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REVIEW ARTICLE

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Running a successful STEMM summer program: A week-by-week guide

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Abstract

While some established undergraduate summer programs are effective across many institutions, these programs may only be available to some principal investigators or may not fully address the diverse needs of incoming undergraduates. This article outlines a 10-week science, technology, engineering, mathematics, and medicine (STEMM) education program designed to prepare undergraduate students for graduate school through a unique model incorporating mentoring dyads and triads, cultural exchanges, and diverse activities while emphasizing critical thinking, research skills, and cultural sensitivity. Specifically, we offer a straightforward and adaptable guide that we have used for mentoring undergraduate students in a laboratory focused on mitochondria and microscopy, but which may be customized for other disciplines. Key components include self-guided projects, journal clubs, various weekly activities such as mindfulness training and laboratory techniques, and a focus on individual and cultural expression. Beyond this unique format, this 10-week program also seeks to offer an intensive research program that emulates graduate-level experiences, offering an immersive environment for personal

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and professional development, which has led to numerous achievements for past students, including publications and award-winning posters.

KEYWORDS
DEI, mentoring, professional development, summer program

1 | INTRODUCTION

A central component of undergraduate success in science, technology, engineering, mathematics, and medicine (STEMM) is participation in internships and summer research programs (Bradford et al., 2021). These opportunities are particularly important for underrepresented groups (per NIH guidelines: https://www.niaid.nih.gov/grants-contracts/underrepresented-person-definition), including underrepresented minority (URM) students (e.g., African American, Hispanic, Native American/Alaska Native), first-generation college students, persons with financial or social disadvantages, and those with disabilities (Bradford et al., 2021; Bruthers & Matyas, 2020; Jackson et al., 2023; Jeffe et al., 2012). Innovative mechanisms targeting URMs are essential today, as there remains a "leaky" pipeline, marked by low recruitment and subsequent retention for URM students in STEMM (Allen-Ramdial & Campbell, 2014; Hinton, Termini, et al., 2020). Although there has been a gradual increase in diversity within STEMM compared to the general population, STEMM has less diversity, especially at higher educational and leadership levels (Fry et al., 2021; Funk, 2018; National Center for Science and Engineering Statistics [NCSES], 2023). For example, in 2021, despite URM students making up about 37% of the total population, they account for only 16% of individuals with doctoral degrees in STEMM (NCSES, 2023). As URMs are further disaggregated, and high-level leadership positions are considered, these disparities become more apparent (Fry et al., 2021; Funk, 2018; NCSES, 2023), highlighting that not only is the recruitment of URM students into STEMM an issue, but so is their subsequent retention in high-level positions. While the case for increasing diversity within STEMM is multifaceted, at a fundamental level, the business case advocates for positive dividends for all groups through increased diversity (Herring, 2009). In STEMM, this is partially exemplified by the increased rate of innovation concomitantly with increased diversity (Hofstra et al., 2020). Thus, creating high-quality summer programs for undergraduates has arisen as a critical mechanism to encourage the retention of students, especially those who are URM in STEMM.

Among URM students, participation in research activities remains one of the most significant predictors of future full-time faculty academic appointment (Jeffe et al., 2012). More broadly, research activities positively influence undergraduates. Past student interviews at other institutions show that these experiences aided them in thinking and working like a scientist and preparing for their future career goals (Seymour et al., 2004). Undergraduate research experiences have been reported to have many positive outcomes as they help students internalize science concepts by giving them ownership of their projects (Hernandez et al., 2018). Other undergraduate research programs have been proven effective in improving students' skills in experiment design, data management, lab safety, statistical analysis, scientific communication, ethical research practices, and career development in the scientific field, along with other common skills for graduate school (Bruthers et al., 2021). Beyond providing research activities, STEMM research summer programs provide an avenue for individualized and intentional mentoring (Shuler et al., 2021), which may offer long-term benefits, especially for URM students (Beech et al., 2013). Generally, these summer research programs (while potentially having a significant cost commitment) attract diverse individuals, increase the interest of students in STEMM careers by involving them in the "culture" of research, and relatively retains a high percent of students' interest in science, with less than 10% losing interest in science (Russell et al., 2007). While students in intensive summer programs may report being surprised by the amount of work required to make scientific discoveries and produce data, they generally reported having increased motivation (Bruthers & Matyas, 2020). Past studies have shown that for individuals with intersectional identities, such as African American females, summer programs increase students' confidence in pursuing STEMM graduate studies (Jackson-Smith, 2015). In particular, beyond being especially beneficial for URM students (Bruthers & Matyas, 2020), past analyses of these research programs have shown them to be particularly effective for individuals with little or no previous research experience (Bruthers et al., 2021). In a similar vein, we have previously established a comprehensive undergraduate mentoring and research program known as *Project Strengthen*, which parallels Maximizing Access to Research Careers (MARC) programs while requiring a lower cost requirement, which is especially beneficial for URM undergraduates with little or no research programs (Barongan et al., 2023; Marshall, Brady, et al., 2022; Marshall, Palavicino-Maggio, et al., 2022a; Marshall, Vue, Palavicino-Maggio, et al., 2022). Based on the effectiveness of this program and prior positive outcomes from undergraduate summer research programs (Bradford et al., 2021; Bruthers & Matyas, 2020; Cohodes et al., 2022; Hernandez et al., 2018), we sought to formulate and provide a guide for our undergraduate summer research program.

Summer research programs can vary in length and goals with differing outcomes, as previously discussed (Cohodes et al., 2022). For example, some summer bridge programs can only be a couple of weeks long and aid in preparing students for the adjustment of college (Cooper et al., 2017). Other summer research models represent student-centered and course-based research models that occur over extended periods, such as 8 weeks (Jackson et al., 2023). While existing reviews have more comprehensively assessed both summer bridge programs (Cooper et al., 2017), we sought to formulate a summer program that applies to students with no research or existing programs. Previous studies have highlighted that summer programs must be designed with clear goals in mind, as the short (10-week) time frame of summer

programs can often lead to limited student success (Butler et al., 2008). While these programs can require substantial time commitment on the part of research faculty, this may be all the more difficult without a plan to make the most of the limited time available to mentor students (Butler et al., 2008). While graduate students can be effectively utilized to alleviate these time burdens from principal investigators (PIs), without the proper training, graduate students may leave their undergraduate trainees without adequate mentoring (Butler et al., 2008). A previous survey of students in otolaryngology programs shows that mentoring is one of the most significant deciding factors for URM students in choosing summer research programs (Timothee et al., 2024). Beyond mentoring, past studies at the Virtual Vanderbilt Summer Science Academy have demonstrated that while students may initially have a strong interest in STEMM, summer programs can still be essential interventions to increase the sense of belonging (Oliver et al., 2021). This underscores the importance of developing a summer program that prioritizes both mentorship and fostering a sense of belonging.

Historical evidence indicates that summer programs have generally proven to be highly effective (Bradford et al., 2021; Bruthers & Matyas, 2020; Cohodes et al., 2022; Hernandez et al., 2018). Within STEMM, The Leadership Alliance, founded at Brown University, which is a partnership between American universities and conferences, is one of the largest of such summer programs, providing training to 4000+ undergraduate students, many of whom are URMs, and bolstering a multitude of skills including research interest and data analysis (Ghee et al., 2016). Much of the existing literature similarly focused on a relatively small number of established programs nationwide. Still, programs such as the Meyerhoff Scholarship Program demonstrate the impact of summer programs specifically focused on increasing PhD aspirations for URM students (Pender et al., 2010). Other programs, on an institutional level, such as at the University of Arkansas for Medical Sciences, have found that URM students can benefit from research-focused STEMM summer programs, with most participants maintaining contact with their mentor following the program's conclusion (Prince et al., 2023). For medical-focused programs, Summer Clinical Oncology Research Experience at Memorial Sloan Kettering had 98% of students progress toward higher STEMM degree fields, with 54% of participants having co-author publications (Liberman et al., 2023). Beyond this, STEMM summer bridge programs, while similar, are distinct in often focusing on adjustment to college and have been extensively reviewed previously (Ashley et al., 2017; Bradford et al., 2021).

While these past organized summer programs have had positive effects, they are only available at some institutions. Furthermore, some PIs may want to provide a higher quality of training for students outside of these formalized summer programs. The limited funding for many of these programs, especially in light of recent National Institutes of Health and National Science Foundation funding cuts (see https://www.ascb.org/science-policy/grim-nih-nsf-budget-news-including-policy-landmines/), may mean that PIs limit the number of summer students they take due to feeling they cannot provide comprehensive mentoring without the aid of these programs. Finally, even if all summer undergraduates interns in a laboratory can secure acceptance into formalized programs, these programs may not offer comprehensive mentorship within the laboratory. Furthermore, summer undergraduate interns are split across multiple discrete programs. In that case, they may not feel a sense of community with their other undergraduate interns, which is a positive factor for summer research programs (Bruthers & Matyas, 2020). This guide aims to ease these challenges by providing a 10-week template to follow, which has been proven to yield successful summer students with notable outcomes including publications, awards, and graduate school. Hence, this guide may be used for students within and outside established summer research programs and modified to the needs within each STEMM field.

2 | FRAMEWORK

While the duration of summer programs can range from 8 to 12 weeks, our model is specifically designed to be 10 weeks long. Our summer program draws previous inspiration from STEMM education initiatives we have conducted, with a particular emphasis on the proven success of the *Project Strengthen* program (Barongan et al., 2023; Marshall, Brady, et al., 2022; Marshall, Palavicino-Maggio, et al., 2022; Marshall, Vue, Palavicino-Maggio, et al., 2022). This laboratory experience is highly focused on individual training and allowing individuals in the laboratory to experience challenges without any training at the beginning, followed by more intentional mentoring (Shuler et al., 2021). Generally, this approach seeks to emulate graduate school or the equivalent to higher education for undergraduate students so that they have a better understanding of what to expect.

In the past, while the positive aspects of summer programs are commonly discussed, the potential for them to act as a "brain drain" mechanism at minority-serving institutions has also been discussed (Carrero-Martínez, 2011). Thus, we focused on ensuring that URM students could understand both the importance of minority-serving institutions and connect them with collaborators and mentors from both traditional R1 or research institutions and institutions not as heavily focused on research. Beyond this, we have incorporated previous helpful guides that offer general guidance for effective summer research programs (Ayoob & Ramírez-Lugo, 2022; Pennings et al., 2020).

This unique model for a summer program utilizes mentoring dyads and triads to mentor students and prepare them more effectivley for graduate school. Crucially, our approach incorporates a multitiered mentoring hierarchy (Marshall, Vue, Beasley, et al., 2023; Montgomery & Page, 2018), which provides direct mentorship from both graduate students and postdoctoral fellows, a PI as an advocate, and casual mentors and networking with individuals from other institutions (De Lora et al., 2022). Hereafter, in this context, the main mentor, referred to as "mentor," is a postdoctoral fellow or staff scientist, distinct from the PI. However, in smaller laboratories, this may be the same as the PI. Notably, within summer research programs, mentoring relationship heterogeneity (i.e., different identities between the mentor and mentee), in the absence of substantial faculty-undergraduate mentoring, may inhibit summer undergraduates' science identity development (Morales et al., 2021). Thus, this exclusively dyadic system allows individuals to engage with multiple mentors and interact with their preferred mentors.

This central pillar of mentoring is important, as past studies have shown that beyond increasing interest in science, strong mentorship in research also results in URM students having significantly higher grade point averages (Haeger & Fresquez, 2016). Past students at other summer programs, such as the University of Texas System (UT System) Louis Stokes Alliance for Minority Participation Summer Research Academy, reported seeking summer mentorship that included regular meetings and clear expectations and communications throughout (Gorbett et al., 2022). Another analysis of eleven National Science Foundation's Research Experience for Undergraduates outcomes found that the most effective programs had successful mentoring, with the key dimensions of mentorship constituting safety (teaching students about protocols), preparedness (i.e., plans in place), proactiveness (i.e., responds to students' needs), patience (i.e., understanding of students' learning), presence (i.e., available for meetings and questions), and positivity (i.e., offering positive feedback with a good attitude) (Raman et al., 2016). Thus, we sought to ensure mentorship was delivered through multiple forms including casual, intentional, and peer (Davis-Reyes et al., 2022; Hinton, Vue, et al., 2020; Johnson, 2002; De Lora et al., 2022; National Academies of Sciences, Engineering, and Medicine, et al., 2019; McReynolds et al., 2020; Montgomery et al., 2014; Montgomery & Page, 2018; Murray, Shuler, et al., 2022; National Academies of Sciences, Engineering, and Medicine, 2020; Shuler et al., 2021; Termini, Hinton, et al., 2021; Termini, McReynolds, et al., 2021), and all mentors were required to read these previous publications. In contrast, scholars were required to engage in regularly scheduled meetings with mentors from all career stages.

Beyond only engaging students in research experiences and mentoring, we seek to cultivate a sense of belonging and identity, in science and within the cohort. Past studies have shown that varied experiences and activities can increase engagement (Schmidt et al., 2020), so this summer program has multiple weekly experiences and activities, which may be combined with regularly scheduled university events. To further enhance cultural humility and competency (Ang & Dyne, 2015; Bar-On, 1997; Conway-Klaassen & Maness, 2017; Foronda, 2020; Heppner, 2017; Murray, Hinton, et al., 2022), on a weekly basis, we encourage students to “lead” in showcasing their culture during lunches and weekly laboratory meeting activities. This allows everyone to consistently immerse themselves in diverse cultural experiences. Furthermore, a policy of complete freedom of faith allows individuals to pursue any interest, including faith-based science.

Alongside this focus on mentoring, our summer program focuses on self-determined research goals, which leads to undergraduate authorship most of the time. Students are contacted before entry to choose from several research projects so they may select a topic that interests them and begin researching it before starting the summer program. Students are assigned a project in the first week and are expected to work with complete independence. This self-guided project is designed to be much too complex for the students to complete. This exercise evaluates how far they get on their own, their strategies in dealing with an unreasonable project, and prompt recognition of personal limitations and the value of collaborators. This initial week also encourages students to consider proper boundaries. These boundaries may include setting clear expectations for an eight-hour workday, as well as opportunities for supplementary work and consideration of specific needs and responsibilities stipulated by the funding sources. If students have any other outside laboratory activities, such as studying for the Medical College Admission Test (MCAT), this difficult time also prompts them to begin contemplating effective time management (Seminar Topic; Table 2). This formative first week also creates a sense of shared adversity among the many new undergraduate students (Bastian et al., 2018). Thus, they are more likely to turn to each other and form early relationships and friendships for supportive interactions (Bastian et al., 2018).

While Week 1 is designed to replicate the overwhelming atmosphere of graduate school, Week 2 allows students to critically assess their responses and begin using the support system to effectively manage this workload adequately. After measuring undergraduate response to the stressful experience of navigating unreasonable expectations without a support system in Week 1, Week 2 is meant to emphasize the availability of support afforded during challenging periods. Students are also encouraged to better reflect on the amount of time they wish to devote to the laboratory across the summer and be realistic about the goals they seek to attain (e.g., only learning laboratory skills, publishing a co-authored manuscript, or publishing a first-author manuscript). From Week 2 and thereafter, students are expected to work more directly with their mentors and better learn how to use a support system. Subsequently, the remainder of the summer program is designed to equip students with the necessary tools and provide support from mentors and PIs to help them achieve this objective.

3 | TARGET POPULATION

While this summer program's techniques and experiences are pertinent to students of all backgrounds, given the long-spanning lack of retention of URM students, this summer program offers essential laboratory and writing skills URM students need to thrive in graduate school. On the same note, while this summer program's framework is applicable to all individuals in various stages in their undergraduate careers, it is most effective for undergraduate juniors (i.e., the summer following one's second year of undergraduate education), Past studies have highlighted the need for summer programs tailored to undergraduate students (Betz et al., 2021), and our program has successfully accommodated numerous community college students as well. Furthermore, past studies have shown that remote research projects may be practical even for high school juniors and seniors (Stainbrook, 2022). Though high school student participation in our summer framework has been limited, those who have participated have gone on to earn co-authorship on manuscripts, suggesting that this summer program may be just as beneficial for high school students.

4 | WEEKLY ACTIVITIES

- Students are invited to regular weekly mini-group meetings between supervisors, laboratory members, and other students (Table 1). While mentors and their mentees often plan additional meetings, including additional retreats across the department or university, generally these meetings are aimed at laboratory members and all undergraduate students having a chance to interact regularly. These mini-group meetings, characterized as "fun activities," may include going out for meals, physical activities (e.g. weightlifing), mindfulness activities, and other pieces of training, which can be chosen freely and attended on a regular

TABLE 1 Weekly fun activities students may optionally engage in across the summer alongside regular laboratory staff.

Week	Activity	Summary	References
Week 1	Dinner and movie	Lab-funded introductory dinner, which typically aims to highlight a local cuisine. Aimed at allowing everyone to meet everyone in an informal setting, followed by a student-decided film at a local cinema or art house theater. These dinners offer the chance for a neutral icebreaking environment that has been shown to facilitate team building and associated performance.	Dyer and Dyer (2013)
Week 2	Escape room	A team-building activity that allows students and laboratory members to work together in a fun and collaborative setting. Previous research highlights that the gamification of teamwork can help recontextualize long-lasting interest in teamwork.	Zhang et al. (2018)
Week 3	Axe throwing/ rage room	While there is limited research on the positive effects of both axe throwing and rage rooms, these activities are often offered in the same or adjacent facilities. Students often enjoy both activities, engaging in socializing over axe throwing and friendly competition. Some may elect to participate in "rage rooms," where they can smash items freely.	Lee (2020)
Week 4	Karaoke	Karaoke has commonly been cited as a fun team building activity. In this excursion, students are encouraged to share songs from their culture, if, for example, their native language is not English. Students are also exposed to the versatility of karaoke as a language learning technique and avenue to active learning.	Grossman and Richards (2016)
Week 5	Hike	Hiking has often been touted as a positive mechanism to increase both mental and physical exercise. During this excursion, students interested are transported to a local park to either hike as a group or independently. In some cases, hiking can also be combined with a group picnic or antecedent lunch.	Nordbø and Prebensen (2015)
Week 6	Gym day	Throughout the summer, participants frequently worked out together or went to the gym at similar times. Since exercise is well-understood to be linked to mental health, this may be an important avenue and opportunity for students to go to the gym and potentially get into a new routine by exercising together.	Taylor et al. (1985)
Week 7	Self-organized class	This week is specifically set aside to encourage summer undergraduates to organize an event among themselves. In the past, this has included self-defense, art, cooking, and pottery classes, some of which have previously been validated to be therapeutic. While students are encouraged to organize intrastudent activities throughout the summer, this week is specifically allocated for a self-organized event only among students to encourage their independence.	Afat (2019); Feen-Calligan et al. (2018)
Week 8	Museum	This event typically occurs at a free museum day or museum night, so there are no associated costs. While there is flexibility in museum to be chosen, in the past, within Nashville, past museums visited has included the National Museum of African American Music. Museums have often been lauded as a mechanism to learn about often forgotten history as well as to mutually engage in an educational experience.	Causey (2011)
Week 9	Reflection day	As the workload intensifies in the final push before the end of summer, this day is designed for reflection, encouraging activities such as journaling, mediation, or forest walks. Notably, in academic settings, a day dedication to reflection has been shown to be positive for both academic and professional development.	Harvey and Vlachopoulos (2020)
Week 10	Brunch	Similar to the first week, this event is a casual time for students and lab members to be able to interact and network while eating at a local favorite brunch location.	Dyer and Dyer (2013)

Note: These events, to accommodate student's schedules, are typically held on a Friday afternoon or Saturday morning.

basis based on student interests. Students are further encouraged to set up additional meetings and activities among themselves, which is bolstered by students being given a list of free or low cost activities occurring near the university upon entry in to the summer program.

- Students can also elect to participate in a weekly writing accountability group (WAG), which is formulated based on previously discussed publications (Neikirk, Barongan, Shao, et al., 2023; Spencer, Neikirk, et al., 2022). These WAGs, which are conducted virtually, offer a unique avenue for students to engage with faculty across institutions and academic levels. Students are strongly encouraged to join these meetings, scheduled for Friday afternoons, to interact with new potential mentors and gain a better understanding of the writing process.
- Each student will be expected to individually prepare a presentation on a seminal piece of literature (Supporting Information: File 1), and present independently in journal clubs. Students are given a minimum of four weeks to prepare for a 15-30 minute journal club presentation. A full roster of student presentation order, dates of presentation, and journal article that the presentation should be focused onare given on the first Friday at the start of the program. Every Friday, one to three students (depending on the size of the program) are expected to present. In preparing for these journal clubs' presentations, undergraduates are given minimal to no assistance outside of seeing previous journal clubs in the laboratory and are expected to independently analyze the literature by themselves. During their presentations, they are also questioned by laboratory members. While this can be an intense experience for undergraduates, it provides them an opportunity on how to critically read literature. Following the presentations, students are given feedback from lab members and other students. Subsequently, their mentor works with them one-on-one on how the presentation could be improved and how further improvements may be made in future presentations.
- Each Friday, following the journal club, a new professional development or career seminar topic is led by laboratory members (Table 2). These are typically held over a two hour period, and students are encouraged to read the supplied references and other documentation about the topic before attendance. A brief introduction to the topic is given by a rotating laboratory member, giving that laboratory member the opportunity to acclimate to the role of teacher or mentor. Following this introduction, a lively and interactive discussion is had about the topic, prompting students to explore how the topic may be utilized in their daily lives.
- Students are supplied a textbook, as well as multimedia links, which they independently review on a weekly basis (Table 3). While Table 3 provides an example format of homework, this may be altered based on topics of interest. Following the professional seminar each Friday, the homework and topics of the week are briefly reviewed, with time for any questions students may have as well as any thoughts they have on the topic. Incorporating fundamental biology and laboratory-specific STEMM topics into weekly homework encourages students to actively learning throughout the summer. This is particularly beneficial as many students plan to take exams such as the MCAT or Graduate Record Examination (GRE) during or shortly after the summer.

4.1 | Week-by-Week

4.1.1 | Week 1

- Introductions and Icebreakers: If possible, a group orientation is held with all students, which includes introductions made by all students as well as existing laboratory members. A guided laboratory tour is provided along with an introduction to the weekly replenishment of snacks and drinks available in the laboratory. Basic icebreaker activities includetwo truths and a lie (Chlup & Collins, 2010), as well as a chance to briefly share personal pursuits and backgrounds over dinner (Table 1).
- Privately, the PI or mentors discuss pay schedules to ensure that students can effectively manage their food expenses. Additionally, mechanisms are established to providestudents with access to food ahead of paychecks or stipends, particularly if their specific summer program reimbursement is limited. The mentors assigned to each student are asked to continue to check in and ensure all needs of students are being met, given how common undergraduate food insecurity is among undergraduates (Olfert et al., 2021).
- All students participate in a collective dorm visit to assess suitability for the summer program. In addition, students are accompanied by their mentors or go as a group to a nearby supermarket, allowing them to acquire necessary items for a comfortable living environment (e.g., portable air conditioning unit, toiletries).
- A simple tailored pretest is administered to assess the students' laboratory knowledge . This is designed for the mentoring team to understand the student's field-specific background knowledge. Laboratory safety rules and expectations for the summer are explicitly communicated.
- Students are introduced to the laboratory group chat, hosted on a platform like GroupMe or Slack, as an avenue to converse with members of the lab. Our program utilizes GroupMe for this purpose.
- Students receive guidance on the structure of the summer program along with a detailed syllabus in a dedicated notebook (Figure 1), and access to previous publications that highlight the format and purpose of summer programs (Ayoob & Ramírez-Lugo, 2022).
- A laboratory notebook is provided to each student. Laboratory notebooks are widely acknowledged as crucial tools at the graduate level, yet many students report not effectively using them until after a period of trial and error (Stanley & Lewandowski, 2016). Additional resources (Schnell, 2015) are offered to students to help them understand the best practices for maintaining a laboratory notebook.

TABLE 2 Weekly discussion and seminar material.

Week	Topic of discussion	Summary	References
Week 1	Individual development plan and mentoring maps	The purpose of individual development plans and mentoring maps are discussed. Additional guidance is given to those who express interest in creating one, as well as vision boards and other materials. Furthermore, they are provided with resources to understand how to use these tools properly and effectively.	Davis et al. (2023); Montgomery (2017); Vincent et al. (2015)
Week 2	Multifaceted mentoring: The many different forms of mentoring	This is an extended seminar often split across multiple days, to discuss what mentoring is, as well as the many forms mentoring can take (e.g. intentional, casual, and shadow mentoring). This session also explores how mentoring may be altered under certain circumstances, including virtual settings, as well as the benefit of having multiple mentors.	Davis-Reyes et al. (2022); De Lora et al. (2022); Hinton, Vue, et al. (2020); Johnson (2002); National Academies of Sciences, Engineering, and Medicine, et al., (2019); McReynolds et al. (2020); Montgomery et al. (2014); Montgomery and Page (2018); Murray, Shuler, et al. (2022); National Academies of Sciences, Engineering, and Medicine (2020); Shuler et al. (2021); Termini, Hinton, et al. (2021); Termini, McReynolds, et al. (2021)
Week 3	Quotients, implicit bias, and cultural competency/ humility	Quotients, such as emotional intelligence, can be valuable for mentors and students to utilize. These workshops expose students to these quotients as well as how to use them. Moreover, the concepts of cultural competency/humility are introduced, as well as their importance in mitigating implicit biases which students may unknowingly encounter.	Ang and Dyne (2015); Bar-On (1997); Conway-Klaassen and Maness (2017); Farley et al. (2012); Foronda (2020); Heppner (2017); Murray, Hinton, et al. (2022); Neikirk, Barongan, Rolle, et al. (2023)
Week 4	The "Leaky Pipeline" in STEMM and how to overcome it	The leaky pipeline, or lack of retention in STEMM, is an ongoing issue, which has been given several names, including varied pathways. Students are introduced to this phenomenon, as well as potential ways to mitigate it (e.g. expanded mentoring trainings through DEI and mentoring offices standardized across institutions).	Allen-Ramdial and Campbell (2014); Davis et al. (2023); Hinton, Termini, et al. (2020)
Week 5	Historically Black Colleges and Universities and other minority serving institutions	Historically Black Colleges and Universities and other minority serving institutions, such as tribal serving institutions and Hispanic serving institutions, have several differences from primarily white institutions. This seminar highlights what these institutions are, as well as the advantages of attending these institutions or collaborating with them if attending a primarily white institution.	Campbell et al. (2013); O'Brien and Zudak (1998); Shuler et al. (2022)
Week 6	Networking and asking for letters of recommendations	Networking is an important component of academia and the basic fundamentals of it, as it relates to undergraduates, is introduced. Discussion includes methods of obtaining letters through nonconfrontational ways and using existing networks.	Beasley et al. (2023); Chang et al. (2023); Rojas-Guyler et al. (2007); Streeter (2014)
Week 7	Leadership	Different forms of leadership and how to effectively become a leader are discussed. In this seminar, students are encouraged to try a new form of leadership each day across the week to explore different forms of leadership and consider which works the best for them in their daily life.	Black (2015); Ruiz et al. (2022)

(Continues)

TABLE 2 (Continued)

Week	Topic of discussion	Summary	References
Week 8	The power of saying "No" and time management	Discussion of the importance of time management and how to effectively manage time.Group activities involve thinking of different requests and tactfully saying "no" sets clear boundaries, whether professional or personal, without offending the individual making the request.	Hinton, McReynolds, et al. (2020); Murray, Davis, et al. (2022); Trueman and Hartley (1996)
Week 9	Graduate school and associated interviews	This seminar consists of multiple mock interviews for graduate school or upcoming opportunities (e.g., fellowships, medical school) whichstudents may be pursuing. Examples of questions, preparation for interviews, and stress mangaement during upcoming interviews, are comprehensively discussed.	Myers (2006); Ransey et al. (2023); Williams et al. (2015)
Week 10	Looking beyond graduate school	Whether students are interested in graduate/professional schools, academia, or industry, this seminar is designed to address the expectations within each of these endeavors so that students may make informed decisions about their future career goals. In this collaborative seminar, individuals from other careers and life paths are invited to visit with students to facilitate networking and explore future opportunities.	Evans and Brown (2015); Murray, Spencer, and Hinton (2022a, 2022b); Spencer, Shuler, et al. (2022)

Note: This weekly guide utilizes the *Project Strengthen* (Barongan et al., 2023) framework in a single summer, but previous topics of discussion in *Project Strengthen*, or other topics, can be selected based on the summer program's aims. These weekly discussion materials consist of giving readings, followed by an hour-long group discussion.

- Students receive a "Welcome Notebook," as a dedicated tool for tracking important nonexperimental information (Figure 1). In the notebook, we include people in the laboratory and their roles (with contact information), individuals in the department and university who students may need to contact. Additionally, we provide a list of select literature from the field and historical laboratory papers meant to help student begin to contextualize their project in the grand scheme of the lab's focus. This notebook also provides blank pages for note-taking and goal-setting (e.g., goals for individuals they aim to network with).
- Students have a brief meeting with their mentor to introduce the assigned project (intended to be completed across 10 weeks). During this session, they mutually agree on working hours which are typically 9 a.m. to 5 p.m. If weekend or after-hours experiments are anticipated, the student and mentor will discuss how to approach these occurrences and make plans so that the student is never left unattended in the lab.
- Students' proficiency in using basic laboratory equipment (e.g. pipettes and basic plate assays) is determined and students are taught if they are unfamiliar with these tools.
- Students are provided laboratory protocols – protocols for transmission electron microscopy and three diemensional electron microscopy (3D EM) (Garza-Lopez et al., 2022; Lam et al., 2021; Marshall, Damo, et al., 2023; Marshall, Neikirk, Stephens, Vang, et al., 2023; Neikirk, Lopez, et al., 2023; Neikirk, Vue, et al., 2023) in the case of our lab – and asked to independently read and annotate the protocols before beginning analysis. In addition to written protocols, video resources are available for learning laboratory procedures, with online guidance suggested if further clarification is needed.
- Following initial guidance, students are entrusted to work independently for the rest of the week, with minimal interaction from their primary mentor unless urgently needed. To ensure data integrity, students are only given access to backed-up and limited data sets.

4.1.2 | Week 2

- In a casual environment, students meet with both the PI and direct supervisors/mentors. During this time, students are asked to critically reflect on the first week of their project. Here, we encourage them to voice their concerns and ask questions. During this meeting, students are assisted in creating strategies to work on research goals and foster collaborations. This meeting is also for setting realistic milestones for the rest of the summer, as well

TABLE 3 Layout of weekly homework schedule.

Week	Main focus	Book readings	Mitochondria biology lecture	Cell biology lecture	Homework assignments
1	Goal awakening and choices	Transcultural Health Care: Ch 6–7	Mitochondrial fusion/fission	Protein sorting	Go over Personal Statements, Resumes/Curriculum Vitae, Practice Interview Questions for Graduate School, and Individual Development Plans Please watch and write down your thoughts on Ted Talk- Peggy Oki- Allow things to unfold and you will find your Purpose in Life. https://www.youtube.com/watch?v=ycB29FkoylE Please answer questions from Cultural Handouts – Vignette 6.1, 6.2, 6.3 and Vignette 7.1, 7.2, 7.3. Please watch and write down your thoughts on Ted Talk: "Choices that can change your life" – Caroline Myss – https://www.youtube.com/watch?v=-KysuBl2m_w
2	Building relationships and conversations	Transcultural Health Care: Ch 3, Caribbean Culture	Cristae dynamics	Nucleus signaling	Sign up for National Research Mentoring Network, Researchgate, and LinkedIn; complete all components of profile Watch and write out your thoughts on Ted Talk: "The surprising truth about rejection" – Cam Adair: https://www.youtube.com/watch?v=dsT5eV_m7BA Watch and write out your thoughts on Ted Talk: "Select the right relationship" – Alexandra Redcay https://www.youtube.com/watch?v=jodhovumkHQ Watch and Write how do you have a good conversation: "How to have a good conversation" – Celeste Headlee: https://www.youtube.com/watch?v=H6n3iNh4XLI Answer questions from Cultural Handouts – Vignette 3.1–3.7 Watch and write out your thoughts on Ted Talk: "The Dangers of Whitewashing Black History" – David Ikard: https://www.youtube.com/watch?v=bb04xj7LS34
3	Personal growth and team goals	Transcultural Health Care: Ch 16	Mitochondrial biogenesis	ER transport/ signaling	Take the Love Language Test (link: https://s3.amazonaws.com/moody-nprofiles/uploads/profile/attachment/5/5LLPersonalProfile_COUPLES__1_.pdf), Big Five Personality Test (https://www.outofservice.com/bigfive/), and the Myers Briggs Personality Test (https://www.16personalities.com/free-personality-test). Write down how knowing your personality and love language can help you do science and benefit you when you are studying in a group. Please watch Ted Talk: "How to tell if someone truly loves you" – Femi Ogunjinmi: https://www.youtube.com/watch?v=44J3FGYKltI and "How to love and be loved" – Billy Ward: https://www.youtube.com/watch?v=vMeEKBaiPbg Answer questions from Cultural Handouts – Vignette 16.1–16.3. Watch and write out your thoughts on Ted Talk: "White Men: Time to Discover your Cultural Blind Spots" – Micheal Welp: https://www.youtube.com/watch?v=rR5zDIjUrfk Watch the following and reflect on how to work as a team with Contrasting Personalities. Working in a team for studying purposes, a laboratory, or a job can be challenging. Ted talk: "Build a tower, build a Team" – Tom Wujec: https://www.youtube.com/watch?v=H0_yKBitO8M Ted talk: "Working together to make things happen" – JP Cardoso: https://www.youtube.com/watch?v=Fd_nkBHgX8s Ted talk: "Cultivating Collaboration – Don't be so Defensive" – Jim Tamm: https://www.youtube.com/watch?v=vjSTNv4gyMM Ted talk: "Stop Trying to Motivate Your Employees" – Kerry Goyette: https://www.youtube.com/watch?v=7lhVUedc1a4
4	Body Language	Transcultural Health Care: Ch 18, Cuban and Puerto Rican Heritage	MERCs/MAMs	Golgi/vesicle transport	Watch and write out all of the steps: "How to Have Attractive Body Language" – Practical Psychology Link: https://www.youtube.com/watch?v=Avb3owsE6YM

(Continues)

TABLE 3 (Continued)

Week	Main focus	Book readings	Mitochondria biology lecture	Cell biology lecture	Homework assignments
					Watch and write out all of the steps "How to Establish Yourself as a Leader" – Practical Psychology Link: https://www.youtube.com/watch?v=R2qu_j6GAG8 Watch and write your thoughts on Ted Talk: "The Importance of Being inauthentic" – Mark Bowden: https://www.youtube.com/watch?v=1zpf8H_Dd40 Watch and write your opinion on Ted Talk: "The Power of Nonverbal Communication" – Joe Navarro: https://www.youtube.com/watch?v=HRl0dvPRkSI Answer questions from Cultural Handouts – Vignette 18.1–18.3
5	Self-control and boundaries	Transcultural Health Care: Sections: Where to Draw the Line – How to Set Healthy Boundaries Every Day – Setting Limits on Attack (pp. 88–94), Anger Boundaries (pp. 95–102), and Sexual Boundaries (pp. 163–171).	Outer mitochondrial membrane	Basic apoptosis	Write down the most pressing thoughts that you encountered from reading about anger and self-control. Discuss where you think you can improve at with your work life and personal goals. Write down the most pressing thoughts that you encountered from reading about Sexual Boundaries. This is inferring that one must think about potential sexual harassment at work, the lab, or in study groups. Watch and write a quick reflection on the following. Based on them, write about an experience (that you feel comfortable sharing) in which you should have experienced more self-control or exerted more boundaries, and how might this best changed in the future. "The secret of self-control" – Jonathan Bricker: https://www.youtube.com/watch?v=tTb3d5cjSFI "The Unstoppable Power of Letting Go" – Jill Sherer: https://www.youtube.com/watch?v=nirKw3mWB3I "The Uncomfortable Truth about underlying anger" – Peter Knoope: https://www.youtube.com/watch?v=9q22WAUnpPs "Good Boundaries free you" – Sarri Gilman: https://www.youtube.com/watch?v=rtsHUeKnkC8 "Say No to Say Yes" – Caryn Aviv: https://www.youtube.com/watch?v=-iUag3c9HRc
6	Respect, lies and judgment	Transcultural Health Care: Ch 15	Mitochondrial dysfunction/aging	Lysosomes/peroxisomes	Answer questions from Cultural Handouts, Vignette 15.1–15.7. Watch and write a quick reflection to the following TED Talks. Once all have been watched, write either a key tenant of judgment or body language that stood out to you and may be relevant to your daily life. "How to Spot a Lie" – Former CIA Agent, Susan Carnicero: https://www.youtube.com/watch?v=pni_kDv9BsU "Boyd Language, the power is in the palm of your hands." – Allan Pease: https://www.youtube.com/watch?v=ZZZ7k8cMA-4 "How to practice emotional hygiene" – Guy Winch: https://www.youtube.com/watch?v=rni41c9iq54&index=5&list=PLEy6rD5hH5qxvaVnqq_Cp817WedPP_8ch "Judgement. Don't let it frighten you" – Aimee Bateman: https://www.youtube.com/watch?v=wBTEJsDP-nU "You've likely already judged me" – Marjory Curry: https://www.youtube.com/watch?v=DmWonttSEDs "Judging and Shaming" – Brendan Buchholz: https://www.youtube.com/watch?v=CCj44WmgcLE
7	Personal branding and appearance	Transcultural Health Care: Ch 15 (Korean Heritage)	Mitochondrial metabolism part 1	Signal transduction – RTKs, GPCRs, and kinases (part 1)	Watch the following videos, if they interest you. 30 Psychology Tricks that work on Everyone: https://www.youtube.com/watch?v=mIDbnz9W3-c 32 Tricks to read someone's mind: https://www.youtube.com/watch?v=4MwkyWhYySs 10 Questions that will reveal who you really are: https://www.youtube.com/watch?v=tenNJ9yzVbI

TABLE 3 (Continued)

Week	Main focus	Book readings	Mitochondria biology lecture	Cell biology lecture	Homework assignments
					Ted Talk: "How to reinvent yourself" – Jay Morrison: https://www.youtube.com/watch?v=V8ZLXBLBfqI. How to stand up for yourself without being a Jerk: https://www.youtube.com/watch?v=LyBIT0Q7fOc How to avoid embarrassing yourself in an argument: https://www.youtube.com/watch?v=nS9W-wlJHPA Take notes and write down your thoughts after reading the 12 habits of highly effective entrepreneurs. Compare the following sources and decide which traits you feel are the most important. List 1: https://www.entrepreneur.com/article/294080 List 2: https://www.lifehack.org/articles/productivity/21-habits-successful-entrepreneurs-that-everyone-should-learn.html List 3: https://www.wanderlustworker.com/17-good-habits-of-really-great-entrepreneurs/ Ted Talk: "Why comfort will ruin your life" – Bill Exkstrom: https://www.youtube.com/watch?v=LBvHI1awWaI Ted Talk: "Change your mindset and achieve anything" – Colin O-Brady: https://www.youtube.com/watch?v=vo_lZiytsMw Take notes and write down your thoughts after reading the shorthand of the seven habits of highly effective people. Link: http://www.pnbhs.school.nz/wp-content/uploads/2015/11/7-Habits-of-Highly-Effective-People-Summary-Covey.pdf You can read about this in more detail by utilizing this link: http://www.stafforini.com/docs/Covey%20-%20The%207%20habits%20of%20highly%20effective%20people.pdf Additionally utilize the following Ted Talks: "The Power of Habit" – Charles Duhigg: https://www.youtube.com/watch?v=OMbsGBlpP30 "Four keys for setting and achieving your goals" – William Barr: https://www.youtube.com/watch?v=13MYY8qMWQg "How to break away from habits and follow through on your goals" – Sabine Doebel: https://www.youtube.com/watch?v=9EDl2INyJgw
8	Stress, anxiety and time management	Handout 1: https://www.fcs.uga.edu/docs/time_management.pdf Handout 2: https://mcgraw.princeton.edu/sites/mcgraw/files/media/effective-time-management.pdf	Mitochondrial metabolism part 2	Signal transduction – RTKs, GPCRs, and kinases (part 2)	After watching the following Ted Talks, reflect on a current anxiety in your life (that you feel comfortable sharing), as well as some newly learned strategies to potentially deal with it. "Be the warrior not the worrier – Fighting Anxiety & Fear" – Angela Ceberano: https://www.youtube.com/watch?v=-FyVetL1MEw "How to cope with anxiety" – Olivia Remes: https://www.youtube.com/watch?v=WWloIAQpMcQ "Anxiety: A cancer of the mind" – Aneysha Bhat: https://www.youtube.com/watch?v=85QY_d-8J2M Watch the following and take notes on how to better manage time: "How to multiple your time" – Rory Vaden: https://www.youtube.com/watch?v=y2X7c9TUQJ8 "The philosophy of Time management" – Brad Aeon: https://www.youtube.com/watch?v=WXBA4eWskrc "How to gain control of your free time" – Laura Vanderkam: https://www.youtube.com/watch?v=n3kNlFMXslo Watch the at least three of the following videos on stress and awfulizing and write short reflections about what you learned from them and how it may relate to your own life. "Why your critics aren't the ones who count" – Brene Brown: https://www.youtube.com/watch?v=8-JXOnFOXQk

(Continues)

TABLE 3 (Continued)

Week	Main focus	Book readings	Mitochondria biology lecture	Cell biology lecture	Homework assignments
					"Removing Negative self-talk" – Abria Joseph: https://www.youtube.com/watch?v=teVE3VGrBhM "Don't believe everything you think" – Lauren Weinstein: https://www.youtube.com/watch?v=Xdhmgp4IUL0 "How to stay calm when you know you'll be stressed" – Daniel Levitin: https://www.youtube.com/watch?v=8jPQjjsBbIc "The secret to performing under stress" – Captain Tom Chaby: https://www.youtube.com/watch?v=_aqNjEzHgVg "How to end stress, unhappiness and anxiety to live in a beautiful state" – Preetha Ji: https://www.youtube.com/watch?v=TqxxCYnAxo8

Note: Based on our laboratory, weekly readings were derived from Transcultural Health Care: A Culturally Competent Approach (Purnell & Fenkl, 2021), which is provided to students at no cost. Additionally, homework assignments incorporate multimedia avenues to further student engagement. While this table offers specific homework assignments, they may be adapted as desired and reduced based on student needs.

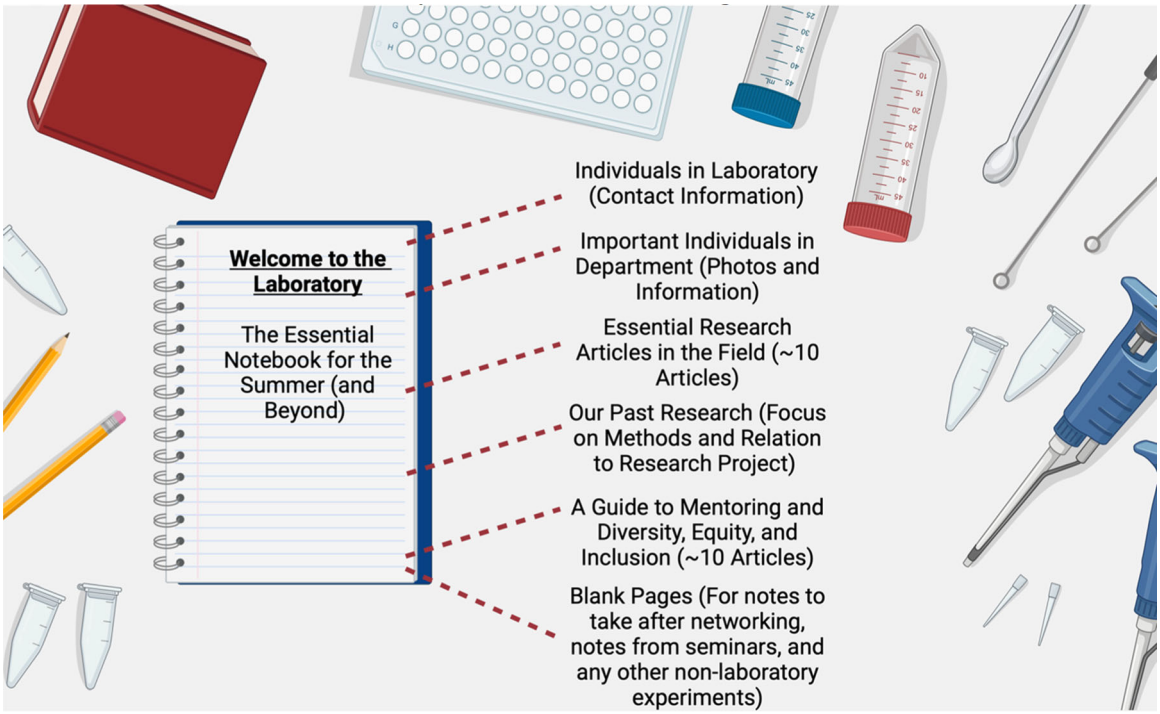

FIGURE 1 Graphic of introductory notebook for incoming summer undergraduate participants.

as critically discussing the goals the student has for the summer (e.g., authorship; mentorship; diversity, equity, and inclusion articles; experience teaching, etc.).

- Mentors set up frequent follow-up meetings with the students to discuss research projects and help them feel supported.
- As a group, students are given an overview of pertinant topics relevant to our laboratory (e.g. mitochondria and 3D EM), which is further facilitated by weekly assigned readings (Table 3). With their mentors, they then have a follow-up meeting for individualized feedback on their understanding of the literature. Mentors will continue to work individually with students to ensure that they understand any material relevant to their project through regular meetings and analyses of existing literature. Here, mentors must act in an intentional manner (Shuler et al., 2021) to ensure that students are conducting their research projects.
- With the mentor, students' data collected or progress during Week reviewed, and mentors aid students in fixing any data that is incorrect and giving more individualized guidance and tips.
- Mentors begin taking notes regarding each student's learning style and sharing their observations with other laboratory members and the PI (Pashler et al., 2008). Every person is known to have different cultural, educational, and life experiences; this week

offers a chance for laboratory members, undergraduate students, and mentors to identify different learning styles and adapt to ensure students are grasping the fundamental information they need. Tailoring learning and teaching styles for mentees can ensure that the students are able to perform to the best of their ability.

4.1.3 | Week 3

- Additional interactive icebreaker activities are organized which include participants marking their origin, places they have lived, or cultural background on a global map with a pin. During this seminar, lab members are encouraged to highlight places they live or have lived so they can begin to build more intentional relationships with the students.
- A variation of the "culture box" (McGee et al., 2021), another icebreaker activity, occurs where students are asked to write where they are from, the foods they like, and a choice of cuisine that fits "who they are" and what that would be. Based on the number of students, we set up weekly lunches that incorporate these lunch options (e.g., with15 students, which is typical, spread across eight weeks, two different meal cuisines are had on a weekly basis on seminars on Fridays).
- In meetings with mentors, students are confidentially asked how their laboratory and overall experience may be improved. This may include, asking whether any culturally specific snacks, drinks, or decorations should be included in the weekly laboratory snack supply to make it more comfortable.
- Students are offered the chance to work on an existing manuscript (e.g., revisions, analyzing data and writing results, etc.). For those interested, the mentor or PI has a clear discussion with the student regarding the expectations of authorship, which may extend beyond a typical forty-hour work week. The student will need to evaluate time commitments and practice time management if they wish to make substantial contributions to the manuscript to warrant authorship. Ultimately, students will begin to understand the magnitude of work that goes into a manuscript, as well as what needs to be done to qualify for authorship.
- Students continue to work on their assigned research project but are also given opportunities to learn other techniques. In our case, they continue to work on projects rleating to transmission electron microscopyand 3D EM, but are also given opportunities to learn other laboratory techniques, including cell culture and assays, should they think they can manage their current workload.

4.1.4 | Week 4

- Students begin working with mentors on writing abstracts (Andrade, 2011). Emulating the manuscript submission process, students independently draft abstracts and receive multiple rounds of feedback from their mentors and PIs before submission. Additionally, if students are a part of the weekly WAG group (Neikirk, Barongan, Shao, et al., 2023; Spencer, Neikirk, et al., 2022), they are encouraged to share abstracts there for additional feedback.
- Students are asked to read literature about how to make a good poster (Erren & Bourne, 2007). They are also given examples of previous posters from past summer students or award-winning posters from lab members as references. The mentor emphasizes a focus on considering the layout of the poster and goes over the minimalistic poster movement (i.e., #BetterPosters, see https://www.insidehighered.com/news/2019/06/24/theres-movement-better-scientific-posters-are-they-really-better). However, they also allow students to make more traditional posters should they wish (Supporting Information: Files 2–3).
- A previous undergraduate student, typically a past awardee, gives a mock presentation with their poster to demonstrate to the students poster presentation formats.
- Students meet with their mentor to discuss how they need to prepare for the poster presentation.
- Students are tasked with initiating independent research and poster preparation. However, mentors refrain from reminders or encouragement until Week 8. Consequently, students may either complete posters independently or face a sense of urgency when reminded close to the due dates. This allows students to take ownership of their schedule and further hone their time management skills.

4.1.5 | Week 5

- At this halfway point, students are given publications about the goals of a summer research program and tips for excelling (Manzanares et al., 2023). Working in collaboration with their mentor, students privately reassess their summer goals and make any desired changes to their plan.
- Students fill out release forms for pictures.
- Students work with mentors to consider how to best present a poster. This may include watching poster presentation videos or asking lab mates for tips and advice.
- Students continue collecting data and begin analyzing data. While a primer on statistical analysis will be given, students are asked to independently search the literature to draft a discussion of results. Once formulated, they work with their mentor to explore literature that may have been overlooked in their original analysis.
- Students are asked to consider whether they want to submit abstracts for conferences such as the Annual Biomedical Research Conference for Minoritized Scientists (ABRCMs), Society for the Advancement of Chicanos/Hispanics and Native Americans in Science (SACNAS), or another undergraduate conference of interest.
- Students work with mentors to begin looking for external and internal funding for undergraduate conferences. While laboratory

funding can be provided in some cases, it is expected that all students proactively seek funding opportunities before receiving laboratory funding to ensure familiarity with the rigorous application process common.

4.1.6 | Week 6

- A retest of laboratory satisfaction (originally assessed in Week 1) is conducted. Adjustments to the summer program are made based on the results of these evaluations to better cater to the diverse needs of all students. For example, if students highlight that they want more independence, mentors may give students more unsupervised time or allow them to run experiments with minimal input.
- Students work with their mentor to strategize and enhance their skills in delivering an effective oral presentation, as per previous recommendations (Harrison, 2021; Siedlecki, 2022).
- Students will engage in a group discussion on how to effectively collaborate with others in the laboratory. This includes practice scenarios of both effective and ineffective introductions to introduce the student to the importance of networking.
- Students are given the opportunity to explore other passions tangential to but outside of their research commitments. For example, students have worked with scientific artists to craft artwork and cover designs for scientific articles. As another example, students have had the opportunity to participate in blog post writing with guidance and support (e.g., previous students have published the following https://massivesci.com/articles/opinion-hawaii-telescope-tmt-imperialism-astronomy/, https://crosstalk.cell.com/blog/the-journey-to-becoming-an-impactful-mentor-the-story-of-antentor-hinton, and https://crosstalk.cell.com/blog/not-a-moment-but-a-movement-how-organizations-like-blackincmdbio-increase-diversity-in-science). Individuals expressing interest in enhancing their teaching and mentoring skills are given the chance to participate in and lead previously established seminars delivered to middle-school students (Marshall, Neikirk, Stephens, Garza-Lopez, et al., 2023). Moreover, if students have additional interests outside of what is routinely offered, mentors and PIs will actively support trainees in pursuing them.

4.1.7 | Week 7

- Students are provided guides on networking through presentations and "practice scenarios" (Table 2).
- By Week 7, students have reached a heightened sense of comfort in their research capabilities and are they encouraged to begin networking beyond the laboratory. Advanced students will have already begun formulating connections with other individuals in the department (e.g., through events or collaborations) or at other institutions (e.g., through WAGs). All students are supported and encouraged to meet mentors from other areas and fields of study. For example, students who are interested in shadowing experiences with medical or veterinary doctors will have dedicated time for these opportunities, in addition to their laboratory commitments, with the PI helping to coordinate such experiences. Furthermore, trainees will have the chance to meet with PhDs in other research areas, including junior and senior faculty, which may align with their research interests. Moreover, students may collaborate with other laboratories and have the opportunity to connect with senior faculty at different institutions which could potentially pave the way for future summer opportunities and graduate school applications.

4.1.8 | Week 8

- Mentors guide students to request letters of recommendation, per the instruction of previous guides (Burrell et al., 2023; Chang et al., 2023; Kong et al., 2021). Students are introduced to the concept of obtaining letters of recommendation from suitable individuals and offered tips on how to ensure letters of recommendation are strong and tailored for a specific application.
- Students are given the chance to initiate preparation for the GRE and MCAT, including informational interviews with past trainees or laboratory members who have experience with these exams. If students have an interest in national/international scholarships (e.g. Fulbright Program, Marshall Scholarship), students are connected with previous trainees who have applied or been funded for these awards. Other scholarships that the students are interested in can also be discussed, and interested students may be connected to prior winners and offered resources for preparing for these opportunities.
- By Week 8, students are afforded opportunities to practice poster presentations through multiple scheduled meetings, both individually with their mentor and with the broader laboratory group. For those who did not work on posters independently, this phase involves direct collaboration with their mentor to create the poster rather than practice it. This approach aims to motivate students by emphasizing the importance of timely preparation, as those who procrastinate (during Weeks 5–8) may miss dedicated practice sessions with the broader group.
- Students are given the chance to review previous personal statements that have resulted in graduate school acceptance (Supporting Information: File 4), as well as craft their own personal statements for upcoming opportunities such as graduate school or scholarships. Students can share personal statements with each other to receive peer feedback, fostering peer mentoring (Ahmed et al., 2021), as well as obtain feedback from their mentor and secondary mentors (e.g., those found in WAGs).

4.1.9 | Week 9

- On request, the laboratory orders test prep guides – for MCAT, Law School Admission Test (LSAT), and GRE, or any other tests – that students are allowed to take with them following their time in the laboratory. Students are also given the chance to work with

their mentor to develop study plans for these tests in the subsequent year.
- Students work with their mentors to discuss needs outside of the summer program and current challenges, as well as how to overcome them. This includes reflection on resources at their institution that they may not have been fully utilized before. Working in their "welcome notebook," students are given the chance to write down their goals for the next year as well as plans to reach these goals.
- Students have the option to meet anonymously with a counselor and life coach, thereby allowing students to assess the value of priortizing their mental health and access associated resources.
- Students continue research projects, posters, and any outside activities they have chosen to participate in across the summer. This may include notifying mentors or lab mates where data or samples are located, and/or updating their laboratory notebook.

4.1.10 | Week 10

- Students finish research and attend any end-of-summer activities, including a regularly scheduled brunch or dinner with the laboratory (Table 1).
- Mentors work to prepare mentees for any poster presentations or future opportunities they may plan. During this time, mentors highlight that not every competition will result in a "win" during the poster stage. The purpose of this final meeting is to celebrate the achievements and progress made throughout the entire summer experience, irrespective of the final outcome.
- The PI offers students letters of recommendation for any future planned programs.
- Mentors engage students regarding their mentorship, including planning and evaluating whether students wish to continue receiving guidance from laboratory members, and if so, in what capacity. For individuals seeking to pursue authorship on a manuscript, or multiple manuscripts, continued contact with their mentor is encouraged to see the manuscript through to completion. For those seeking more extensive mentorship, further options, such as a continued laboratory position, are available.
- An outside evaluator conducts anonymous exit interviews to collect feedback based on pros, cons, and changes students would like to see in the future.
- Students are removed from the group chat with an option to rejoin should they later rejoin the laboratory or be involved in any future conferences.

5 | AFTER WEEK 10/END OF SUMMER PROGRAM

After completion of the summer program, these alumni summer program students are encouraged to continue being involved with the laboratory, with several central opportunities available to them.

- Students can contact two scientific editors within the laboratory who offer editing of personal statements as needed. Furthermore, students can continue to get feedback for these personal statements and be provided with templates, if needed.
- Letters of recommendation are availabl, so long as students make the request to the PI or mentor at least two months before the letter due date.
- Students can continue to practice poster presentations, as needed, with their mentor and other collaborators.
- Students may have additional mentoring in the capacity discussed during the summer.
- Students have opportunities to continue working in the laboratory if external funding is obtained. This includes continuing to finish experiments and write (co)first-author research manuscripts, as numerous previous summer undergraduates have done (Barongan et al., 2023; Lam et al., 2021; Neikirk, Vue, et al., 2023; Vue, Neikirk, et al., 2023).
- Students may continue to provide input on future DEI articles and are given the chance to write about topics that they may have a passion for.

6 | CONCLUSION

Previous studies have shown that faculty are more inclined to participate in undergraduate summer research programs when they perceive mentoring undergraduates as beneficial to their own research (Morales et al., 2016). These findings imply a positive feedback loop, where enhanced positive mentoring experiences contribute to a greater willingness among mentors to train undergraduates in the future. This underscores the importance of mechanisms aimed at improving the effectiveness of summer mentoring programs. To enhance student engagement, we modeled our summer program on *Project Strengthen*, a broader four-year program that we have demonstrated effective at improving undergraduate URM outcomes (Barongan et al., 2023). We also leveraged longitudinal analyses exploring the factors contributing to student persistence in undergraduate research experiences. These studies emphasize that mentor relationships and project ownership are the primary drivers of engagement (Hernandez et al., 2018). Furthermore, students frequently highlight the importance of cultivating positive relationships with laboratory members as a critical factor in their desired summer research programs (Bruthers & Matyas, 2020). Thus, in our summer program, we sought to intentionally nurture these factors through a variety of weekly activities and by creating shared experiences of adversity among undergraduate students, an approach designed to facilitate the development of friendships and future connections among laboratory interns (Montgomery & Page, 2018).

Additionally, we sought to allow individuals to explore their passions through direct mentoring within the laboratory through previously described multihierarchical systems (Marshall, Vue,

Beasley, et al., 2023; Montgomery & Page, 2018) and casual mentor relationships (De Lora et al., 2022). In this summer program, we seek to balance educational objectives around professional development (Tables 2–3), and research skills. Together, we have found that this program has produced tremendous results, including many first-author undergraduate manuscripts, awards from prestigious fellowships (e.g., Fulbright Program, Marshall Scholarship), poster presentation awards, and students who go onto graduate or professional school programs. Thus, the 10-week program presented here represents a viable alternative that PIs may utilize in addition to, or in place of, traditional organized summer programs.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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