher Education, 36*(1 suppl), 93-132. http://dx.doi.org/10.1353/rhe.2012.0050

Garces, L. M., Jayakumar, U. M., & Park, J. J. (2018). Reclaiming diversity: Advancing the next generation of diversity research toward racial equity. In M. B. Paulsen (Ed.), *Higher education: Handbook of theory and research: Published under the sponsorship of the Association for Institutional Research (AIR) and the Association for the Study of Higher Education (ASHE)* (Vol. 33, pp. 11-79). https://doi.org/10.1007/978-3-319-72490-4

Geiger, R. L. (2017). *To advance knowledge: The growth of American research universities, 1900-1940*. Taylor and Francis. https://doi.org/10.4324/9781315135694

Ghaffarzadegan, N., Hawley, J., & Desai, A. (2014). Research workforce diversity: The case of balancing national versus international postdocs in US biomedical research. *Syst Res Behav Sci, 31*(2), 301-315. https://doi.org/10.1002/sres.2190

Gibbs, K. D., Jr., Basson, J., Xierali, I. M., & Broniatowski, D. A. (2016). Decoupling of the minority PhD talent pool and assistant professor hiring in medical school basic science departments in the US. *eLife, 5*. https://doi.org/10.7554/eLife.21393

Gibbs, K. D., Jr., & Griffin, K. A. (2013). What do i want to be with my PhD? The roles of personal values and structural dynamics in shaping the career interests of recent biomedical science PhD graduates. *CBE Life Sci Educ, 12*(4), 711-723. https://doi.org/10.1187/cbe.13-02-0021

Gibbs, K. D., Jr., McGready, J., Bennett, J. C., & Griffin, K. (2014). Biomedical science Ph.D. Career interest patterns by race/ethnicity and gender. *PloS one, 9*(12), 1-18. https://doi.org/10.1371/journal.pone.0114736

Gibbs, K. D., McGready, J., & Griffin, K. (2015). Career development among American biomedical postdocs. *CBE Life Sci Educ, 14*(4). https://doi.org/10.1187/cbe.15-03-0075

Guest, G., Bunce, A., & Johnson, L. (2006). How many interviews are enough? An experiment with data saturation and variability. *Field Methods, 18*(1), 59-82. https://doi.org/10.1177/1525822X05279903

Gurin, P., Dey, E. L., Hurtado, S., & Gurin, G. (2002). Diversity and higher education: Theory and impact on educational outcomes. *Harvard Educational Review, 72*(3), 330-366. https://doi.org/10.17763/haer.72.3.01151786u134n051

Hoppe, T. A., Litovitz, A., Willis, K. A., Meseroll, R. A., Perkins, M. J., Hutchins, B. I., Davis, A. F., Lauer, M. S., Valantine, H. A., Anderson, J. M., & Santangelo, G. M. (2019). Topic choice contributes to the lower rate of NIH awards to African-American/black scientists. *Science Advances, 5*(10), eaaw7238. https://doi.org/10.1126/sciadv.aaw7238

Hurtado, S., Cabrera, N., Lin, M., Arellano, L., & Espinosa, L. (2009). Diversifying science: Underrepresented student experiences in structured research programs. *Research in Higher Education, 50*(2), 189-214. https://doi.org/10.1007/s11162-008-9114-7

Hurtado, S., Eagan, M., Cabrera, N., Lin, M., Park, J., & Lopez, M. (2008). Training future scientists: Predicting first-year minority student participation in health science research. *Research in Higher Education, 49*(2), 126-152. https://doi.org/10.1007/s11162-007-9068-1

Hurtado, S., Han, J. C., Saenz, V. B., Espinosa, L. L., Cabrera, N. L., & Cerna, O. S. (2007). Predicting transition and adjustment to college: Biomedical and behavioral science aspirants' and minority students' first year of college. *Research in Higher Education, 48*(7), 841-887. http://dx.doi.org/10.1007/s11162-007-9051-x

Institute of Medicine. (2000). *Enhancing the postdoctoral experience for scientists and engineeers: A guide for postdoctoral scholars, advisers, institutions, funding organizations, and disciplinary societies*. The National Academies Press. https://doi.org/https://doi.org/10.17226/9831

Institute of Medicine. (2014). *The postdoctoral experience revisited*. The National Academies Press. https://doi.org/10.17226/18982

Jackson, P. W. (1968). *Life in classrooms*. Holt, Rinehart and Winston.

Jayakumar, U. M., Howard, T. C., Allen, W. R., & Han, J. C. (2009). Racial privilege in the professoriate: An exploration of campus climate, retention, and satisfaction. *Journal of Higher Education, 80*(5), 538-563. http://dx.doi.org/10.1353/jhe.0.0063

Jimenez, M. F., Laverty, T. M., Bombaci, S. P., Wilkins, K., Bennett, D. E., & Pejchar, L. (2019). Underrepresented faculty play a disproportionate role in advancing diversity and inclusion. *Nat Ecol Evol, 3*(7), 1030-1033. https://doi.org/10.1038/s41559-019-0911-5

Kallio, R. E. (1995). Factors influencing the college choice decisions of graduate students. *Research in Higher Education, 36*, 109-124. https://doi.org/10.1007/BF02207769

Lam, A., & de Campos, A. (2015). 'Content to be sad' or 'runaway apprentice'? The psychological contract and career agency of young scientists in the entrepreneurial university. *Human Relations, 68*(5), 811-841. https://doi.org/10.1177/0018726714545483

Lambert, W. M., Wells, M. T., Cipriano, M. F., Sneva, J. N., Morris, J. A., & Golightly, L. M. (2020). Research culture: Career choices of underrepresented and female postdocs in the biomedical sciences. *eLife, 9*. https://doi.org/10.7554/eLife.48774

Malone, K. R., & Barabino, G. (2009). Narrations of race in STEM research settings: Identity formation and its discontents. *Science Education, 93*(3), 485-510. https://doi.org/10.1002/sce.20307

Martinez, E. D., Botos, J., Dohoney, K. M., Geiman, T. M., Kolla, S. S., Olivera, A., Qiu, Y., Rayasam, G. V., Stavreva, D. A., & Cohen-Fix, O. (2007). Falling off the academic bandwagon. Women are more likely to quit at the postdoc to principal investigator transition. *EMBO reports, 8*(11), 977-981. https://doi.org/10.1038/sj.embor.7401110

Maton, K. I., Beason, T. S., Godsay, S., Domingo, M. R. S., Bailey, T. C., Sun, S., & Hrabowski, F. A., III. (2016). Outcomes and processes in the Meyerhoff Scholars Program: STEM PhD completion, sense of community, perceived program benefit, science identity, and research self-efficacy. *15*. https://doi.org/10.1187/cbe.16-01-0062

McGee, R. (2016). "Biomedical workforce diversity: The context for mentoring to develop talents and foster success within the 'pipeline'". *AIDS and behavior, 20 Suppl 2*(Suppl 2), 231-237. https://doi.org/10.1007/s10461-016-1486-7

Melanie, T. J., Amy, E. L. B., & Merna, V. (2010). Importance of undergraduate research for minority persistence and achievement in biology. *The Journal of Higher Education, 81*(1), 82. www.jstor.org/stable/27750767

Merolla, D. M., & Serpe, R. T. (2013). STEM enrichment programs and graduate school matriculation: The role of science identity salience. *Soc Psychol Educ, 16*(4), 575-597. https://doi.org/10.1007/s11218-013-9233-7

Merriam, S. B., & Tisdell, E. J. (2016). *Qualitative research : A guide to design and implementation* (4th ed.). John Wiley & Sons.

Mervis, J. (2020). NIH's new cluster hiring program aims to help schools attract diverse faculty. *Sciencemag.org*, N.PAG-N.PAG.

http://www.library.illinois.edu/proxy/go.php?url=https://search.ebscohost.com/login.aspx?direct=true&db=edb&AN=141494760&site=eds-live&scope=site

Mervis, J. (2020). NIH hopes 'cluster hiring' will improve diversity. *Science, 367*(6479), 726. https://doi.org/10.1126/science.367.6479.726

Miller, J. M., & Feldman, M. P. (2015). Isolated in the lab: Examining dissatisfaction with postdoctoral appointments. *Journal of Higher Education, 86*(5), 697-724. https://doi.org/10.1353/jhe.2015.0029

National Center for Science and Engineering Statistics. (2021). *Women, minorities, and persons with disabilities in science and engineering*. https://ncses.nsf.gov/pubs/nsf21321/report

National Postdoctoral Association. (2021). *Growing progress in supporting postdocs: 2021 national postdoctoral association institutional policy report*. https://www.nationalpostdoc.org/page/policy_report_databa#2021PolicyReport

National Postdoctoral Association. (n.d.). *What is a postdoc?* Retrieved August 1, 2020 from https://www.nationalpostdoc.org/page/What_is_a_postdoc

National Research Council. (1969). *The invisible university: Postdoctoral education in the United States. Report of a study conducted under the auspices of the national research council*. National Academy of Sciences. https://catalog.hathitrust.org/Record/001116782?

National Science Foundation, & National Center for Science and Engineering Statistics. (2019). *Women, minorities, and persons with disabilities in science and engineering: 2019*. https://www.nsf.gov/statistics/wmpd.

National Science Foundation, & National Science Board. (2018). *Science & engineering indicators 2018*. https://nsf.gov/statistics/2018/nsb20181/report/sections/academic-research-and-development/doctoral-scientists-and-engineers-in-academia

Nguyen, T.-H., Boland, W. C., & Gasman, M. (2019). Historically Black Colleges and Universities, STEM education, and the pursuit for legitimacy? *British Journal of Sociology of Education, 40*(8), 1055-1071. http://dx.doi.org/10.1080/01425692.2019.1646114

Outcalt, C. L., & Skewes-Cox, T. E. (2002). Involvement, interaction, and satisfaction: The human environment at HBCUs. *Review of Higher Education, 25*(3), 331. https://doi.org/10.1353/rhe.2002.0015

Owens, E. W., Shelton, A. J., Bloom, C. M., & Kenyatta Cavil, J. (2012). The significance of HBCUs to the production of STEM graduates: Answering the call. *Educational Foundations, 26*(3/4), 33-47. https://eric.ed.gov/?id=EJ1000229

Perna, L., Lundy-Wagner, V., Drezner, N. D., Gasman, M., Yoon, S., Bose, E., & Gary, S. (2009). The contribution of HBCUS to the preparation of African American women for stem careers: A case study. *Research in Higher Education, 50*(1), 1-23. https://doi.org/10.1007/s11162-008-9110-y

Posselt, J., Reyes, K. A., Slay, K. E., Kamimura, A., & Porter, K. B. (2017). Equity efforts as boundary work: How symbolic and social boundaries shape access and inclusion in graduate education. *Teachers College Record, 119*(10), 38, Article 100307. <Go to ISI>://WOS:000412873500007

Posselt, J. R. (2014). Toward inclusive excellence in graduate education: Constructing merit and diversity in PhD admissions. *American Journal of Education, 120*(4), 481-514. http://dx.doi.org/10.1086/676910

Posselt, J. R., Jaquette, O., Bielby, R., & Bastedo, M. N. (2012). Access without equity: Longitudinal analyses of institutional stratification by race and ethnicity, 1972-2004. *American Educational Research Journal, 49*(6), 1074-1111. http://dx.doi.org/10.3102/0002831212439456

Rybarczyk, B., Lerea, L., Lund, P. K., Whittington, D., & Dykstra, L. (2011). Postdoctoral training aligned with the academic professoriate. *BioScience, 61*(9), 699-705. https://doi.org/10.1525/bio.2011.61.9.8

Rybarczyk, B. J., Lerea, L., Whittington, D., & Dykstra, L. (2016). Analysis of postdoctoral training outcomes that broaden participation in science careers. *CBE Life Sci Educ, 15*(3). https://doi.org/10.1187/cbe.16-01-0032

Saldaña, J. (2016). *The coding manual for qualitative researchers* (3rd ed.). SAGE.

Scaffidi, A., & Berman, J. (2011). A positive postdoctoral experience is related to quality supervision and career mentoring, collaborations, networking and a nurturing research environment. *Higher Education (00181560), 62*(6), 685-698. https://doi.org/10.1007/s10734-011-9407-1

Scherr, R. E., Plisch, M., Gray, K. E., Potvin, G., & Hodapp, T. (2017). Fixed and growth mindsets in physics graduate admissions. *Physical Review Physics Education Research, 13*(2), 020133. https://journals.aps.org/prper/abstract/10.1103/PhysRevPhysEducRes.13.020133

Slaughter, S., and Rhoades, G. (2004). *Academic capitalism and the new economy : Markets, state, and higher education*. Johns Hopkins University Press.

Slay, K. E., Reyes, K. A., & Posselt, J. R. (2019). Bait and switch: Representation, climate, and tensions of diversity work in graduate education. *Review of Higher Education, 42*, 255-286. https://doi.org/10.1353/rhe.2019.0052

U.S. Department of Labor. (2021). *Fastest growing occupations*. https://www.bls.gov/ooh/fastest-growing.htm

Villanueva, I., Carothers, T., Di Stefano, M., & Khan, M. T. H. (2018). "There is never a break": The hidden curriculum of professionalization for engineering faculty. *Education Sciences, 8*(4), 157. https://doi.org/10.3390/educsci8040157

Yadav, A., Seals, C. D., Sullivan, C. M. S., Lachney, M., Clark, Q., Dixon, K. G., & Smith, M. J. T. (2020). The forgotten scholar: Underrepresented minority postdoc experiences in STEM fields. *Educational Studies, 56*(2), 160-185. https://doi.org/10.1080/00131946.2019.1702552

Yosso, T. J. (2005). Whose culture has capital? A critical race theory discussion of community cultural wealth. *Race Ethnicity and Education, 8*(1), 69-91. https://doi.org/10.1080/1361332052000341006

Zumeta, W. (1984). Anatomy of the boom in postdoctoral appointments during the 1970s: Troubling implications for quality science? . *Science, Technology, & Human Values, 9*(2), 23-37. https://doi.org/10.1177/016224398400900203

Zumeta, W. M. (1985). *Extending the educational ladder: The changing quality and value of postdoctoral study*. Lexington Books.