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EDITED BY
Kotaro Komatsu,
University of Tsukuba,
Japan

REVIEWED BY
Annette Kappert,
Breda University of Applied Sciences,
Netherlands
Yuka Funahashi,
Nara University of Education, Japan

*CORRESPONDENCE
Yifan Zhang
✉ yifan@broadinstitute.org

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The production of laboratory scientists: Negotiating membership and (re)producing culture

Yifan Zhang[1,2]*

[1]Department of Anthropology, Bryn Mawr College, Bryn Mawr, PA, United States, [2]Broad Institute of MIT and Harvard, Cambridge, MA, United States

This ethnographic work is about the recruitment and enculturation of novice scientists in the laboratory. Interviews and participant observation were conducted in a biochemistry research lab at a small liberal arts college. I take a predominantly interpretive approach and ask the question of how novice scientists make sense of their decisions and behaviors as they gain membership into the laboratory and the community of scientists. Revising the value-neutral and the structure-centered depiction of science, I represent novice scientists as agents who are subjected to their sociohistorical positionalities but also who consciously maneuver with purpose and agenda. Novice scientists' attempts to strategize and negotiate access to resources are epitomized by the culture of cold emailing. Additionally, I elucidate a process of how prospective medical students later gravitate to careers in science. While many initially anticipate a career in medicine, high retention in science has been observed when quality mentorship, friendly workplace culture, and supportive family members are present. I also present episodes of normative, value-laden practices—and how novices engage with them—to capture the cosmology of scientists. I make the interpretation that the becoming of scientists is a rite of passage facilitated by behavioral habituation and values imprinting, *via* which cultural norms are transmitted and reproduced.

KEYWORDS
science education, anthropology and sociology of science, laboratory, ethnography, science and technology studies, habitus

Introduction

Laboratory studies

Science and its practitioners enjoy a special epistemic status in the popular imagination. Science seems to be an authoritative corpus of knowledge that aims for a uniform, universally valid theory of reality, and scientists are experts who are licensed to produce scientific knowledge and who have privileged access to reality (Sassower, 1993; Sturdy, 1995). What sets modern scientists apart from the rest of history and society is that they claim to construct reality but not to be themselves constructed (Martin, 1998). In Traweek's terms, they appear to be "cultures of no culture" (Traweek, 1988).

Sociologists and philosophers have long recognized the involvement of personal bias, normative commitment, and other sociocultural forces throughout the production of scientific knowledge: Which problem to investigate, how hypothesis is formed and tested, and how results are interpreted and assessed, etc. (Harding, 1993; Shapin, 2012; Stefanidou and Skordoulis, 2014). The practitioners of science are actors who are socially and historically situated, whose observations are filtered through the lenses of theories, and whose findings are communally negotiated (Kuhn, 1962; Hempel, 1966; Harding, 1993). In this revised picture, scientific knowledge and behaviors cannot be fully understood solely with some universal and timeless *objectivity* and *rationality* but instead, this picture invites depictions of the production of scientific knowledge as an actor-centered sociocultural process.

Laboratories are central to the organization of the scientific community. Each lab is a team of researchers working together to resolve some thematically or methodologically related problems. Data, methods, and scientific papers generated from each project are considered intellectual properties of individual authors but also of the lab of which they are a member. When scientists give a presentation at a conference or to the public, they often start with "my lab works on…" or "my lab is interested in…" instead of using the pronoun *I*. Indeed, advances in modern science are built upon collaborations, and each lab is the smallest unit where daily collaborations between individual researchers take place. If we consider science as a corpus of knowledge, then the lab is where such knowledge is physically and linguistically produced, and the engagement of social relations is obligatory in this process.

The human behaviors and social relations centered around the site of laboratories provide diverse and complex materials for anthropological investigations. Latour et al.'s (1986) *Laboratory Life* pioneered the ethnographic investigation of natural scientists. This book is the result of more than a year spent by Latour and his colleague Steven Woolgar observing molecular biologists in the laboratories at the Salk Institute for Biological Sciences in La Jolla, California. Latour and Woolgar's account rejects the positivist view of science as a rational and largely asocial process capable of discovering a singular, universally valid truth regarding the natural world. They instead presented scientific knowledge as an artificial product of various network-building, ally-enrolling activities, most of them competitive.

Traweek's (1988) *Beamtimes and Lifetimes* is another landmark study of the laboratory. Based on her observations at SLAC National Accelerator Laboratory in California, United States and KEK High Energy Accelerator Research Organization in Japan, Traweek contrasted "beamtimes" (amount of time spent on the particle accelerator) with "lifetimes" (the careers of individual physicists) to depict the culture of high-energy physicists as one defined by shared goals, understandings, codes of conduct, and definitions of time and space. Traweek described some of the basic preconceptions about time, space, matter, and persons that give meaning to the world of a high-energy physicist. She has also shown how those preconceptions take quite different forms in the United States and in Japan, demonstrating the historical contingency in local cultures.

The works by Latour and Traweek and others in science studies have broken down the wall between science and the rest of the world: Science is not value-neutral but instead, science is made of distinct local cultures, practices, and priorities, and the cultural values of science are deeply felt by its practitioners.

After its foundation in the last century, ethnographic studies on science laboratories continue to develop in the new millennium (Stephens and Lewis, 2019). Doing (2008) explicitly challenged the notion that earlier works by Latour, Traweek and alike have fully resolved the influence of social factors on the ontological status of scientific knowledge. Multiple ethnographers focused on studying the production of knowledge in the digital age. Alač (2011) used videotaping to study the interaction between neuroscientists and their computer screens, highlighting scientists' manual engagement with digital visuals of the human brain. Beaulieu (2010) advocated for using co-presence rather than co-location as the epistemic strategy to conceptualize ethnographic research. Co-presence decentralizes the boundedness of the physical space and can better "embrace textuality, infrastructure and mediation" in the digital age (Beaulieu, 2010).

Researchers have also been leveraging laboratory ethnography as a tool to transform science education (i.e., Ritchie and Rigano, 1996; Buxton, 2001; Brandt and Carlone, 2012; Carlone and Johnson, 2012). While science education research had been historically experimental, there was a naturalistic turn to ethnographic methods with the rise of social constructivism in the field in the late 1980s (Driver and Oldham, 1986; Joslin et al., 2008; Brandt and Carlone, 2012). One notable example was the laboratory ethnography by Buxton. He noted the formation of single-gender groups in a university lab, and that groups exhibit different conformity and resistance to culture norms in science (Buxton, 2001). For example, an all-female group quietly disrupts the competitive culture of science by sharing resources and helping lab members, while the all-male group was deeply engaged in the normative competition for resources (Buxton, 2001). He proposed that K-16 science education should include such an examination of how status hierarchy influences how individuals can contribute to science and the differential opportunities they are given (Buxton, 2001).

Researching novice scientists

The training of novice scientists is central to the activities of the lab. Most American academic labs rely on trainees as their main, if not only, workforce. The reproduction of the lab as an organization and of its culture depends on the selection and induction of new members from the *outside*. Science as a guild-like higher-order community of practice also relies on the active recruitment of individuals to reproduce itself and secure its prestige, competitiveness, and longevity (Lave, 1991). Inversely, the laboratory plays an irreplaceable role in the training of scientists (Argyris, 1967; Hofstein and Lunetta, 2004; Abdulwahed and Nagy, 2009). The formal training of scientists starts in the classroom, where students learn about the historical background and conceptual foundations of the field. Bridging the classroom with the profession of science, the laboratory is the site where *science students* undergo their rite of passage and become *scientists*. The profession of scientists is defined by its production of scientific knowledge. In the laboratory, both as a physical space and as a social organization, students learn the practice of producing scientific knowledge and more generally, the practice of *scienc-ing*. They learn the design, instrumentation, and theoretical background of experimentation. They mimic how to ask appropriate scientific questions and how to choose the right projects. They experiment with how to talk to scientists and talk like a scientist. They have their first taste of what it entails to work and live as a scientist. It is through these human-human and human-non-human interactions that novice scientists develop their scientific maturity and independence (Lave, 1991; Sethi, 2012; Rowbottom, 2016).

There has been an increasing interest in studying the training of novice scientists. For example, Austin (2002) and Bieber and Worley (2006) focused on the graduate students' career trajectory towards faculty positions; Minshew et al. (2021) reviewed the use of apprenticeship-based framework in STEM graduate training; Ayar and Yalvac (2022) studied how engineering graduate students learn through mentorship; Barab and Hay (2001), Walker and Sampson (2013), and Huang (2021) examined classroom-based teaching strategies for science students. Nevertheless, very few studies have examined the "critical period" of career development for most scientists, namely when they were first recruited and introduced to the laboratories in their undergraduate years. The vast majority of scientists started their laboratory career as undergraduates (Russell et al., 2007). This period is worthy of educators' closer examination since almost all participants in undergraduate research reported remarkably greater understanding, confidence, interests in science, and anticipation of scientific careers (Russell et al., 2007). Furthermore, as Bieber and Worley (2006) noted, graduate students seem to have formed their positive conception of a career in academia during their undergraduate years, which remained largely unchanged since (Kardash and Edwards, 2012). Early-in-career research experience has a truly formative influence on nascent scientists' career.

Newly recruited trainees contribute their own funds of knowledge and generate rich experiences and interactions in and beyond the laboratory space—an ideal sample for ethnographic analysis (Sampson et al., 2018; Bisht, 2021). Nevertheless, no existing literature has leveraged the tool of ethnography to record and interpret the dynamic process of how novice scientists are recruited and enculturated during their formative undergraduate years.

Research aim and questions

In this study, I aim to ethnographically characterize how novice scientists are initially recruited and enculturated into the laboratory. Interviews and participant observation were conducted in a biochemistry research lab at a small liberal arts college. Taking a predominantly interpretive approach, I ask the primary question:

> How do novice scientists make sense of their decisions and behaviors as they gain membership into the laboratory and the community of scientists?

I have devised several follow-up questions to guide the step-wise investigation of the primary question, which will be addressed one-by-one in the coming sections and eventually emerge as a coherent description of scientists' becoming. In the section "New to the Lab" after a brief description of the field site, I zoom in onto a novice scientist's first encounter with the lab and ask the questions: What is the motivation underlying the individual's participation in research? What is the process for a novice scientist to gain membership to a laboratory, and how do they make sense of that? In the section "Becoming a Scientist" I focus on the enculturation of novice scientists: What—and how—are the laboratory norms and values transmitted to a novice scientist? How do scientists make sense of them and the underlying cosmology?

Materials and methods

In my research, I studied how novice scientists are recruited and trained in a biochemistry laboratory at a small, private, predominantly undergraduate liberal arts college in the northeast United States. Unlike most research institutions, where the focus of training is on graduate students, and unlike most small colleges, where research activity is minimal, the institution where I conducted my research has maintained a high level of research activities while only having undergraduate students as trainees. This institution has also been successful in producing high-profile scientists. It has produced multiple Nobel prize laureates in the sciences and numerous members of the National Academies of Sciences, Engineering, and Medicine, making it one of the top producers of high-profile scientists in the country (Wai and Hsu, 2015). My membership in this institution affords me the opportunity to observe how scientists get their start as undergraduate students in the laboratory. Its proven track record of producing high-impact scientists also makes its model of selecting and training scientists informative to scientists and educators.

Latour et al. (1986) and Traweek (1988) have attempted to justify the functioning of laboratory science with their structure-centered, social constructivist paradigms, in part due to the fact that these ethnographers did not receive formal training in the laboratory sciences and thus lack the cultural fluency and common identity required to coherently assign meanings to practices. My work is unique in its Weberian interpretive and subjectivist approach (Weber, 1963; Burger, 1977). I am interested in how individual actors—novice scientists—giving meaning to their own behaviors in the laboratory in the context of their identities, dispositions, desires, goals, and life experience. My positionality as a scientist-anthropologist and my relationship with the participants afford me the privileged opportunity to empathize reflexively with my informants, tell the story from an insider perspective, and translate scientists' subject experiences into the lexicon of anthropology.

To conceptualize and articulate my findings, I further adopt the analytical framework of practice theory, specifically that of Pierre (Bourdieu, 1977a). Ideal for bridging the individual to the structure, practice theory pays attention to both micro- (i.e., an individual's everyday practice) and macro-level (i.e., gender, class, and race) factors to explore how individuals behave and exhibit agency within constraints of the social structure (Buxton, 2001; Carlone and Johnson, 2012). While, through agency, individuals have the opportunity to re-envision the culture in which they function, they are at the same time constrained by the existing culture and larger societal forces and structures (Buxton, 2001). In this view, culture is seen as a continuously constructed process rather than a set of traits handed down through generations (Buxton, 2001; Carlone and Johnson, 2012).

A community of scientists in a highly developed western country is not an example of the traditional communities that anthropologists study. Historically, anthropologists study communities in non-western, non-industrialized, "backward" and "exotic" places, whose cultures are different from that of *ours*. As a contemporary development, there is a trend among anthropologists to look back at their own societies and study people with power as well as those without. A notable early example is Benedict's (2006) *Chrysanthemum and the Sword*, which compared the culture and world view of industrialized, World War II-era Japan with that of the United States. More recently, Ho's (2009) *Liquidated* examined the culture of Wall Street investment bankers and how such culture perpetuates and reproduces itself. My current work is similar in that I adopt an anthropological perspective that was traditionally used to study *other* cultures to study a group of people with significant social and cultural capitals, of whom I am a member of.

Conversely, my own positionality as a scientist may bias my approach to studying how scientists behave (Jacobs-Huey, 2002; Holden, 2021). One goal of anthropology is to defamiliarize and problematize the uncontested, to find out what are the hidden meanings and norms underlying seemingly mundane practices that might be "meaningless" or "commonsense" to insiders. Traweek argues that the fieldworker needs to stay socially marginal: "If she were to become a fully integrated participant in the community, its sociocultural assumptions would no longer stand out in the foreground of her attention; and in any case it would no longer then be appropriate for her to be asking questions about the meaning of social actions" (Traweek, 1988). I often experience similar frustration in my work. Although as a scientist, I have easy access to the community, and although I speak the language of scientists, I could not help but to overlook many practices that I consider as "commonplace" and whose meaning I consider as "obvious". This unconscious ignorance costs me many possible "thick descriptions" of my conversations and observations. During the observation component of this study, I forced myself to adapt to a temporary suspension of assumptions and beliefs and to examine every behavior and decision with curiosity. I could by no means forgo all my assumptions and study the scientists I work with every day as if I am an alien visitor to the Earth. Nevertheless, I tried to ask my informants to justify every major decision they made on their journey to science and many discrete behaviors they perform in the lab, although oftentimes I assume I know the answers since I share very similar experience and background with them. I hope that with my insider knowledge on the development of individual scientists and my ethnographical suspension of assumptions, this work will contribute to our collective thick description of the scientific community.

Data collection and analysis

I joined the field site laboratory as a thesis student in May 2020. I performed in-person lab research during a period of 14 months and participated in all lab activities, such as lab space maintenance, new member recruitment, weekly group meetings and weekly one-on-one meetings with my advisor. I became close with my advisor and many lab members, who later voluntarily became my interviewees and the subjects of my observation.

Interview transcripts and field notes were my primary source of data, complemented by autoethnographic information. In total, I formally interviewed five individuals, all from this laboratory. One of them is the supervisor of the lab, a renowned biochemist, who is a tenured full professor. The other four individuals are undergraduate students working in the laboratory. One of them is a sophomore, two are juniors, and the other one is a senior thesis student. Besides my PI, who is a male, all my interviewees are self-identified as female, which reflects the demographic composition of the lab and the department: Among 13 thesis students in the lab, only two students self-identify as male, including myself. In this paper, I refer to all the people I interviewed using pseudonyms in order to protect their identity.

My research consisted of semi-structured interviews. I gave a recruitment information session at one of the group meetings, and the interviewees volunteered to participate in the study. The interviews were conducted over the Zoom video platform for COVID-19 safety concerns. I brought a list of prepared questions to each interview but tried to follow the natural flow of the conversation as much as I could while touching on the topics that were of interest to me. The primary goals of the interviews were to (1) learn about my informants' life history, (2) understand how they make sense of their practices, and (3) confirm or reject my field observations. Because of my pre-existing relationship with my informants, I was concerned that audio recording might change the dynamics and the nature of our conversations and therefore, I only took handwritten notes for all my interviews.

I analyzed my interview transcripts and field notes with standard ethnographic coding procedures, particularly semantic structure analysis as outlined by Spradley (1980) and Buxton (2001). Semantic structure analysis is a systematic and rigorous way to analyze ethnographic data and to reveal cultural knowledge and patterns. I started by identifying recurring terms and elements in my data, organized them into a hierarchical structure, and attempted to identify new associations by relating, contrasting, and synthesizing.

New to the lab

The institution where I did my research rests several miles away from a major metropolitan downtown. It is a small, undergraduate-only liberal arts college. The campus is surrounded by predominantly middle-class suburban neighborhoods. Designated as an arboretum, the campus is very spacious and scenic. On a 200-acre campus with merely 1,000 students, it is not hard to find a spot on campus—say, somewhere in the woods—where you cannot notice any human activity for the whole day. Most students and faculty members reside on or near campus and spend most of their time on campus. Students can take classes at other small colleges in the area, connected by a shuttle bus system, and take advantage of curricular opportunities at a major research university in the city downtown, reachable by train.

The lab where I did my fieldwork is a part of the newly renovated science building, located in the heart of the campus. While the building itself is historical, the interior has a simple, modern look. The physical space of the lab, which from now on I will refer to as the Jessen Lab, has a “wet” lab space for experiments and an adjacent “dry” space dedicated to paperwork but also as a social space for lab workers. The wet lab space consists of a central island bench and surrounding benches. There are several “stations” around the lab, which are dedicated to specific tasks, for example, dissection, measurement, and solution preparation. Each station is equipped with the instruments and reagents required for the specific tasks: the dissection station has a dissecting microscope and dissecting tools, and the measurement station has several analytical balances and common reagents to be weighted. Lab workers usually do work for an extended period of time at one station before moving on to the next.

The Jessen Lab is headed by a renowned biochemist, who I will refer to as Prof. Jessen. Prof. Jessen is a white male in his 50s. Prof. Jessen is an expert of analytical ultracentrifugation, a highly sensitive method to measure protein weight and concentration. In the corner of the lab is the analytical ultracentrifuge instrument that Prof. Jessen has used for more than 20 years. Prof. Jessen started to use this instrument during his previous job at a pharmaceutical company. After he relocated to the current institution, he applied for a federal research grant to purchase this instrument from his former employer and brought it here with him. The instrument and his expertise in using the instrument has helped Prof. Jessen generate numerous high-impact publications, in which he used the instrument to measure protein samples. The instrument has been sitting quietly in the lab for several years, since it is getting close to the end of its life cycle. People have placed random items, such as cardboard boxes, on top of the once glorious instrument.

The Jessen Lab currently has around 20 members in the 2020–2021 academic year. Unlike labs at major research universities, the Jessen Lab does not have any graduate students or postdocs. Besides Prof. Jessen, all members of the lab are undergraduate students currently enrolled at the institution. All students at this institution are required to finish a research project and to submit a thesis before they can graduate. There are four senior thesis students who are writing their theses this year and six junior students who will be writing their theses next year with Prof. Jessen. There are also around ten non-seniors who sometimes participate in lab meetings or work in the lab. Many of them are “interns” of the lab and are interested in performing their theses research in this lab when they are seniors. The size of the lab group has fluctuated over the years. In 2019, there were ten people in the group: Five seniors and four non-seniors. While most junior students will become senior thesis students in the lab, not all senior thesis students have participated in lab activities before their senior year.

The department assigned senior students to labs following a two-way match and lottery system. Each student can rank their preferred thesis labs, and each lab head, or Principle Investigator (PI), can rank their preferred students. Then, the ranking information will be inputted into a lottery algorithm that is designed to assign as many people as possible to their top-ranked labs with preference given to students who have also been ranked highly by the PI of their lab of choice. This black-box algorithm has been used in the department for many years, and the exact weighing mechanism is not well known. However, it is widely accepted that the lab PI’s ranking can play a determining role in whether a student can get assigned to a specific lab. This is how junior students in a lab often become senior members of the same lab since both the student and the PI tend to select each other when they already know each other. To get into a certain lab, it can be crucial to reach out to the PI in advance and have some participation in the lab before the lottery process. Everyone who declared a major in biology will be assigned to a lab, although which lab to join may not be their choice.

Although the process of joining a lab involves stochastic components, this process is predominated by analyzable, non-stochastic human-human and human-non-human interactions. Whether someone will join a lab—or a particular lab—is the product of the individual’s behaviors, disposition, and socio-historical milieu: A combination of the individual’s agency and the objective social structure. To investigate people’s journey to the lab, I start by looking at how they made the first contact with the lab and under what circumstances they first joined the lab as a non-senior member. What are their motivations to reach out and join a lab? What determines the timing of their entrance into the lab? Why did they choose this particular lab instead of another? What factors are involved in their acceptance into the lab?

The culture of cold emailing

In this section, I will characterize the strategies that students use to make the first contact with their current PIs and to seek membership in the lab. Among my interviewees and based on my personal experience, there are usually two scenarios in which this first encounter unfolds. In the first scenario, before reaching out to seek membership in the PI's lab, the student gets to first establish personal rapport with the PI through formal, college-sponsored opportunities, such as classes taught by the PI or invited presentations given by the PI. In the second scenario, which is more common among my interlocutors, the student has no pre-existing relationship with the PI, and the initial contact has to be established through unsolicited "cold emails"

My experience is an example of the first scenario, in which my request to join the lab is facilitated by my pre-existing rapport with Prof. Jessen. He taught my introductory biochemistry class, during which I contacted him frequently for class-related logistics. In addition, Prof. Jessen's lab is physically connected to the lab I was working for prior to joining his lab, and we often briefly exchange greetings when we run into each other. Through my contact with Prof. Jessen, I realized that his expertise in protein chemistry perfectly matches my interest and that I really appreciate his caring, highly individualized mentoring style. These pieces of intelligence are the determining factors in my eventual selection of his lab as my top choice for thesis lab.

I was more comfortable making the request to join Prof. Jessen's lab given our pre-existing relationship. The process felt more legitimized. At this point, Prof. Jessen is well aware of my ability, motivation, and potential contributions to his lab. I perceived the request to join his lab as a proposal for a fair exchange of labor and mentorship. If we did not have any previous contact and if he had no knowledge of my ability, there would be less equity between us due to the student-teacher power imbalance. I would perceive this request as asking him a favor to mentor me while I have little to return. I would also be more intimidated by the prospect of getting rejected by him.

Many of my interlocutors share a similar experience of establishing some forms of student-teacher or speaker-audience relationships before seeking lab memberships. Marie is a third-year student in the lab from the Philippines. She had Prof. Jessen as the lecturer for her introductory biology class: "I met [Prof. Jessen] in a class that I took and we liked each other. He is doing protein stuff and is very approachable. That's how I joined his lab." Helen is a second-year student in the lab. She will work for a laboratory at the major research university downtown. She met the lab PI during a talk the PI invited to give at the college. She reached out to the PI after the talk, who happened to be an alumnus of the college, and expressed her interest in working with him over the summer.

The recruitment of novice scientists into the lab often presents a difficult case for the PI of the lab. Recruitment in science relies heavily, if not mostly, on achievements in and endorsement from the candidate's previous research experience (also see Keith-Spiegel et al., 1993; Madera et al., 2019). Endorsement and past achievement are used as predictors for future success, and endorsement from previous PIs is trusted as basis for assessing the candidate's scientific and behavioral "fitness" for the lab, a common yet elusive concept in scientist recruitment. When admitting scientists-to-be without prior research experience into the lab, PIs often do not have the basis for an informed judgment. Oftentimes PIs would favor individuals who they have a pre-existing rapport with, such as students in their class or academic program; nepotism has also been reported in some labs.

On the other hand, it is not uncommon for students to initiate contact with PIs with whom they had no previous relationship. College students usually do not have an extensive scholarly network beyond the lecturers they had for their taught courses towards their degrees. Since most science majors require their students to take a set of prescribed courses, many students would have the same group of lecturers in their network, making the labs of these lecturers unusually popular among underclassmen and the slots in these labs highly contested. Therefore, students who wish to join a lab often need to go beyond their pre-existing scholarly network and reach out to people who are total strangers. Liz, a senior in the lab, first found Prof. Jessen off the department webpage.

> *"You know, you go to the [department] page, you look at the different bio professors and their synopses. And I cold emailed [Prof. Jessen] my sophomore spring and like right away, he wanted to have a meeting and he was like, OK, cool, come to the lab, you seem motivated enough."*

Ariana, a junior in the lab, described her experience of finding research opportunities as "just cold emailing after Profs." Indeed, oftentimes students need to email multiple PIs before they can get a reply. As mentioned previously, not all labs recruit undergraduates, and for labs that do recruit undergraduates, there may not be available slots at the time of the request.

The experience of reaching out to multiple PIs but only getting a few replies can be disheartening and even intimidating for students who hope to join a lab. To find summer research opportunities, Marie cold emailed more than ten PIs but only heard back from two of them. She is quite happy with the responses she received, but she also expressed her disappointment that many PIs just "ignored" her email without even saying no. When asked whether she is discouraged from reaching out to PIs by this experience, she commented that it is an uncomfortable process that all young scientists need to go through: "You gotta do what you gotta do."

The culture of cold emailing embodied the complex power relations between students and faculty members. From the perspective of students, the opportunity to work for a particular PI, or any PI, is a social capital that can further their careers. For faculty members, having students working for them is a form of human capital that would advance their research agenda. If the student later becomes successful in academia, this mentorship relationship would additionally become a social capital for the PI, since it expands the PI's network in the field. Despite the seemingly equitable, mutually beneficial exchange of resources, it is the students who make the initial, uncomfortable contact, and it is the PIs who have the privilege to decide who can get the opportunity and who cannot.

The culture of cold emailing is a product of economic reality, social norms, and power hierarchy. Although more students will bring more human capital to the lab, hosting research students does come with its cost. Senior members of the lab need to spare their precious research time to train novice students, and the lab often needs to pay a handsome stipend to sponsor the student. For high-impact labs, there are simply too many undergraduate students wanting to join the lab than what the lab can accommodate. Notably, while many PIs, including Prof. Jessen, are deeply involved in the training of novice scientists, often out of a sense of purpose and fulfillment, there are also PIs who are more reluctant to mentor novice scientists. Therefore, the supply–demand balance favors the lab and disfavors the students, putting students at a disadvantage in the exchange. Instead of having the PIs advertise opportunities in their lab, it is the students who reach out to inquire about the openings. Instead of having the students decide which lab to join, it is the PIs who decide who can join their labs and who cannot. The distinction of power and capital—material, social, and cultural—between students and faculty members delineates the boundary between the *student positionality* and the *teacher positionality*. Cold emailing is the strategy enacted by the students to maximize their potential in interacting with faculty members, who occupy a higher position in the hierarchical field of power.

The practice of cold emailing also demonstrated how the internet has helped students to transcend the barrier of power distinction. Without means like email, it would be very difficult for a college student to connect with high-impact scientists. Many of my interviewees have noted that although cold emailing PIs can be an uncomfortable experience, it is also a relatively low-cost way to inquire about potential opportunities. Many of them used the same generic template for emails sent to all PIs, which allows them to send cold emails in batches. The email addresses of most PIs—including high-impact scientists such as Nobel Prize laureates—are publicly available online. Students can reach the superstars in science with one simple click. The practice of cold emailing connects college students and established researchers in an unprecedented manner.

From medicine to science

In this section, I discuss the individual's motivation for seeking entry into a laboratory and how it is capitalized by the scientific industry to recruit novice scientists. While many students actively seek entry to research laboratories, very few of them intended to have a career in the scientific industry. In fact, almost all my interviewees, including myself, are pre-med students—college students who seek entry into medical schools—and initially joined the laboratory to boost our future medical school applications. Although some of us are still preparing for medical school, many people have changed their career plans after joining the laboratory, many of whom have decided to pursue a career in research. Our experience in the laboratory played a determining role for those of us who changed our career trajectories. I argue that there is a symbiotic relationship between medical school admission and the recruitment of research scientists. Medical schools rely on research laboratories to provide bench-side scientific training for future physicians. On the other hand, the criteria for medical school admission directs many ambitious students to research laboratories and supplies the field of biomedical research with a talented pool of potential candidates. Research laboratories actively capitalize on the supply of pre-med students and successfully convert many of the students from future physicians to aspiring scientists, thereby maintaining a sustainable influx of fresh blood to the field. I am interested in what determines who will join the scientific industry and who will not.

During my fieldwork, I realized that there is not a simple factor that predicts who will become a scientist but instead, the becoming of a scientist is the product of complex life experiences, social relations, and historical contingencies. Variables like gender, class, cultural affiliation, and actors like parents, mentors, and peers all play important roles in an individual's journey of becoming a scientist. Although the factors contributing to the formation of the scientist identity are multiplexed, there does seem to be a similar set of experiences, world views, and motivations shared by many of my interlocutors. In other words, a common scientist *habitus* has emerged from my interactions with these several individuals from this laboratory. It is not to say that the becoming of a scientist is purely the product of objective forces and social structures. Although one's life history and relative social positions set boundaries for one's behaviors and world views, it is one's free will that determines how the material and social capitals are strategized and mobilized to navigate in the social field and to fulfill one's full potential. Pierre Bourdieu famously argues that while in the practical world there are "procedures to follow, paths to take" the *habitus*—personal dispositions produced by history—"may be accompanied by a strategic calculation tending to perform in a conscious mode" and can create "an infinite number of practices are relatively unpredictable" (Bourdieu, 1977b). It is evident in my fieldwork that novice scientists make conscious decisions regarding their participation in the laboratory and career choices, pursuing their subjective aspirations, motivations and needs. Instead of being propelled by the elusive momentum of the *habitus*, novice scientists give clear justifications to their actions and decisions, while being well aware of the external forces which shaped who they are today.

It is also not to mistake my recognition of a common scientist habitus in this laboratory as a generalization of the experience and disposition of all scientists. Great diversity exists in the scientific community. The Jessen Lab presents a particular field of social relations that on one hand deposits common meanings to its members and on the other hand, is occupied by individuals with common dispositions and capitals, since the lab presents a specific positionality within the higher-order fields, say, the greater scientific community. Instead of being interpreted as the oversimplified notion of "all scientists are the same" my argument aims to convey that the aspiration of becoming a scientist is produced—and enabled—by particular life experiences and socio-historical conditions, many of which are recurring in the current world, and which also determine what kind of scientists is being produced. All my interviewees are considering a career in medicine. While Ariana and Liz want to attend a traditional medical school, Helen and Marie are considering a combined program between medical school and graduate school called MD/PhD program. They all joined the Jessen Lab initially in preparation for medical school admission. It is widely understood that research experience is a "prerequisite" for admission to competitive medical schools. Helen decided to find a lab to join following the advice of her externship supervisor:

> *"I was looking just for a summer experience, my sophomore year of college, and I had just an extern with a neurosurgeon who told me I should really get some research experience under my belt and knowing that I wanted to work with neurodegenerative diseases or neurons in some way."*

When asked why she joined a laboratory, Marie similarly answered that "I always enjoy science. It's ingrained in my life. But [laboratory research] is also expected by medical school." Helen noted: "I've kind of realized right off the bat that research is something that I do want to continue to explore because I'm on like the premed track." The desire to attend medical school is the initial and major motivation for students to join a research laboratory.

When we further unpack their aspirations to attend medical school, I noticed several social conditions contribute to such aspirations. Family has a major impact on the student's decision to pursue medicine. Many parents, especially Asian and new immigrants, put special importance on the socio-cultural status of the medical profession, how the profession can elevate the socio-economic status of the family, and how a stable, well-compensated job is essential for their children's happiness. Many of my interviewees are of Asian descent and new immigrants, and they made sure to highlight how such identities contribute to their parents and their own favorable perception of the medical profession. When asked about why she wants to pursue medicine, Liz, an Asian woman and second-generation immigrant, commented that: "I think a lot of it is like it does go back to my family influence, like it's our collective dream. You know, the typical Asian family." She also mentioned that if she chose science as a career, her parents would "be skeptical of the money" that she would bring in and "they would—I mean, they have gotten better as time has gone on—but I think they would definitely be a little disappointed." Ariana, also an Asian woman and second-generation immigrant, said that medicine is her first choice mostly because of the job prospect and her parents encouraged her decision: "Especially my mom. My dad was more like, you can be like an accountant or professor of law. Law. Yeah. Like those interests, but also medicine."

When asked why they would internalize their parents' expectation, all my interviewees mentioned that they believe in their personal responsibility to the family and to their parents. Liz said she did not realize that career was a choice until college because she was "just trying to make [her parents] proud" and she noted "it's kind of like almost a responsibility for me to follow through with [our collective dream]." Marie also mentioned that she would prefer the better-compensated medical profession to research as a career because "since I am the oldest child of the family, I feel responsible for my parents." To my surprise, all my interviewees are the eldest child in their families. I mentioned this observation to Liz, and she responded that "elder siblings just have to grind it out to make a good example, you know, a little extra pressure" and she is "paving the way" for her younger siblings who also want to be clinicians. Parents' expectations, oftentimes corrective, are not the only way that family members exert influence on their children's career in medicine and science. For example, both parents of Maire work in the health professions, and Maire has gained great familiarity with medicine since a young age. Liz mentioned that the passing of her grandmother due to medical negligence also shaped her aspiration in medicine, and by becoming a physician, she and her family want to prevent the same thing from happening to other people in the future. Both examples illustrated how family can positively inspire aspirations in children without the normative and disciplinary mechanisms through which parental expectation exerts its force.

On the other hand, family sometimes can exert a negative influence on the individual's desire to pursue laboratory science. As previously mentioned, Liz said her parents would be disappointed if she conducts research as a profession because they are "skeptical of the money" that science can bring in comparison to medicine. Helen is also experiencing a "separation of identity" in her family. She is a first-generation college student, and none of her family members went to college. While she truly enjoys science and biology, her relatives are not supportive and "do not understand why I'm pursuing science at all… I feel like I cannot share that identity with them."

While family is the most salient factor contributing to one's decision to pursue medicine, high-quality mentorship is what lures people to science. All my interviewees commented on how their early experiences of high-quality mentorship were essential for their interests in science. When asked when their story with science started, all my interviewees mentioned how great the science teachers they had in elementary, middle and high schools are.

> *"I have had a number of different teachers supporting me, but I would say my seventh-grade teacher, Mrs. Donovan, was really, really cool, and she was always the type of person who likes to meet after class with me and chat about my questions."* (Liz).
>
> *"I'm interested in the sciences because I had a really good science teacher and bio teacher, actually. So she also made me like science, really, like a lot. And she made me really like the molecular side of things."* (Ariana).
>
> *"It wasn't like that until I met my third-grade science teacher. She really made me feel like embracing me for who I was. She knew I had a question before I even raised my hand, and she has confidence in me that was lacking for so long."* (Helen).
>
> *"I attended an all-girls school and there wasn't much pressure from the males. They always encouraged us to picture yourselves in science."* (Marie).

The consensus between these testimonies demonstrates that high-quality early mentorship is key for the becoming of a scientist. My interlocutors highlighted the value of individualized mentorship and the establishment of confidence facilitated by their mentors in fostering the student's interest in science and ultimately, the becoming of a scientist.

The quality of mentorship and mentor-mentee relationship remain important for the satisfaction of student experience and the retention of students in the scientific industry. Prof. Jessen is very popular among his lab members and in the department. All my interviewees noted how approachable he is and how much individual attention he gives to his students. This is consistent with my personal experience with Prof. Jessen. He is an extremely agreeable person and who is never stingy with encouragement and compliments. According to hearsay, he has different sets of usual topics to chat about with different students during their one-on-one meetings, which demonstrates his highly individualized mentorship approach. By doing so, he also makes sure that each student feels special and valued in the lab group. Not only is the mentor-mentee relationship between PI and students important, but my interviewees point out that other senior members of the lab also play important mentorship roles. Helen, who once belonged to another lab group, revealed to me that the reason why she left the previous group is due to the stagnant sense of community in that lab. "It's just that you feel very alone in it." She noted that the Jessen Lab has a much more vibrant sense of community, and senior students are more willing to mentor new members of the lab. She mentioned that every time she leaves the group meeting, "I kind of leave feeling reassured that I want to pursue a career in science and be part of a scientific community."

Pre-med track is an extremely important—sometimes the sole—pipeline that supplies new talents to the scientific industry. I have demonstrated that family plays a key role in potentiating the student's desire to pursue medicine and that the quality of mentorship has deep implications for the recruitment and retention of students in science. For my interlocutors, the career debate between medicine and science is a multiplexed and dynamic process that involves multiple considerations and stakeholders, including job security, filial piety, family responsibility, and personal fulfillment. My interviewees often cite the relative low pay of academic jobs and the competitiveness of tenure track positions as reasons why they would not pursue a career in science. The scientific industry has capitalized on the friendly and supportive community as a key selling point to attract and retain talented students.

For individual subjects, there is seemingly a tension between medicine and science, between the bedside and the benchside, and between the aspiration to practice medicine and the production of scientific knowledge. In the Jessen Lab and seen elsewhere (Thoman et al., 2015), there seems to emerge a *student scientist habitus* of altruistic impact-making. Instead of being two conflicting, incompatible ends, the aspiration to practice medicine and the production of scientific knowledge are two enactments of the same *student scientist habitus*, produced by prior life conditions but also further conditioned by the laboratory experience. Individual novice scientists, instead of expressing two separate, incongruous identities, enact a unified subjectivity in the laboratory. What drew them to both medicine and science is their desire to make altruistic impacts on others' lives.

One salient piece of values that all my interlocutors shared is the importance of making a positive impact on others' lives. When describing medicine as the "collective dream" of her family, Liz made the remark that she and her parents "romanticized the idea of the altruism that comes with medicine, like you are directly improving people's lives in a very tangible way." Similarly, Marie mentioned that her motivation to practice medicine is rooted in her desire to "help others instantly." The desire to make a tangible, positive impact on people's life produces a *particular kind* of science in the laboratory, *via* the durable and transposable mediation of habitus.

This kind of science is altruistic, as evidenced by the biomedical focus of the Jessen Lab on neurodegenerative diseases and the ultimate goal of many lab members to "provide new treatment for a disease." This kind of science is also eager to impact. When asked what makes a good project or good science, most of my interlocutors emphasized how important it is to produce translational and applicable science, or in other words, impactful knowledge. In the field of the Jessen Lab, the habitus of altruistic impact-making—that enacted the aspiration to practice medicine—produces altruistic and impactful scientific knowledge. Helen's comment well recapitulated this point: "For me, science has to connect to helping people, because it's just I have to see the innovations of science having an impact."

Becoming a scientist

The training of novice scientists is a process of status transformation, from laypersons to members of the research community. In this process, students discover how to talk, write, behave, perform, and socialize as a scientist. They learn after the PI and their peers, *via* active instruction and passive observation. As they are accustomed to the practices, they also give meanings to these practices, understand their rationales, and deposit the underlying values into their *scientist habitus*.

In this section, I will present several observational vignettes that focus on quotidian human-human and human-non-human interactions in the laboratory. By describing how new members are introduced and accustomed to these *normal*, *authentic* practices, I represent novices' transformation into scientists as a rite of passage, facilitated by the transmission and internalization of cultural norms. At the same time, I wish to use these snippets of normative practices as a window to illustrate the transactions—local or widespread—performed daily by the scientific community. These daily transactions are the community's means of subsistence, and the transmission of these practices to the novice is how the community reproduces its culture and identity. By studying these enacted practices, we will piece together and gain a deeper understanding of the *scientist habitus*—in which the cosmology of scientists is embedded—that enables and enacts these daily behaviors in the laboratory.

Purity, pollution, and scientific validity

For novices beginning in the lab, the physical preparations when one enters the lab is a strange yet exciting process. You need to wash your hands, put on the lab coat, gloves, and goggles. Prof. Jessen constantly sent out emails to remind people of the importance of wearing protection and cleaning up surfaces before and after the experiment. This ritual-like protocol is quickly learned, deeply memorized, and repetitively practiced by novice scientists.

> *"I would, like, when I go into the lab, I'm thinking, OK, my lab coat on. I got to put on the gloves, I got to do everything."* (Helen).

Sanitation and purity are highly valued in the lab space, especially during the age of COVID. The official rationale is first, to protect experiment samples from bacterial and fungal contamination that humans bring into the lab and second, to protect humans from potentially hazardous lab organisms and reagents. In the time of COVID, an additional rationale is to protect humans from infecting each other. It demonstrates the presence of symbolic boundaries in the lab space, namely the separation of non-human items and human bodies. Non-human items and human bodies are considered dangerous and polluting to each other. To prevent contamination, a barrier device must be worn to separate non-human items and human bodies. In the time of COVID, human bodies must be separated as well.

Purity is a recurring key theme in the laboratory. Lab members frequently refer to concepts such as "DNA purity" "protein purity" and "ultra-pure water." Purity, or the lack of contamination, seems to be essential for the validity of the scientific knowledge produced, as well as the efficiency and productivity of the lab. The validity of the scientific knowledge produced is contingent on one's power to create a highly controlled, contamination-free environment. Although the college and the Jessen Lab both have very limited research funding, the supply shelf for gloves and disposable protection devices is always fully stocked.

Novice scientists—being the liminal intermediates in the rite of passage from laypersons to experienced scientists—themselves are sometimes considered as a source of pollution in the laboratory, which can be dangerous for the "validity" of scientific knowledge and disruptive for the integrity of laboratory practices. When I was a novice scientist under training, my former PI said she is often "concerned" and even "bothered" by how I conducted experiments. I often inevitably deviate from the protocol because I am constantly confused about what is an acceptable practice and what is not. She would correct me all the time, and gradually I learned what is acceptable and what is not. For example, I used to conduct behavioral experiments on fruit flies—the model organism we use—during different times of the day. I later learned that I should always conduct my experiment at the same time of the day to ensure that the circadian rhythm of my flies is *pure* and synchronized. When I became mentor for more junior students, I am also constantly concerned if they are conducting experiments in the correct manner and whether the knowledge they produce is valid and "kosher." By suspending confidence and expressing concerns, my previous PI and I demonstrated the importance of scientific validity to—and exerted corrective forces on—the novice scientists. As mentors and vessels of cultural transmission, we seeded and consolidated scientific values and norms in the novice scientists, powering their transformation into mature scientists.

The usage of the lab space

While the Jessen Lab is a friendly, close-knit community outside of the lab space, my interlocutors noted that there are few interpersonal interactions occurring in the physical lab space, besides occasional "small talks." This is because lab members come in for work at different times of the day, unless a discussion or demonstration was scheduled. When talking about her daily interactions with other lab members in the lab space, Ariana, who just joined the lab, said "they are nice people, but I do not converse with them. Yeah, they come in and out of the lab and whenever they are in the lab, they are just looking at the microscope and stuff. So I feel kind of bad asking them questions."

Indeed, in the lab space, people are more often interacting with non-human items such as microscopes, pipettes, and fruit flies rather than interacting with other lab members. Research is a highly cooperative endeavor, however, most of the cooperation in science happens in offices, meeting rooms (physical and online), national conferences, and grant review panels. Lab space, on the other hand, is used as a personal space of solitude. Many of my interviewees commented how much they enjoy spending time alone in the lab doing experiments and how relaxed such experience is.

> *"I think just the environment is just very calming to me. I like going in. I think the lab is a physical space to zone out a little bit and to just focus on what I'm doing with my hands full time, without my brain thinking."* (Ariana).
>
> *"It is a very Zen experience working in the lab."* (Liz).

For them, the physical lab space has become a space of relaxation and meditation. This is very much due to the repetitive and manual nature of most of the lab work. One can simply mechanically follow the protocol without putting in any intellectual effort. It is contradictory to the popular perception that the lab is a space where knowledge- and brain power-intensive work takes place. In fact, the ability to repeat protocols mechanically without modification is an asset highly sought after in laboratories. Recently, robotic systems have been developed to replace human researchers in the laboratory (Thermo Fisher Scientific, 2021). Similar to how purity is valued in the laboratory, the ability to repeat protocols mechanically represents the power to exert control over living and non-living matters in the environment. More importantly, it signifies the importance of indoctrination in the laboratory: Follow the protocol, no deviation allowed.

Lab notebooks and fly lines

Since the first day they joined the laboratory, novice scientists are told the importance of maintaining a well-documented lab notebook. In the notebook, they must record all procedures performed, all results collected, and all interpretations transpired. Procedures must be documented with sufficient details that other people can repeat exactly the same experiment according to information in the notebook. Every page needs to be numbered and dated, and all attachments must be firmly fixed into the notebook and initialed at the border. Once information is put into the notebook, it should not be erased. Prof. Jessen would regularly check each lab member's notebook, either planned or unannounced, to make sure that all entries are up to date. He often tells students the experience from his previous job in the pharmaceutical industry, where they would have weekly notebook "signing" parties and colleagues would cross-check and put signatures on each other's notebook page by page.

None of my interviewees enjoy the process of maintaining a lab notebook. In fact, it is the least favorite part of lab work for many of them, and Liz mentioned that sometimes the idea of writing a lab notebook makes her not want to come to the lab. Despite how tedious it is to maintain a notebook, all my interviewees acknowledge its importance. The official justification for maintaining a lab notebook is multiplexed but in general, it is used as evidence in situations of dispute. For example, the exact date of when a discovery or invention is made is important for publication review and patent applications. Therefore, it is important to timestamp each page so that the notebook can be submitted as evidence when potential disputes arise. More importantly, there are frequent cases where scientists manipulate and even fabricate data so that their work can be published in high-impact journals. When journal editors or the institution suspect the occurrence of scholarly misconduct, the notebook will again be submitted as evidence, and the reviewers will expect to find sufficient details to replicate the experiment from the notebook. Prof. Jessen once said that he will not consider an experiment as performed unless it is recorded in the notebook.

The practice of maintaining a lab notebook embodied the constant surveillance—both self and mutual—within the scientific community, necessitated by the scholarly dishonesties that are frequently exposed. The practice of transforming *everything* into a document is the mechanism that the scientific community devised to arbitrate disputes and restore the trust within the community. By getting accustomed to the practice of notetaking, novice scientists internalize the externality of the scientific community and enact, thus reproduce, the culture of documentation, surveilling themselves and one another.

What is the cause of scholarly dishonesty? Economist Paula Stephan highlighted the negative impact of the current reward system in the scientific community. She noted that science distributes most of the reward to the *first*: The first to discover, the first to publish, the first to invent. She disagrees that science should be a "winner takes all game" that is to say, only the *first* is getting rewarded. Instead, she argues for a "tournament game" system, "with different levels of leagues and contributions from players with different levels of skill, who may receive recognition at various levels, for example, an honorary degree if not a Nobel prize, that still merits attention." (Etzkowitz, 2013; Stephan, 2015) She emphasized that a performance-based reward system exerts immense pressure on scientists: Under such incentive mechanisms, trivial differences in research ability will be amplified into significant distinctions in terms of reward, and scientists are encouraged to participate in cut-throat competitions with each other and engage in morally questionable actions.

It is the social-historical reality of how scientists are rewarded that potentiated the misconducts in science, which in turn produced more history, and the culture of surveillance is a product of this dynamic process, eventually getting internalized by novice scientists.

It is not to be mistaken that scientists belong to a community devoid of cooperation and trust but instead, collaboration is inevitable in modern science. When you read through high-impact scientific journals, it is very rare to spot articles in which all authors are from the same laboratory. Most recent scientific knowledge is the product of scientific collaborations, and most collaborations are interdisciplinary, meaning that multiple lab groups with different expertise find each other to work on the same problem.

One material embodiment of the cooperative exchange between scientists and lab groups is the transgenic fly lines within the laboratory. In the Jessen Lab, we use fruit flies which are inserted with or deleted of certain genes to study the function of these perturbed genes. It is extremely labor and resource-intensive to generate these transgenic fly lines. To alleviate this burden of the community, scientists from all around the world deposited the fly lines they already generated at one of several major stock centers. The main center responsible for distributing flies in the United States is hosted by the Department of Biology at Indiana University, Bloomington. We acquired almost all our fly lines from Bloomington, which include flies from Stanford, Japan, and Germany.

Scientists are deeply committed to a supra-national, identity-transcending cosmology of science and the scientific community. Few identities can mean so much to members of the community as being a scientist. All my interviewees listed being a scientist as one of their primary identities. This strong sense of shared identity and common goals contributes to the culture of resource sharing among scientists, which conversely strengthens the community.

The culture of resource sharing was demonstrated to and reinforced in novice scientists throughout their training. Many of my interviewees were surprised when they first learned that people share their arduously acquired reagents for free. It is through observing the PI ordering flies from Bloomington and senior students borrowing chemicals from our neighbor labs that novice scientists, learning that reagent sharing is *acceptable* and to in some cases *expected*. Deviance from this norm by refusing to share reagents will risk alienation and even the jeopardy of scholarly credibility, if the reagent is required for reproducing a published result. By internalizing the culture of reagent sharing, the novice scientists adopt the cosmology of a united scientific community. They first consciously mimic the practice and later express the cultural norm fluently, instantaneously, and unconsciously. When the novice scientists later become mentors of others, they will showcase the practice of reagent sharing and pass down the sense of communality to the next generation of novices.

Lab coat, notebook, fruit flies. Through episodes of normative practices and how novices engage with them, I represent the training of novice scientists as a rite of passage that is facilitated by the transmission of cultural norms, namely behavioral habituation and values imprinting. Encountering new situations daily, the novices progressively chart—and make sense of—the landscape of *authentic* scientific practice. They get rewarded when they behave conformably and disciplined when they break the norms. They not only learn to enact scientist but also internalize the norms and priorities of the scientific community: What is normal and what is delinquent? What is valued and what is denigrated? As novices gained cultural fluency, they conclude their neophyte liminality and mark their transformation into *authentic* scientists: No longer destructive, no longer polluting.

Discussion

Few studies have looked the very moment when a nascent scientist emerges in the laboratory. Challenges for studying the becoming of scientist include the transient nature of the process and the sparsity of nascent scientists in each lab site at a given time, which prevent the field study of such population *en mass*. Nevertheless, from a societal standpoint, studies on how novice scientists are first recruited to and trained at laboratories are advisable since these events play a gatekeeping role for the scientific community (Bilimoria et al., 2008; Hunter et al., 2010; Estrada et al., 2016). Laboratory training determines who can become a scientist and more importantly, who will produce our science. Experience in the laboratory is virtually required for being a scientist and for continuing the training and a career in science. However, divergent experiences in the laboratory are heterogeneously distributed among the population and consequently, not everyone has the same probability of becoming a scientist (Estrada et al., 2016; Harper and Kayumova, 2022). As for the career development of individual scientists, the liminal stage of entering a lab also has profound impacts on the formation of their scientific identities (Bieber and Worley, 2006; Russell et al., 2007).

In this study, I aim to characterize how novice scientists are initially recruited and enculturated into the laboratory. I explored the motivations underlying novice scientists' participation in laboratory research, how novice scientists strategize to gain access to the laboratory, and various normative practices that novice scientists encounter and internalize. In particular, I took an interpretative approach in my accounts, highlighting how novice scientists, as individual actors, give meaning to their own decisions and behaviors. I also embrace my positionality as an ethnographer-practitioner, which allows me to engage with my field observations with an autoenthographer's reflexivity, generate richer insights, and then parse the observation with an anthropological orientation.

This work has been one of the first ethnographic accounts that study the recruitment and training of novice researchers in the laboratory setting. I described and analyzed several patterned practices that were absent from the literature, including the culture of cold emailing and the cryptic channeling of pre-medical candidates to graduate schools. Both practices implicate both barriers that impede one's recruitment to science and catalysts that boost the process, highlighting the gatekeeper status of early laboratory training. The phenomenon of is multifaceted, as demonstrated by various quantitative studies. Some people are more interested in science and more motivated to seek laboratory training even before their first laboratory experience (Tai Robert et al., 2006; Archer et al., 2022). Laboratory recruitment efforts are unevenly targeted toward a subset of the public (Baker, 2000; Archer et al., 2022). After joining the laboratory, people encounter different experiences, which can lead to varying interests in scientific careers (Russell et al., 2007; Archer et al., 2022). One's behaviors in and endorsement from their lab group—the two of which are related but not equitable—also greatly influence one's future placement (Keith-Spiegel et al., 1993; Madera et al., 2019).

The ethnographic data in this work focus on not only the immediate, lived experience but also how novice scientists *make sense of* their experiences, giving voice and agency to the novice scientists anonymized in quantitative data.

Many ethnographers have attempted to transcend the boundaries of their field sites and assign wider meanings to their observations (e.g., Latour et al., 1986; Rapp, 1988). In this study, I also observed practices and behaviors that has generalizable implications when situated in the existing literature. In the lab Buxton (2001) studied, many members cited the desire to help others—through research or medicine—as their motivation to join the lab, echoing the altruistic profile of the Jessen lab scientists. Buxton's interviewees also similarly viewed support from family and mentor as career-affirming. However, Buxton also argued that the altruistic motivation and the interpersonal emphasis are highly gendered and have a feminist undertone, which mirror the predominantly female makeup of the Jessen lab. The same linkage between femininity, sociality, altruism, and interest in science careers was supported by another, quantitative analysis as well (Thoman et al., 2015). Combining multi-sited observations, we come to a sketch of a female scientist-in-becoming—who are altruistically driven and who value social networks. To promote the recruitment of women into science, we may want to foster a STEM education environment that emphasizes high-quality mentorship and affords altruistic fulfillment.

Although, regrettably, not extensively explored in this study, social networks and the organizational structure in the laboratory have deep implications for novice training. For example, Feldman et al. (2009) studied how research groups are socially structured. They generalized PIs' conceptualization of lab members as a hierarchy based on their expertise, and individuals can climb up the hierarchy by accumulating more expertise. How does this conceptualization shape how PIs engage with their lab members? How do lab members conceptualize themselves? In the current study, where all lab members are undergraduates, the hierarchy of expertise is flattened. How does it change interpersonal interactions in the lab? Is there any alternative gradient of distinctions? All these are interesting questions for future studies.

A key message from this study is that the qualitative ethnographic research approach can be a power method to gain a deeper understanding of the complex sociocultural interactions present in the science laboratory. This helps as a basis for understanding how laboratory scientists are produced in situated, local settings. Laboratory actors' behaviors and experiences are shaped by—and also re-shaping—the identities, dispositions, and socio-historical positionalities, the complex system of which can benefit from the holistic synthesis through an anthropological lens. Indeed, with attentive fieldwork and in-depth analysis, the current ethnographic study readily synthesized how sociocultural forces at workplace and household interact to influence participants' recruitment to and retention in science, as well as nominating promising remedies for this particular field: e.g., high-quality mentorship. Few quantitative instruments offer comparable richness of data and nuance of analysis. Further ethnographic studies of how scientists are recruited and trained, in laboratories—or non-laboratory disciplines—of various kinds, will help to reveal the diversity of local cultural systems and expand the picture of how scientists are produced. Among the diversity and heterogeneity of cultural systems, one may be able to identify sets of "healthy" practices that nurture young scientists in different situated settings and support the production of high-quality scientific knowledge.

Conclusion

Remodeling the value-neutral and the structure-centered depiction of science, I represent the research laboratory as a social organization with its own ecology and culture. The culture of the laboratory needs to be reproduced, and like other non-kinship organizations, it is achieved through the induction of new members into the community. Novice scientists come into the laboratory with their pre-existing habitus, produced by their life experiences and socio-historical conditions. Strategizing and negotiating, they navigate through the field of the laboratory and chart the landscape of values and normative practices. Habituated and transformed, they internalize the culture of the laboratory and consummate their rite of passage, securing their membership to the research community.

Data availability statement

The data used and analyzed in the study are available from the author on reasonable request.

Ethics statement

The studies involving human participants were reviewed and approved by Institutional Review Board, Bryn Mawr College. The patients/participants provided their written informed consent to participate in this study.

Author contributions

The author confirms being the sole contributor of this work and has approved it for publication.

Conflict of interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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