TRAINING AND MENTORING

Undergraduates from underrepresented groups gain research skills and career aspirations through summer research fellowship

Bruthers CB, Matyas ML. Undergraduates from underrepresented groups gain research skills and career aspirations through summer research fellowship. Adv Physiol Educ 44: 525–539, 2020; doi:10.1152/advan.00014.2020.—Undergraduate research experiences (UREs) have proven to be one of the most valuable approaches to increasing the number of underrepresented students earning degrees in STEM fields. However, there are many questions about how these impacts occur. Improving grades, experiencing laboratory work, and working with research staff are important components, but developing a “science identity” is integral to this process. In this qualitative study, interviews with 25 past summer research fellows who are members of groups underrepresented in STEM (underrepresented minorities, persons with disabilities, first-generation college, and persons with financial or social disadvantages) provide insights into this process. The conversations validate that their summer research experiences helped them attain each of the program objectives, but their experiences differed, in part, based on their prior research experiences. Their narratives emphasized the strong impact that the program had on skills (e.g., research design, data analysis and presentation, time management/organization, writing, speaking, network development, math/statistics), confidence, motivation, and research career aspirations. As fellows learned more about research, they saw its relationship to medicine, and many integrated basic or clinical research into their career plans. Three central themes resulted from the discussions: the need to customize program goals for diverse participants, the pivotal role of the research mentor-student relationship, and the powerful impact of participating in a national scientific meeting. Recommendations for URE programs are proposed.

disability; disadvantaged; research experience; undergraduate; underrepresented minority

INTRODUCTION

For decades, higher education statistical and policy reports have documented the dearth of underrepresented minority (URM) students earning STEM (science, technology, engineering, mathematics) degrees and entering STEM careers (13–15, 18). Yet we know that URM students enter college with STEM aspirations similar to those of White students (5, 9). Numerous program models have tried to increase the retention of URM students in STEM majors (13). Undergraduate research experiences (UREs) have proven to be one of the most valuable, consistently showing positive impacts on both majority and URM students (9, 13, 18). UREs are not a panacea for promoting diversity in STEM but play an important role (13). The recent National Academy of Sciences report on UREs for STEM students calls for additional research and points to research on diverse student groups as a “major research priority” (13, see p. 175).

Although most URE programs have specific objectives and structured program activities, each participant’s experience is highly individualized. Experiences are influenced by the students’ academic background, previous research experiences, previous experience in travel and living away from home, the size and culture of the institution where they do their summer research, the experience and mentoring style of their research mentor, the culture of the specific laboratory environment, and the specific research area in which they are working. URE programs seek to encourage, support, and promote research career interests and involvement, but they ultimately produce different outcomes for different participants in both professional and personal impacts. In recent years, programs have begun to recognize that, in addition to gaining confidence in their research and writing skills, URE participants must develop a “science identity,” and see themselves as part of the culture of science (7, 9). This variety of impacts and outcomes creates challenges for evaluating these programs from a purely quantitative perspective because creating quantitative measures to capture every variation and nuance is not practical (16). Qualitative research can provide insights both into the individualized outcomes experienced by undergraduates in research and into the overall quality and consistency of the program’s implementation (16).

Toward that end, the American Physiological Society (APS) conducted an interview study in 2019 to follow up on the experiences of its Short-Term Research Education Program to Increase Diversity in Health-Related Research (STRIDE) fellows (“fellows”). The goal of the study was to add “depth, detail, and meaning” (16) to the quantitative analysis of survey data of all APS undergraduate summer research fellows (4). We hypothesized that the interview data would support the quantitative analysis findings that the STRIDE program had significant, positive impacts on the fellows’ understanding of research, research skills, and interest in future research careers (4). We further hypothesized that the program impacts would be consistent across underrepresented groups: women, URM, persons with disabilities, and persons from disadvantaged backgrounds (economic and social). We also hoped that the interview conversations would illuminate additional program impacts and suggest program improvements, particularly to increase impacts on underrepresented persons (URP).
METHODS

URE Program Information

The STRIDE program was designed to encourage US undergraduate students to: develop their research and presentation skills, and experience biomedical research in NHLBI-related areas. Fellows were selected by a project advisory board comprising of APS-member physiologists. Selection of both first- and second-year fellows was based on academic merit, the quality of the proposed experience, and the availability of appropriate faculty mentors. Each fellow received a $4,000 stipend during their 10-wk summer research experience. Research mentors received up to $500 for reimbursement of laboratory supplies for the fellows’ research projects. Many of the fellows worked with research mentors who were at institutions other than the fellow’s undergraduate institution, including undergraduate, graduate, and professional school departments.

Program Evaluation

Evaluation of the STRIDE program included data collected through pre- and postfellowship surveys completed by each fellow and information provided by fellowship products (e.g., abstracts, posters, professional development assignments). These findings are reported elsewhere. The evaluation plan was reviewed by the Federation of American Societies for Experimental Biology (FASEB) Institutional Review Board Exemption Review Board and deemed eligible for educational exemption.

Table 1. Demographics for all STRIDE fellows and study participants

| Demographic                  | All Fellows | Interviewed Fellows |
|------------------------------|-------------|---------------------|
| Gender: female               | 66          | 16                  |
| Ethnicity: Hispanic          | 30          | 6                   |
| Race                         |             |                     |
| Asian                        | 15          | 6                   |
| Black/African American       | 26          | 5                   |
| Caucasian/White              | 42          | 10                  |
| Native American/American Indian | 3     | 4                   |
| Native Hawaiian/Pacific Islander | 3   | 4                   |
| Other racial groups          | 11          | 2                   |
| Students with disabilities   | 8           | 5                   |
| Disadvantaged background     |             |                     |
| Economic                     | 23          | 8                   |
| Social                       | 17          | 5                   |

Values are number (n) and percentage of fellows. Demographics were derived from self-reports by fellows on their initial Short-Term Research Education Program to Increase Diversity in Health-Related Research (STRIDE) application forms. On gender, ethnicity, and race questions, applicants could respond, “I prefer to not answer,” but were required to complete the question. Questions related to disability and disadvantaged background were optional. Chi-square test (P < 0.05) was used to determine whether the distribution of interviewed fellows differed significantly from the distribution of all STRIDE fellows in terms of gender, ethnicity, race, disability status, and economic and social disadvantages. The only significant finding was that students with disabilities were overrepresented in the interview sample (P = 0.019).

Study Population

The APS awarded 114 STRIDE fellowships between 2013 and 2019. Ten students (10%) received two STRIDE fellowships; therefore, a total of 104 students received the fellowship. As shown in Table 1, fellows included 66 female students, and 30 Hispanic/Latino, 26 Black/African American, 15 Asian, 3 Native American/American Indian, and 3 Native Hawaiian/Pacific Islander students.

Selection of Fellows for Interview

This evaluation sought to interview at least 25 past STRIDE fellows who participated in the program from 2013 to 2018. First, each of the 104 fellows was contacted by a member of the APS staff by e-mail, asking them for updated contact information. From the pool of 104, an initial group of 35 fellows were selected to participate in interviews using the following criteria in this order. 1) Because they had not yet completed the STRIDE fellowship activities, the 2019 STRIDE cohort was not included in the pool of potential interview candidates. 2) Because there were few persons in these categories, the invitation was sent to ALL fellows who indicated on their application that they their race was Native American/American Indian or Native Hawaiian/Pacific Islander, or they were a person with a disability. 3) Additional fellows were selected to promote representation by Hispanic/Latino and Black/African American students and students from disadvantaged backgrounds (e.g., first-generation college, low-income/socioeconomic status).

The selected interviewees were contacted initially by APS staff to inform them about the evaluation and that they would be contacted directly by an external evaluator (M.L.M.), to set up a telephone interview to gather detailed feedback on several aspects of the fellowship, as well as get an update on their educational and career plans and activities. Staff informed fellows that they would receive a $100 Amazon gift card for participating. The evaluator attempted to contact all 35 fellows for follow-up. Up to four attempts to schedule an interview were made by e-mail over a 4-wk period; 15 of the initial group (43%) volunteered to participate in the study and were inter-
Table 2. Interview questions

| Topic/Themes                                      | Questions                                                                                                                                 |
|--------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|
| Background/overview of research experiences      | 1. What are you doing now?  
2. Briefly tell me about your STRIDE experience.  
3. What were your favorite and least favorite parts about your summer fellowship? Overall, would you describe it as a positive experience?  
4. What were your favorite and least favorite parts about the Experimental Biology (EB) meeting? Overall, would you describe it as a positive experience?  
5. Did you get any publications out of your STRIDE research?  
   a. If applicable: Which journal (APS publication or other)?  
6. Have you given any research presentations (poster or oral) during or after your fellowship (not just related to STRIDE)?  
   a. If applicable: How was your experience at ABRCMS? SACNAS?  
7. Have you participated in any other research experiences?  
8. Did you continue to conduct research after you left your summer laboratory?  
   a. If applicable: Did you conduct research with your summer research mentor? With another researcher at your (home) institution? |
| Learning about the research laboratory environment| 9. What were your favorite and least favorite parts about the research laboratory environment? Did anything about the laboratory environment surprise you?  
10. Did anything surprise you about yourself in the research laboratory environment? Did you find that some things came easily, and others did not? Did you discover some strengths or weaknesses that you didn’t know you had?  
11. What were your favorite and least favorite parts about the people you worked with in the laboratory? Did anything about the people you worked with surprise you?  
12. When was the last time you spoke with or e-mailed/texted your research mentor? Do you feel that you are still in contact with your research mentor? Peers in laboratory? Other fellows?  
13. How often did you interact with your research mentor? Postdocs in the laboratory? Graduate or undergraduate students? Please describe. What kinds of things did you talk about: career advice, help you to understand the laboratory environment and your research project?  
14. Did you feel like you were a part of the laboratory team? If so, what made you feel that way? If not, why not?  
15. If your niece or nephew asked you about being a scientist, what would you tell her or him based on your STRIDE experience? |
| Impacts on education choices/ career path         | 16. Did your STRIDE experience impact your ideas about your education/career path right after your fellowship?  
   a. How about now?  
   b. If applicable: What about your STRIDE experience put you on your current path in the sciences?  
17. What are some of the biggest hurdles you’ve overcome in your education/career? In overcoming those hurdles, did the fellowship experience help, hurt, or have no impact?  
   a. If applicable: Has your STRIDE experience helped with challenges since you graduated? |
| Professional networking and scientific societies   | 18. Based on your STRIDE experience, what is your perception of the role of scientific societies like the APS in the career development of young scientists?  
19. Are you a member of APS or any other professional societies?  
20. During your fellowship, you participated in several networking events both online and in person. Has that experience influenced your current approach to networking? How?  
21. Have you continued to foster your own professional network? |

viewed. One fellow responded that she/he did not want to participate. An additional group of 17 fellows were contacted, and 10 (59%) participated in the study. Overall, 25 (48%) of the 52 fellows who were contacted elected to participate in the study. One additional fellow volunteered, but the interviews had already been completed.

The final interview group represented the diversity of students in the target audience for the program (Table 1). There were no differences in distribution between the fellows in the interviewed group and the total group of STRIDE fellows (2013–2019) by year of program completion (chi-square test, $P = 0.17$), gender ($P = 0.96$), ethnicity ($P = 0.60$), race ($P = 0.78$), economically disadvantaged background ($P = 0.23$), socially disadvantaged background ($P = 0.63$), or whether the student received one or two STRIDE fellowships ($P = 0.08$). The study sample included a significantly higher proportion of STRIDE fellows with disabilities ($P = 0.02$); of the eight STRIDE fellows with disabilities, five participated in the present study.

It should be noted that using the STRIDE fellows for this study was a “purposeful sampling” (16) of the broader pool of undergraduate students in APS’ multiple undergraduate summer research programs. The pool of STRIDE fellows includes a strong sample of underrepresented persons from multiple categories: women, URM students, persons with disabilities, and persons from socially and/or economically disadvantaged backgrounds. All APS undergraduate programs have the same objectives, activities, and evaluation protocols. Therefore, the present study was expected to inform the other programs as well.

**Interview Protocol**

The interviews followed a protocol similar to that of previous APS studies of undergraduate summer research fellows (1, 10). Interviews lasted 90 min and covered the same topics as in the previous studies. Major topics and questions are included in Table 2. Questions asked participants about their experiences, behaviors, opinions, beliefs, knowledge, background, and demographics (16). All but two interviews were conducted via face-to-face videoconference call; the remaining two interviews were done via phone call. Fellows were informed at the start of the call that the video call would be video-recorded and transcribed, but that only the interviewer (M.L.M.) would have access to the videos and transcriptions. Neither APS staff nor the fellows’ research mentors or undergraduate institutions would have access to their interview data.
Qualitative Data Analysis

We used a deductive approach to test the two preset hypotheses (confirming the findings of the previous quantitative study and confirming consistent impact across underrepresented groups) (20). To illuminate additional program impacts and identify possible program improvements, we conducted a modified narrative analysis of the stories told by each interviewed fellow (19). Dr. Matyas took extensive notes during the interviews, then reviewed all transcripts and/or videos and enriched her notes further, including documenting important quotes by the fellows. Analysis focused first on the preset hypotheses, then the narratives were reexamined for additional themes.

To protect confidentiality, names and institutions have been removed from the results and quotes. Non-gender-specific pronouns (e.g., she/he, him/her) were substituted for gender-specific pronouns (e.g., she, he, him, her). The generic pronouns “they,” “them,” and “their” refer only to comments made by groups of two or more fellows to avoid unintentional over weighting of comments made by only one fellow.

The present study sought to deepen our understanding of the fellows’ perspectives on the STRIDE fellowship as their career development progressed. Specifically, interviews addressed five themes:

I. Research experiences both during and after the fellowship
II. Their impressions of the research laboratory environment
III. The impacts of the fellowship on their skills and educational and career choices
IV. Their development of professional networks and relationships with professional societies
V. Their suggestions for improving the fellowship program

RESULTS

Theme 1: Research Experiences

The first set of questions asked fellows about their current status and career plans, as well as their broader research experiences (e.g., STRIDE and beyond). Six fellows (24%) had completed, were completing, or were actively applying to PhD (Doctor of Philosophy) programs in physiology, neuroscience, or other areas of experimental biology. Two fellows (8%) were in MD (Medical Doctor/PhD) programs. Five fellows (20%) were in MD programs and were engaged in or had specific plans for devoting significant time to clinical or basic research. One fellow was planning to complete a master’s degree in computational bioscience, which is considered the terminal degree for this specific area. These 14 fellows (56%) comprised a “Strong Research Career Focus” (SRC) group in the results below.

A second group of 11 fellows (44%) comprised a “Limited Research Career Focus” group (LRC). LRCs included six fellows (24%) who wanted to be MDs with some involvement in clinical research, four fellows (16%) who wanted to be MDs with little or no involvement in research, and one fellow (4%) who was undecided about whether to pursue graduate or medical school, but wanted a STEM career of some kind.

Fellows also described their broader research experiences. For many, the STRIDE fellowship was one of several UREs, often their second or third summer of research. Some fellows worked with the same research mentor for several years; others explored multiple areas of research with different research mentors. Interviewed fellows, some of whom had completed advanced degrees and were already in professional positions, could not distinguish between what they did in STRIDE versus other UREs. Therefore, the discussion of research productivity reflects their overall undergraduate accomplishments.

When asked about additional years of research experience, SRC and LRC fellows were similar in terms of overall years of experience. Over one-half of both groups did multiple years (or summers) of work in the same laboratory (SRC: 57%, LRC: 54%). Overall, only one of the SRC fellows and only two of the LRC fellows did only 1 yr of research work; all remaining fellows had at least two research experiences.

However, when asked about research productivity, there were distinct differences between the SRC and LRC fellows. First, they differed in terms of the publications on which they were authors. Although about one-fifth of each group had published multiple meeting abstracts (SRC: 21%, LRC: 22%), SRC fellows were much more prolific in research productivity. Nearly one-half of SRC fellows (43%), but none of the LRC fellows, had manuscripts in preparation. SRC fellows were more likely than LRC fellows to have a manuscript currently submitted for review (28 vs. 0%), published one paper (21 vs. 11%), published multiple papers (21 vs. 11%), and/or a first author publication (28% versus 0%). Only one LRC had a publication record similar to the records of SRC fellows (e.g., multiple abstracts and published papers including a first author paper).

Similarly, SRC and LRC fellows differed in their undergraduate research presentations following the STRIDE fellowship. While both groups of fellows made presentations at regional and state meetings (SRC: 21%, LRC: 36%), more SRC fellows gave presentations at their local campus (SRC: 57%, LRC: 36%), at national meetings, including EB (SRC: 28%, LRC: 9%), at other universities (SRC: 28%, LRC: 9%), and at international meetings (SRC: 21%, LRC: 0%). This tally does not include multiple presentations at the same type of venue (e.g., presentations at three different universities would only be tallied as one university presentation); a more detailed tally would show a wider gap between SRC and LRC fellows on university presentations and national meeting attendance.

Fellowship expectations, experiences, and EB. When asked what they had hoped to gain from the STRIDE fellowship, 24% of fellows said the fellowship stipend was important. Those in the SRC group wanted to deepen their research experiences: get a paper published, have additional dedicated paid time to continue their research, and understand the entire research process, including presenting at meetings and publishing their work. They wanted a “research immersion” and “view of the whole research circle.” While a few LRC fellows said they wanted to continue research they had already started, others described their STRIDE goals as career exploration. They wanted to find out whether research was their “passion,” get laboratory experience, attend a scientific meeting with funding provided, learn how to do research, and gain motivation for their continued studies.

These expectations were reflected in the fellows’ descriptions of their fellowship. When asked what their favorite things were in the STRIDE fellowship, SRC fellows cited the opportunity to do their research independently, plan their own experiments, and work in a stimulating and supportive environment. They also cited the career connections that they built through the fellowship. LRC fellows noted the unique learning experience offered by the fellowship. Several noted that this was their first “real” research experience, and that research
URP STUDENTS GAIN RESEARCH SKILLS AND ASPIRATIONS

When asked about their least favorite aspects of the fellowship, the SRC and LRC groups responded similarly. APS online professional development assignments were frequently cited by both groups of fellows as not very useful, especially the discussion boards where they were asked to critique or comment on other fellows’ responses. Several fellows said they would prefer face-to-face or real-time/online conversations. Some noted that the other undergraduate students in their laboratories who were part of the universities’ summer research programs got to do different activities (e.g., journal clubs and social events) and network more with other undergraduates on campus; they felt left out of this networking. Fellows also mentioned the negative parts of research: experiments that fail, how long it takes to complete a series of experiments, and the amount of repetitive work and calculations involved. One fellow noted that dealing with a major issue with an animal colony was difficult but became a powerful learning experience. Few fellows noted negative impressions due to interactions with their research mentors. One said that there was visible frustration in the laboratory over the constant need to “grab” research funding; this conveyed to the fellow’s work in being asked to reuse materials and make Western blots by hand rather than purchasing more materials.

Fellows commented specifically about their experiences in attending EB. All fellows were encouraged (but not required) to work with their research mentors to submit an abstract and present a poster at both the regular and undergraduate poster sessions. The latter offered dedicated time for fellows to meet with graduate school representatives. Fellows also attended an undergraduate orientation session (required) and a diversity networking breakfast with graduate students and postdoctoral fellows (optional). All fellows were encouraged to apply for APS undergraduate research awards for best abstracts and best poster presentations. Several fellows (24%) noted that this was their first time attending a large scientific conference. EB dates often overlapped fellows’ campus study week/final exams, so some had to study for finals in their hotel rooms or leave the meeting early.

SRC and LRC fellows said that presenting their research was one of the best things about attending EB. They were proud to receive special recognition: giving an oral presentation instead of a poster presentation, receiving an undergraduate research abstract award, and subsequently presenting their poster for judges during the competition for an additional presentation award. They were clearly excited when they felt their work was recognized or qualified them as part of the scientific community. They especially liked when their work was recognized by the poster competition judges, particularly if they were from a smaller college. They also liked when people who knew about their research field came to their poster. They were proud to stand by their posters; one person was excited to stand at his/her poster, next to the poster of the postdoc from his/her laboratory. Others were excited to have abstracts published in the FASEB Journal. One said that presenting at EB made him/her feel like a “real scientist.”

[STRIDE and EB] reinforced [my career goals]. I think if I didn’t get the opportunity to go to a conference that big, I don’t think I would feel this motivation to continue ... the part where you’re able to stand next to professors and postdocs and see that they’re presenting and then see the interest that they have in your research really reinforced my drive to continue. [Doctor of Pharmacy (PharmD) student with plans for clinical research]

Some fellows said that attending EB helped them understand the purpose of a large meeting, including the science presented (“science immersion”) and seeing how science is a collaborative enterprise. Others said that everyone should get to attend EB so they could see the impact of their own work and that of other scientists. One fellow liked that other researchers talked about his/her work with the same passion that she/he felt. Meeting people, networking, and getting career advice and information were also commonly noted as favorite aspects of EB. The undergraduate poster session and diversity networking breakfast were mentioned as favorite events. The novelty and enjoyment of business travel was also cited. Few fellows mentioned the scientific sessions as their favorite part of the meeting. The level of science presented may have been challenging for the undergraduates. One said that she/he picked some sessions that had big crowds and tried to use his/her background to understand some of what was being discussed.

In terms of their least favorite aspects of EB, many commented on the size and complexity of the meeting, describing it as “overwhelming” and “intimidating.” They wanted more guidance on how to pick sessions to attend and plan their time at the meeting, especially in finding scientific sessions at an understandable level. A few fellows did not like that they had to divide their time between the meeting and studying for finals or to leave early to attend classes. Fellows were disappointed if their posters were not visited at the undergraduate session. Finally, fellows looked for opportunities to get to know the other STRIDE fellows. Because it is open to all undergraduates, the orientation session did not fulfill this need, and several fellows expressed frustration at not having a separate meeting time with the STRIDE fellows.

Theme II: The Laboratory Environment

While the STRIDE program had standards for the research experience, each URE was unique. Laboratories vary not only in the topic of their research but also the type of research (e.g., clinical vs. basic), data sources (e.g., animals, humans, data depositories), institution types (e.g., large research university, medical school, small undergraduate institution), laboratory group composition (e.g., undergraduates, graduate and medical students, postdoctoral fellows, laboratory technicians, laboratory managers), and the research mentors’ background (e.g., years of experience, current research funding, experience in working with undergraduates). Each factor contributes to an overall laboratory environment, where work can vary from highly collaborative and collegial to highly individualized.

SRC and LRC fellows provided similar descriptions for the laboratory environments they experienced and their interactions with their research mentor and laboratory mates. Overwhelmingly, fellows’ favorite thing was the people in the laboratory group. They especially liked working with their laboratory mates and research mentor, getting questions answered, and getting encouragement for being in the laboratory. They liked doing the experiments, learning new techniques, working independently, and working in a collaborative environment. When asked what they liked the least, few com-
mented. Those who responded did not like waiting on experiments to finish, having to repeat experiments that did not work, and being at the laboratory early or late.

When asked whether the laboratory environment was surprising or different from what they expected, fellows were surprised that they were treated as a colleague, as a fellow researcher, and as an equal in their laboratory:

I didn’t expect ... a place at the table ... to want my opinion on things. I just thought I was going to come in, they give me a list of things to do, and I do it. So, to my surprise ... [my research mentor] really appreciated us speaking up in lab meeting and in any conversation about how we felt about how things are going in lab, how the experiments are going, and just how people are with each other. In general, the environment ... [the research mentor] was really big on that.... [If] you [the undergrads] just stayed in the back, kind of quiet, then [the research mentor] would at every meeting ask us to speak up and talk. Every single meeting, every week. I guess I didn’t expect that.... I really appreciated to be able to be not just the person in the background but actually giving some kind of feedback.

So that was my biggest surprise coming in, and at first, I was too nervous to actually speak up but, over time, I was able to. I would prepare my little thing that I was going to say for each meeting. I learned how to use that and actually give useful advice and make comments that were valuable. (Graduate student in neuroscience)

Two fellows said they were surprised how much autonomy they had, with latitude to organize and schedule their experiments. Several others commented on the laboratory group structure and environment, noting that laboratories can differ in their structure, from loosely structured to very rigid. Others noted how friendly everyone was and that the laboratory was “team oriented.” In that environment, the fellow had to work both independently and as a team member:

I was pleased with myself in that I was able to [succeed in the lab]. I am so independent. It’s a lot of multitasking that you have to do. Even beyond that, [you have to do] a lot of communication because there will be things you need like a material from someone, and a technician works on creating a solution ... that you need to inject in your rat. I was shocked that eventually I was able to put it all together.... Doing all of that at the same time in one day and then coming home really late was a growing experience.... (Undergraduate in neuroscience)

...[B]ecause there are so many different backgrounds in the lab, collaborating was really fun ... because everyone really had different skill sets ... (Postbaccalaureate applying to medical school with clinical research goals)

Fellows also discovered the realities of doing scientific research: research does not move quickly but takes a long time, requires precision in measurement and technique, and accurate documentation of methods and results, and involves a lot of writing. They were surprised that research is not secret but very collaborative, that all data generated are not ultimately used in posters or manuscripts, and that research includes many failed experiments:

It really surprised me how many failed experiments it took to get any data at all. I cannot tell you how many Western blots I ruined before I actually got a good one. It probably took the whole summer. It was just interesting to see how many failures it takes to get one tiny piece of information. That really surprised me. I thought it would be a lot faster than that. (Medical student with clinical research goals)

There were also a few less-positive discoveries. One fellow felt that most of the people she/he worked with were “unhappy people” and another was surprised that there are “a lot of politics” in research.

Some discoveries were about research careers. Fellows were surprised that there are “lots of ways to do research,” including bench, clinical, survey, and observational research. A third fellow was pleased to learn that experiments can usually be scheduled from “9 to 5” rather than all-nighters in the laboratory.

When asked what their favorite and least favorite things were about their laboratory mates, fellows from both groups cited a positive, cooperative laboratory environment as their favorite thing. They liked open communication, where they could ask coworkers for information and help. One fellow noted that she/he was “fresh out of high school” and thought, “I will be on my own.” She/he was surprised at the level of help offered, even keeping his/her experiments going when she/he was in class.

They also liked when they could be of help to others in the laboratory; one proudly noted that she/he taught a high school student how to use the equipment. Fellows also liked becoming friends with colleagues in the laboratory, having dinner at the research mentor’s home, getting lunch or an after-work drink with laboratory mates, or talking about science and careers as they walked to the animal facility. One fellow found preconceptions about researchers to be wrong: his/her laboratory mates were very social and interactive, “helpful,” “down-to-earth,” and “forgiving.” Another fellow described his/her laboratory mates as “very driven” and said they shared a common love of science which helped them to bond as a team. Finally, one fellow was surprised that his/her laboratory mates made all of the arrangements to enable him/her to do research. She/he said it was inspiring: “It was time to step up. I have to give that opportunity to someone else when the time comes.”

A few fellows cited a “least favorite” thing about working in the laboratory, typically communication issues with laboratory mates or the research mentor. Two fellows said some laboratory members “looked down on them” because they were undergraduates. Some found laboratory mates, primarily postdocs, did not respond to the needs of the undergraduate students or viewed them as technicians: undergraduates could only use equipment at night or were asked to do animal care. An experienced undergraduate researcher struggled with the attitudes of some senior laboratory mates. She/he was frustrated by “those who look down on you,” don’t value others’ opinions, “always have to be right,” and value publications more than scientific discovery.

With few exceptions, fellows spoke very highly of their STRIDE research mentors. As noted earlier, several worked with the same research mentor for multiple years. The STRIDE program requires the fellow and mentor to communicate regularly. Most fellows (64%) met with their research mentor at least once per week, and more than one-third (36%) talked with their research mentor daily. About one-half of the fellows got career advice from the research mentor and/or laboratory mates. Some noted that the research mentor wrote a letter of recommendation for them, but this was not uniform across the group. As noted earlier, fellows especially liked when the research mentor asked for their input and treated them as a member of the team. A fellow who is currently working on an
MD/PhD degree said his/her research mentor set the tone for the STRIDE fellowship by giving him/her both autonomy and respect and being an advocate for him/her at meetings.

However, relationships between fellows and research mentors could be fragile, especially for fellows working with a mentor for the first time. These fellows had to learn the laboratory structure and the role their research mentor expected them to play in it, as well as assess how much they should turn to the research mentor and laboratory mates for help. As novice researchers, they had to learn new techniques, and they made mistakes, often a new experience for these academically high-achieving students. Communication gaps with the research mentor were especially detrimental to fellows’ views of the research experience and their role in the laboratory. One fellow had a good working relationship with his/her research mentor but, after returning to his/her undergraduate institution, e-mail responses from the research mentor lagged. When the fellow repeated his/her requests for assistance in preparing for EB (e.g., abstract and poster), she/he got feedback from one of the graduate students, reporting that the research mentor had complained to the laboratory group about the fellow’s requests and said the fellow was “being annoying.” The fellow felt betrayed by the research mentor she/he had come to trust and respect. Although they were friendly and civil at EB, the fellow has never contacted the research mentor again. Another fellow wanted more feedback:

I think, at times ... I did feel a little lost or ... like I could have been given a little bit more direction from my PI because at times I would have ideas and then they would be put down, but I really wasn’t sure why they weren’t good ideas. And so, getting to have more of that interaction and feedback would have been nice. But I know it’s also learning experience to just grow on your own.... (Undergraduate in neuroscience)

Overall, however, most fellows had strong, positive relationships with their research mentors.

Nearly all fellows (88%) felt that they were a member of the laboratory team. Spending multiple years in the same laboratory strengthened this feeling. Being asked for help by other laboratory mates, being included in conversations and research discussions, attending social events (e.g., lunch, dinners), and giving laboratory meeting presentations reinforced the feelings of team membership:

We would talk about what we wanted out of the research [and] how to work together. Having that kind of meeting with everyone and seeing that you’re part of it, getting feedback from others and having input, made me feel like I was part of the team. (MD/PhD student)

Conversely, one fellow said she/he only felt “a little bit” on the team because she/he helped with things but was not responsible for anything.

The importance of these laboratory relationships was evident when looking at long-term contacts. Many fellows (80%) enthusiastically reported they were still in contact with their research mentors, either regularly or periodically, mostly via e-mail. Similarly, many fellows (68%) were in contact with laboratory mates from their STRIDE fellowship, often via social media. Some felt that they had become lifelong friends and colleagues. However, fewer were in contact with STRIDE fellows (36%), most often fellows who were at the same university or who were their roommates at EB.

Finally, to gain perspectives on how they viewed research careers, we asked fellows how they would describe “being a researcher” to a middle or high school student. Both SRC and LRC fellows said researchers are puzzle solvers, explorers, or people who can figure out how to answer a question. Several described research as pursuing one’s passion. Interestingly, most of the more negative descriptors came from LRC fellows who said research requires a lot of hard work, researchers are anxious or stressful about grant money, and research is “difficult,” “frustrating,” and “repetitive.” Sample descriptions include the following:

I would compare it to building a puzzle.... There are so many different components to putting together that puzzle that we don’t even really think about and that’s kind of what lab science is. They’re the people behind all of the media that we see today about vaccines.... They’re the people who do all the hard work that we don’t really think about before we can give a drug to a patient. So many steps have to come before that, starting with lab work to understand how the mechanism of the heart works and then applying that to a new drug that could help with hypertension. All of that starts with basic lab science. So if that’s something you’re interested in doing, it’s going to be very different than the person that may put together the puzzle pieces at the end, which I would consider being like clinicians and ... the patients themselves.... Eventually, it forms this big picture and every single person that contributed to making that puzzle is vital to making positive change for patients.... (Medical student with clinical research goals)

Research is very collaborative.... Come in with a mindset that you’re ... willing to communicate, efficiently and effectively with other people and become codependent because that just is what a lab is.... People take on different parts .... [Second] ... be okay with stalemates and being frustrated or failures ... be adaptive and collaborative.... (Undergrad in neuroscience)

You have to be persistent, and sometimes it’s frustrating, but it’s also rewarding. You have to be open minded, a creative thinker.... (Medical school student)

All of those images that are any stereotypical thoughts that you have about what a scientist is, just get rid of them.... It’s not [being] in this dark room with all these tubes and chemicals and everything.... I like the amount of room for ... creativity within research.... (Undergraduate premied with plans for clinical research)

I would probably say, ‘Be ready for a lot of failures’.... But I think it is fulfilling once you get some good data. And it is also nice to learn a lot about one specific thing and kind of be an expert in that. (Medical school student)

Theme III: Impacts on Skills and Educational and Career Choices

Throughout the conversations, fellows detailed the impacts that the program had on their skills, their self-image, and their aspirations. When asked whether they discovered that they had strengths and weaknesses when they started doing research and whether the fellowship helped them build their skills, both SRC and LRC fellows most often cited laboratory skills along with their ability to work independently and to communicate well with others. Some SRC fellows noted their writing and organizational/time management skills as strengths. In terms of weaknesses, many fellows (36%) felt they needed better independent work skills. They had to learn to organize their time,
plan experiments, schedule meetings, and allow time to prepare for laboratory meeting presentations. These tasks were difficult at first but became easier over time and could transfer to future tasks. One fellow said they help with his/her current leadership position, including leading a diverse team. The other common weakness noted by both groups was mathematics and/or statistics. Many said they had to gain skills in one or both areas over the course of the fellowship. One fellow progressed from needing calculations for his/her project to be done by the postdoc, to doing the calculations him/herself and having them checked by the postdoc, and finally to doing the calculations on his/her own. Another taught him/herself to use the statistic program and then taught the technician. The two groups differed somewhat in that communication and presentation skills were noted as weaknesses more often by SRC fellows (36%) than LRC fellows (9%).

Both SRC and LRC fellows (72%) felt they gained skills through the fellowship, improving their data analysis skills, and learning to do statistical analysis and use programs to do a variety of statistical and analysis functions. The majority learned how to communicate their findings, with 68% describing skills gained in developing graphs and figures of their data, using editing software to appropriately prepare photos of gels and other images, and create poster layouts. Most fellows also said that they improved their writing (68%) and presentation (60%) skills, especially in the specific area of scientific writing. They said they had to learn to write concisely, to get rid of “fluff,” receive less “red” in reviewer comments, and be more straightforward. Nearly one-half (40%) learned about data management, including cleanup of data for analysis and data storage and annotation. Interestingly, few of the fellows (28%) emphasized the specific laboratory skills they learned; the skills they particularly remembered were most often ones that were transferable to future tasks.

[Before STRIDE], I would see a research article ... [and] would tend to skip [the results section]. I don’t really know what those numbers even mean or what the symbols even mean... Just right to the discussion to figure out what they’re saying. But this experience has made me slow down a little bit and look at the numbers, see what they’re telling us. Being from the opposite side, being the person who’s conducting the project and trying to take away what you would then write for a discussion post-results, it’s definitely a different aspect on how I actually look at those numbers. (Undergraduate premed with clinical research plans)

I had some skills and knew how to use some machines which is actually how I got my job [technician] now. (It) was because I worked in the lab for two summers, so I knew a basic understanding of lab workflow and even some of the machines that we had in my [STRIDE] lab we are using in my lab now. (Undergraduate premed student)

Because the research experience was often the first time that the fellows dealt with real experimental data rather than coursework laboratory data, we asked whether they learned any new approaches to data analysis. One fellow said that in class you do the same type of analysis all the time, but researchers must deal with unexpected data: “You had to learn from scratch how to do data analysis.” Several noted that they had to learn to clean up the data before analysis. In doing the analysis, they noted that it is important to not just look for differences, but to understand why they are happening. In terms of statistics, they learned to not just look for a specific $P$ value, but to understand what the statistics and analysis means.

I would say that analyzing data from my Excel sheet was what I learned because I could produce data all day long, but could I actually understand what I was producing? I would say half the time, ‘No,’ until I started working in the lab. (Undergraduate premed student)

In terms of sharing what they found, one fellow said that, when sharing results, the researcher must not try to trick the reader into overinterpreting the findings. And some noted the converse: as they read journal articles, they became much more aware of how the analysis was done and how that influenced the conclusions. Interestingly, only one fellow mentioned learning the four standard steps for analyzing data (plot the data, study the data, analyze the data, analyze the analysis) (2).

Communication. Several fellows strengthened their communication skills via the fellowship activities. One SRC fellow said that communicating with people outside of his/her family was difficult but through the fellowship she/he got practice in communicating both one on one in the laboratory and to groups at the poster session. Another said the fellowship helped get him/her “out of my shell” and gain confidence in public speaking. STRIDE helped one fellow learn how to successfully get information from other people, including critical information for his/her application to an MD/PhD program.

Confidence. Several fellows noted that they lacked confidence and were impacted by imposter syndrome (see Ref. 6 and discussion below). They described how the fellowship helped them. One felt she/he was getting burned out academically, but taking on the challenge of doing research was invigorating and helped him/her to build confidence and learn to trust him/herself. Another fellow, who is now in a leadership position on campus, gained confidence in his/her leadership skills through the fellowship. One SRC fellow said that moving from a behavioral science major to physiology was difficult and, combined with his/her physical disability, led him/her to experience significant imposter syndrome. The research activities of the fellowship and attending EB helped him/her gain confidence and better deal with self-doubt. Other fellows noted confidence issues as well:

I had a feeling of being underestimated, being from a small school and Hispanic. I had imposter syndrome. STRIDE helped me to overcome that. It set the tone for the rest of my undergraduate work. I realized there are opportunities everywhere. I changed to a ‘go-getter’ mentality. It increased my networking, keeping me tough, doing workshops online to gain skills. (Postbac applying to medical school)

I had doubts about what I could do. This fellowship gave me confidence. Being able to trust myself, working on a technique over and over and over again. Being able to troubleshoot was a really important part in [research] because sometimes things don’t go well. Having the guidance to go through that, especially in a lab ... not everyone can get that experience. I really enjoyed it. (PharmD student with plans for clinical research)

Motivation for coursework. The research experience gave some fellows new perspectives on how their coursework applies to real world research. One fellow said she/he did not like science classes, but after the STRIDE fellowship, she/he had a new respect for science. It became clearer how the classroom information applies to research and understanding science.
Another said that research helped him/her enjoy learning a lot more. Before STRIDE, she/he did not enjoy science classes and did not find them relevant. After STRIDE, she/he took high-level classes and could see the real-life applications of his/her coursework. Other fellows said that working in the laboratory taught them skills that benefited their coursework: persistence, patience, how to take good notes, and organizational skills.

I was also taking genetics and biochemistry and a lot of the hard-core sciences and actually using those machines, and using those methods [in STRIDE] that we talked about in the classroom helped solidify the understanding. I actually knew more than some of my classmates because I was doing this hands-on [work].... (Undergraduate premed student)

Financial impacts. The STRIDE summer stipend was essential to many fellows’ ability to experience research; summer was normally a time for earning money for the coming school year. One fellow noted that while she/he was in college, his/her father was unemployed. Without the STRIDE fellowship, she/he could not continue his/her research. Similarly, another fellow said that his/her family was poor and had been homeless for a while. “STRIDE made it possible for me to stay there at school, save money, and do research.” This fellow was proud to share that she/he now owns his/her own home. Another fellow said the STRIDE fellowship allowed him/her to do a third year of research. All three of these fellows are now in strongly research-focused careers.

It [STRIDE fellowship] did help out, especially someone who’s first gen, low income. It helped me out because ... [normally] I would have to go back home and help my parents out.... I probably wouldn’t be able to do research unless I was given some sort of financial aid—the stipend that they [STRIDE] gave me, and they were really generous with EB too. I probably wouldn’t have afforded, or my parents would not have allowed me to go if it wasn’t for the grant they provided. So, these resources, even if they seem small, were really, really essential to me being able to do research over the summer. (Undergraduate in neuroscience)

STRIDE impacts on career goals. For SRC fellows, STRIDE had a strong, positive influence on their career goals. Everyone in this group described firm plans to pursue (or has already received) a PhD (or equivalent MS), MD/PhD, or MD with strong engagement in clinical research. Each one described how STRIDE either solidified their original plans for a research-rich career or moved them toward inclusion of research in their career goals. Two fellows who are currently in PhD programs originally set goals as high school students to get MDs, one following in his/her sibling’s footsteps into the STRIDE program. The STRIDE program solidified their career choices as it did for another fellow who is now a postdoctoral fellow in neuroscience. Two fellows who were originally focused on medical school switched to PhD programs after their STRIDE fellowship, one in physiology and another in neuroscience. Two fellows who are currently in MD/PhD programs were originally headed for either a MD or a PhD program. Through STRIDE, both discovered a passion for both research and patient care. The STRIDE program gave some fellows confidence to pursue research careers, one fellow in a master’s program in computational bioscience (the typical terminal degree for this field) and another fellow in a PharmD program with plans for clinical research. Five fellows who were originally planning to get an MD degree and focus exclusively on patient care discovered a passion for research through their STRIDE fellowship, as well as learning about the possibilities for MD involvement in clinical research. Each of them refocused their career goals to include a strong focus on clinical research. Some fellows already in medical school are heavily engaged in clinical and/or basic research, actively publishing papers, and presenting their work at clinical meetings.

This was my first experience with basic science research.... [Y]ou can be in a classroom and you can learn about all these kinds of things and you can try to understand the Krebs cycle, but you’re not really going to understand until you apply it and use your hands and ... figure things out based on experiments.... It exposed me to applying the knowledge that I knew .... and start critically thinking for myself because, up until that point, you’re basically just memorizing what other people have discovered, whereas when you’re doing research you’re doing the discovery, which is just so cool. I don’t know which [medical] specialty I’ll be in or what kind of research I’ll be pursuing. I just know that that’s what I want to do, because I think, as a physician, the best thing you can do is to apply all your skills. I do love research and I think being involved in problem-solving through research questions is a great way to contribute to medicine. (Medical student with clinical research plans)

...[STRIDE] was the first step to where I am today. It gave me an appreciation for research that I didn’t previously have.... The STRIDE program is so prestigious that, if I didn’t have that program, I probably wouldn’t have gotten into the [clinical research internship] program the next summer. I probably wouldn’t have gotten different scholarships that I got during college. And I don’t even know that I’d be in medical school if I didn’t take that first step with the STRIDE program.... When I applied for the [STRIDE] program my PI didn’t tell me how difficult it was to receive [it].... So, when I got the email that I received a STRIDE fellowship, [my PI] was so excited. ‘I didn’t tell you this, but this is a really big deal. Most undergrads don’t get this opportunity.’ So that was really cool, and it gave me the confidence to apply broadly to other programs and to try for different things I wouldn’t have otherwise tried. (Medical school student with clinical research plans)

Because of my time at [medical research institution] and as a STRIDE Fellow, I found that research is just a really good way of getting involved and familiar with a field. So anytime I’m interested in a field. I just try to get [involved].... ‘Maybe I could hop on this project with you.’ And then they send me all the relevant literature. I’ve just found it’s a really good way to expose myself to different fields. (Medical school student engaged in clinical research)

Originally, I wanted to do just an MD. Maybe by the end of the [STRIDE] summer, I wanted to do an MD with a research track. It was when I presented at EB that I fully knew I wanted to get a PhD.... I pretty much owe APS my complete academic career. It wouldn’t be possible if not for the [STRIDE] fellowship, I think. If I hadn’t been in the lab that summer, I would have done something totally different. So, I am really grateful.... It made a very, very important positive impact in my life. (Undergraduate student applying for PhD program)

STRIDE also had a strong influence on LRC fellows, that is, those who did not end up choosing a strongly research-focused career. Many noted that they gained a deep respect for basic research and learned about the existence of clinical research...
and how MDs can be involved. Several indicated interest, if not commitment, to including clinical research involvement in their future work as medical practitioners. One said that, toward that goal, she/he wanted to go to a large research-oriented medical school rather than the smaller schools she/he originally chose so she/he would have research options during training. Another was intrigued by what she/he learned about basic and clinical research and did a clinical research fellowship the following summer. For some fellows, however, the STRIDE research experience helped them learn that research was not a good “fit” for them. Two noted that, after learning about the constant struggle for funding by researchers, the politics of the research environment, and the constant writing required by a research career, they felt that research was not a good career choice for them. Both chose to apply to medical school without plans to include research in their careers. Another fellow who originally planned to have a clinical research career, learned about other jobs during his/her time as a STRIDE fellow. She/he decided to work on science and medicine from the human resource aspect, getting an MD and training to be a manager of a research facility or hospital.

At first, I thought I wanted to get my PhD. Then I discovered I hated writing, and they were showing me how to apply for grants and stuff. And that was not enjoyable…. I actually helped my PI peer review a couple of papers, and I did not enjoy that. [I thought] maybe I should not get my PhD and that’s when I settled 100% on [getting an] MD…. [The stress about getting a grant, because it’s not always guaranteed…. I never wanted to have that stress, I guess. (Undergraduate premed student)

I’ll be honest. I would not want to do research as a job for the rest of my life. I could do it for a little bit, but the stuff I was doing I would occasionally find repetitive…. But I did like the part, of course, where something doesn’t work. You have to try it again a different way. You have to use your brain and your skills to figure out how to optimize something. I did enjoy that…. (Medical school student)

When asked whether they learned things about scientific research that they would take forward into their careers, LRC fellows described the value of research in medicine. They said they had learned not just take things at face value but to dig in, find the evidence, find the best treatment for each patient, understand why something happens, and understand how the drug works and not just accept drug company information. They also understood more deeply that the science they were learning in coursework came from research. For SRC fellows, what they learned was more personal and unique. They described multiple insights: the collaborative nature of research, that details count in research, discovering a passion for research, and that skills learned are transferable. Three fellows who plan clinical research careers learned the importance of evidence-based medicine: that solving a science puzzle can impact many patients, not just one; that many factors and studies contribute to clinical treatments; and that there are strong connections between basic research and clinical medicine.

It’s made me realize, especially with medicine, that there are so many factors that you have to take into account. You have physical, psychological, mental, behavioral—all these different factors you have to take into account before you come to a conclusion. I feel that relates directly to how you make a conclusion with your research and what steps you are going to take. (Undergraduate premed with clinical research plans)

Value-added fellowship. Many fellows (88%) felt they got more than they hoped for from the STRIDE fellowship, including gaining friends (laboratory mates and/or research mentor), deeper understanding of what research is, publications (abstracts and papers), and a chance to find out if research was their passion.

[What I wanted to get was] … motivation to continue my studies and also just confirmation, I guess, of what I wanted to do. [What I got out of it]: I got the motivation and confirmation but also, I respect research so much more now, and now it’s not just some vague idea. It’s real … it’s reality. I love that. (Undergraduate premed student)

Of the three remaining fellows, two had hoped to get a research publication from the summer fellowship but did not do so. One of those had communication difficulties with his/her research mentor near the end of the fellowship. The third fellow had hoped for more career coaching during the fellowship.

The STRIDE fellowship was targeted toward persons underrepresented in STEM: underrepresented racial/ethnic minorities (URM), persons with disabilities, and persons from disadvantaged backgrounds (e.g., low income, first generation college). The fellows participating in this study included persons from each of these groups: More than one-half of the fellows self-identified as being from a URM group, 32% were low income, 20% were first-generation college, and at least 20% were persons with disabilities. When asked whether STRIDE met their needs, two of the fellows with disabilities noted that they had difficulties with EB travel. One asked for assistance from staff, but the other did not. One fellow said it would be nice to meet a scientist with the same disability.

Fellows who were first-generation college said the program’s financial support was helpful. However, they also said that they would like a chance to network with other first-generation students to share strategies and support. Similarly, fellows who were from lower income backgrounds applauded the financial support provided by the program. One fellow who had experienced homelessness due to low income said that people sometimes see him/her as a privileged person because she/he is white; she/he said people should expand their image of who may need assistance.

I’m a first-generation college student so coming to college itself was very different…. I had no idea what to expect from a research lab. No one in my family works in medicine [and] no one works in a research lab, obviously. So, I think this program was very tailored to me simply because it allowed me to go through that step-by-step process and [learn] what it actually means to be someone who works in a research lab, someone who is a scientist. (Undergraduate premed with clinical research plans)

URM fellows had mixed impressions of the program’s ability to meet their needs. Several found the program met their needs with financial support and good research mentors. Some fellows noted that having living expenses for the summer would have been helpful. A fellow who was from a historically black college or university said graduate school was like “shell shock.” She/he would have liked to learn from the STRIDE
fellowship how to deal with being the only URM student in a department.

Theme IV: Professional Networking and Professional Societies

The STRIDE fellowship included professional development activities on networking skills. We asked fellows what they had learned about professional networking that they now use. Some felt they already had networking skills or had built a network before the fellowship. Interestingly, about one-half of those people went on to note things about networking that they learned from the fellowship (e.g., elevator talks, how to meet people at EB). One of those fellows said that, other than the undergraduate sessions, there was little opportunity to network at EB because she/he was with a group from his/her laboratory.

Most fellows, however, cited specific skills and experiences they gained in networking as a direct result of the fellowship. Several said they learned to prepare to network at a meeting by practicing elevator talks and one-line descriptions of their research, bringing contact (business) cards, and having questions ready to ask of speakers and other people they wanted to meet. While not all fellows found the APS lessons on networking useful, many did and credited STRIDE for helping them understand that effective networking building has value, structure, and methods. Others found it scary and intimidating. The STRIDE lessons seemed to demystify networking and give it purpose and structure for many of the fellows. We also asked whether and how they build their professional network now. More SRC fellows (57%) described engaging in active professional network building activities than did LRC fellows (36%).

Because STRIDE is coordinated by a professional society, fellows received information on what the APS does and got to see firsthand at EB how a professional society facilitates the sharing of scientific discoveries. We asked STRIDE fellows what they thought the role of professional societies, like APS, is. Most of their answers centered around facilitating communication among scientists. They voiced strong support for the involvement of professional societies in training the next generation and in building communities of researchers. They listed building professional networks (28%), bringing researchers together to meet each other (24%), fostering communities (12%), and nurturing communications (8%) as important tasks for professional societies. They also said that societies should peak undergraduates’ interests in their fields through fellowships like the STRIDE fellowship (24%).

I feel like this program is very different [because] it’s a 2-in-1: They’re giving you the resources and opportunities to do research, but they’re [also] building your career, which is very different from when an undergrad or graduate just goes to a PI and just says, “Can I join your lab?” Providing a support structure like that to the student is very helpful, especially for STRIDE because it helps a lot of people from disadvantaged backgrounds, low-income backgrounds. (Undergraduate in neuroscience)

When we asked what professional societies or organizations they belonged to, not surprisingly, the SRC fellows were more likely to currently be a member of a scientific society (SRC: 84%, LRC: 45%) and were more likely to have multiple professional society memberships (SRC: 29%, LRC: 0%). There were fellows in both groups who had one professional membership (SRC: 57%, LRC: 45%), most often the APS membership they initially received as STRIDE fellows. On average, SRC fellows (mean = 1.4) had more memberships than did LRC fellows (mean = 0.4) (t test, P = 0.011).

Theme V: Suggestions for Improving the Fellowship Program

Fellows offered numerous suggestions for improving the program. In some cases, the program had already addressed the issue. For example, direct deposits replaced mailed stipend checks to eliminate paycheck delays, and assigning two to three APS members to visit each poster prevented undergraduates from standing by their poster without visitors. Fellows suggested improvements in the program in three areas: networking, EB planning, and professional development assignments.

Fellows asked for greater attention to building networking skills, more specific opportunities for networking, and greater structure for networking sessions. They strongly supported creating more opportunities for STRIDE fellows to get to know one another, to talk online and at EB, and have dedicated time to meet at EB. They also asked for contact information for the STRIDE fellows in their cohort and for the research mentors.

They also wanted more opportunities to meet other researchers in their field and to meet with researchers, graduate students/postdocs, and STRIDE fellows from their specific subgroup (URM, first-generation college, persons with disabilities). They noted that their background did not provide enough information on how to negotiate the career path to a research career, and guidance from someone who had successfully navigated the same path could be helpful. Some asked to be paired with an additional mentor throughout the program who could offer advice. This mentor could help fellows to communicate specific needs to the program staff and/or research mentor. For example, some fellows with disabilities needed additional travel and hotel accommodations at EB but did not tell the staff. Another had great difficulty with their summer housing during the research experience but did not ask the staff or research mentor for advice or help. Undergraduate students usually do not have much experience in how organizations and employers can help in these types of situations and may try to resolve them on their own.

Fellows wanted more guidance for EB planning, including how to select sessions to attend, what the different session types were, and how to find session rooms. Some were alone at EB, without a mentor or laboratory mates. They asked for more opportunities to meet with the STRIDE fellows and undergraduate students. Some comments indicated that they did not understand the networking opportunities provided by sessions, such as the undergraduate orientation and poster session. They also wanted to see more than graduate schools represented at the pre-poster session career fair. Many were interested in medical school for both MD and MD/PhD programs and hoped to build contacts at EB.

In terms of the online professional development modules, fellows wanted these to directly address their specific needs. Many noted throughout the interviews that one module or another did not “fit” their situation. For example, fellows who were applying for medical school did not want to write a personal statement appropriate for graduate school applications. Although most of the assignments focused on skills
broadly transferable to many professional situations, some fellows did not have enough experience to recognize the flexibility and applicability of these skills. For one group, these concerns were especially germane; those fellows who had significant previous research experience found some of the professional development activities redundant. They hoped to get assignments that moved them forward in their understanding of research careers and opportunities. They wanted to engage with APS members and learn how to become active in APS programs and activities. And they wanted coaching from researchers in their field. One SRC fellow recommended having “tracks” of assignments so fellows can customize their professional development to their needs.

A second problem with the assignments was noted by several fellows: they were hesitant to offer constructive criticism to other fellows about their blog entries, abstracts, etc. They said they did not feel qualified to do this. Finally, many fellows noted that they did not like the discussion boards. They were frustrated at the last-minute comments by other fellows, which did not leave time for discussion. Several said they would prefer a direct conversation with other fellows about the topics.

**DISCUSSION**

Several major themes arose from the interviews. These themes cut across different questions and topics but were emphasized by most of the STRIDE fellows who were interviewed: 1) personalize the program, 2) strengthen the research mentor relationship, and 3) participate in the broader scientific community.

**Personalize the Program**

The STRIDE program attracted a diverse population, in terms of demographics, past research experiences, career goals, and expectations for the fellowship. Many fellows expressed a wish for the program to directly meet their personal needs. Their comments suggest several possible programmatic changes that could make URE programs more adaptive to a diverse group of fellows.

Provide advice from past fellows. Simple videos or letters could allow previous fellows to share what they struggled with and gained through their fellowships. A structured sharing opportunity could allow past fellows to describe how they felt when entering the laboratory, what skills they discovered they were missing, and how they strengthened these skills during their time in the laboratory. It also provides a window into how the skills gained through the fellowship are transferable to future studies and careers.

Customize the objectives to match the needs of the fellow. While some fellowship objectives are static, fellows could work with staff and their research mentors to identify skills, content, publications, and career information that they hope to gain through the fellowship. Some of these may be facilitated by the research mentor. Others might be webinars or online conversations with researchers in careers of interest or from specific subgroups (first-generation college, URM, persons with disabilities, etc.). Webinars could discuss common types of research and who does them (e.g., bench, clinical, big data); the pros/cons of PhDs, MDs, and MD/PhD training and careers; the value of research in medicine; best strategies for working with a research mentor, including troubleshooting common problems; and engaging with your professional society (especially for more advanced undergraduate researchers). Customized offerings may help undergraduate research fellows to accomplish their personal goals and build stronger communication channels with both their research mentor and the program staff.

Provide support for skills development. UREs could provide online resources to help fellows target and work on specific skills they are lacking. Common skills gaps in this study were time management, organizational skills, public speaking, and statistics. For more experienced undergraduate researchers, programs could offer opportunities to learn advanced skills, such as research design and data reporting for rigor and reproducibility of data (2), journal reviewing skills (12), and professional ethics (e.g., conflicts of interest, data management/integrity, overlapping publications) (3).

Include a strong focus on networking and communication skills. In the interviews, this area showed the greatest gaps in fellows’ current skills. Some were in graduate or medical schools, yet still did not describe well-developed networking and communication skills. Most who were still undergraduates or recent graduates described poorly developed networking and communication skills. While undergraduates majoring in business have coursework in personal communications and developing professional networks, this is not emphasized in the science disciplines. The STRIDE program provided professional development activities to help fellows understand the importance of networking and collaboration in research and provided exercises to develop networking skills. Fellows learned to prepare and use an elevator talk, one-line descriptions of their research, and questions to ask a new contact. They used these at EB and found them very valuable (4).

However, most fellows did not follow through with contacts they made at EB or through their fellowship. Except for friendships they made in the laboratory, they did not keep in touch with laboratory mates and sometimes did not reach out to the research mentor. They did not contact people they met at EB and did not actively work to increase their network. Fellows enrolled in PhD programs were more likely to engage in these activities but not consistently. Fellows who were in medical school or planning to go to medical school did not place great value on building a professional network. Some thought networking would only become important when it was time to apply for residencies.

These misconceptions and/or missed opportunities also constitute a missed opportunity to hone critical networking skills. Programs should consider asking fellows to set personal goals for networking building during and after the fellowship. They should provide a schematic on what to do before, during, and after a scientific meeting, e-mail inquiry, personal meeting, or phone call to incorporate appropriate follow up. Fellows should be encouraged to send out an annual e-mail or social media update on their career development and accomplishments. Finally, fellows should hear from experienced PhDs, MDs, and MD/PhDs on the importance of, and methods for, actively building a network early in their training.

Build communication and trust with staff early in the fellowship. After acceptance, program staff could schedule a brief phone call with each fellow, especially those with specific needs (financial, disability). Some of the fellows in the study
had significant physical disabilities that required accommodation, but they never disclosed their disability on the application or to the staff. Offering a personal and confidential call would build trust with the new fellows. In addition, program staff should share more information with fellows on how staff can help when they encounter difficulties, emphasizing that “dealing with it yourself” can compromise the benefits of one’s fellowship. Staff could prepare a bullet list of “times to contact the staff” and should assure that fellows understand that staff communications are confidential.

Communication with staff is critical in terms of financial support for the undergraduate researchers. While none of the fellows in this study made comments about the amount of the STRIDE fellowship stipend, there were other financial needs that left some students with disabilities and with financial disadvantages struggling to focus on the fellowship. For some, securing affordable summer housing was difficult, especially the need to pay considerable sums in advance of earning any fellowship stipends. Programs should consider providing support for summer housing for those who need it. For economically disadvantaged students, summer job earnings are essential to continue their education. If their fellowship stipend must be used to pay for summer housing, many students in this group will not be able to participate. Another issue was accommodation needs for fellows with disabilities. In this small sample, there were fellows who had to travel by bus across country to EB because they could not fly, and others had to support a family member or aide to help them travel. If this information was disclosed, the APS program tried to provide additional support. However, other programs may not have this support built into their budgets, yet it can be pivotal in engaging students with disabilities in summer research programs.

Strengthen the Student-Mentor Relationship

The undergraduate research fellow’s relationship with the research mentor is critical to assuring a positive outcome for the fellow’s research experience. Toward that end, URE programs must work closely with research mentors to help them understand and meet the needs of the fellows, especially URP fellows. All mentors and, where possible, all laboratory personnel should complete a professional development program on working with undergraduate students, including students from URP groups. Mentors should consider the following recommendations based on fellows’ interview comments:

Recognize and address imposter syndrome. Mentors should assume that fellows experience imposter syndrome to a greater or lesser degree. Not to be confused with low self-esteem or lack of self-confidence, persons with imposter syndrome “...suffer from chronic self-doubt and a sense of intellectual fraudulence that override any feelings of success or external proof of their competence” (6). Among women and academics, including medical and graduate school students (17), it is often linked with perfectionism: you must not fail, or you will be discovered to be a fraud, not worthy of your current status or accomplishments (6, 11). High-achieving undergraduate science majors enter the research laboratory environment where they do not know the scientific content of the research area or the methods and equipment being used, and do not have any guarantee of success. Feelings of “I don’t belong here” can be compounded when the student believes they are the “only” person like them in the larger group (e.g., female, minority, disabled, first-generation college). Mentors should help fellows to recognize that failure is a normal and important part of science, not an indicator that they are an inept scientist. There are numerous resources for working with persons with imposter syndrome, and even simple checklists can provide an opportunity for sharing among the laboratory group (8, 21), and undergraduate educators have identified ways to help their students recognize and challenge their imposter syndrome (11, 17).

Build an ongoing conversation. Undergraduate students from URP groups may have specific needs that they were unlikely to disclose on an application form or even as they worked with the research mentor on a summer research plan. Many will be embarrassed or too intimidated to raise concerns about summer finances, needed accommodations for a disability, family/work conflicts, or transportation issues. Mentors need to work before and during the summer to build trust, actively listen to fellows’ concerns, and respond appropriately. Many times, student needs can be addressed through university support services.

Part of that ongoing conversation should be constructive feedback. Mentors should explain: how and why the student should expect both positive and negative feedback during the summer, that this is a normal process for research collaborations, that everyone in the laboratory receives both kinds of feedback, and what the student should do when she/he receives feedback. For many students, this may be the first time they have had to act on feedback, rather than just accepting a “grade” and moving on to the next assignment.

Of course, feedback should be shared directly with the student, especially negative feedback or constructive criticism. Mentors should never talk negatively about the fellow to other members of the laboratory or to the laboratory group. When the fellow hears about it, it can be devastating to their confidence. Communication from the fellow after the summer should not be ignored; even a quick response to say “super busy ... will get back to you next week” assures the fellow that he/she is still part of the team.

Mentor-student conversations should also include a discussion of the pros and cons of research careers. However, fully conveying the mentor’s frustrations about funding challenges or departmental issues can be discouraging to undergraduate students. All professions have pros and cons; research mentors should share both, but within the context of a mentor/student relationship, not as if sharing concerns with a peer.

Laboratory atmosphere counts. Fellows recognized that the research mentor sets the tone for his/her laboratory group. They found collaborative laboratories where help is offered to be encouraging and exciting. Mentors should help fellows and the laboratory group members understand the roles of undergraduate researchers. They should encourage laboratory personnel to help support and train undergraduate researchers and recognize them for their efforts. As fellows spend additional years in the laboratory, mentors should give them responsibilities to teach new laboratory staff and students procedures and equipment. Furthermore, undergraduate researchers should present regularly at laboratory meetings to build confidence and a sense of belonging to the research team.
Help the student identify additional “mentors.” Fellows in our study valued getting feedback from other researchers as part of the online professional development lessons and encouraged APS to expand this in the future. Mentors and/or program staff can assure that fellows have additional “mentors” to provide a broader perspective and serve as a sounding board. These mentors could be senior researchers, postdocs, or graduate students from a similar background or research area.

Participate in the Broader Scientific Community

Attending a large scientific meeting was a pivotal experience for many of the fellows interviewed. Even years later, their voices were filled with excitement when talking about presenting their research for the first time and, for most, feeling like they were truly a scientific researcher. However, scientific meetings are about more than one’s poster presentation. Ensuring that fellows fully and positively experience a large meeting is worth providing additional guidance for these young scientists. Large meeting programs can be especially hard to decipher, particularly for the first-time attendee. Program staff should provide adequate guidance on how to plan a meeting schedule. They should give definitions of each session type (e.g., symposium, featured topic, distinguished lecture), including whether these sessions would include review material that undergraduate students would understand. The fellow’s research mentor can provide valuable information for the meeting, as well.

Many fellows in our study asked for more undergraduate networking sessions at EB. The large undergraduate orientation session did not provide enough time to network, and they wanted to meet specifically with other STRIDE fellows. APS added dedicated networking time for STRIDE fellows at EB in 2019. URE programs should consider offering dedicated networking sessions, including informal “meet up” times where they can meet in the lobby to go to dinner or have coffee. Smaller sessions also could offer time for networking with professionals from fellows’ subgroups (e.g., first-generation college, low income, URM, disability).

Summary

The STRIDE fellowship was clearly a different experience for undergraduate students, depending on their prior research experience. For undergraduate students with little or no prior experience, STRIDE opened a door into the world of research, with all its excitement and tedium, its triumphs and disappointments, and its beauties and warts. They learned how laboratory groups are structured, how to access resources, how to ask for help, and how to report what they had learned. For many, it was the first time they had organized their own work in a substantive way. Courses provide considerable structure compared with work in the research laboratory. Learning to plan and organize one’s experiments, analyses, and presentations led to gains in both skills and confidence for nearly all STRIDE fellows. For those fellows who had substantial prior research experience, the fellowship offered opportunities to not only continue their work, but expand and deepen their research, writing, presentation skills, and, for many, their leadership skills as they became the “experts” for new laboratory group members.

One of the unique aspects of the STRIDE fellowship was the opportunity to attend and present at a major international scientific meeting. Whether they were experienced undergraduate researchers or novices, EB had a tremendous impact. For those who were strongly interested in research careers, it provided a vision of the future and a chance to build their networks. For those who were not bound for a research career, it “closed the loop” on how researchers share information and launch collaborations, and the important role that professional societies play by bringing trainees together with experienced researchers.

Finally, for good or bad, the long-term impact of the URE hinges on the relationships between the student, the research mentor, and the other people in the laboratory. The research mentor sets the tone for the laboratory that can help or hinder undergraduate student researchers. For students from groups underrepresented in STEM, the relationship with the mentor and laboratory staff is especially critical because they are the people who validate that the student has the potential to do research. Most fellows described experiencing “imposter syndrome” during the research experience, questioning whether they fit into the laboratory and, more broadly, into the scientific research community. Support and encouragement from the research mentor and their laboratory mates helped reduce the impact of their doubts, but, conversely, negative interactions and unconstructive criticism had even stronger adverse effects.

UREs have many documented impacts, including increasing retention in STEM majors, taking additional science courses, increasing motivation and STEM career interest, and earning higher grades (13). These impacts are especially strong for students from underrepresented groups. The conversations with past STRIDE fellows in this study agree with these findings: They described increased commitment to STEM career plans and increased motivation and interest in their science courses. For some students, one summer of research can serve as a decisive moment in their career path. Two fellows wanted APS to know that the STRIDE fellowship was a such a moment for them:

I think they should know that their programs really do go a long way. I think even if it was a summer (two summers for me), that’s one summer out of twenty-something that I’ve lived in my whole life. And this is probably the one that’s impacted my future the most.... I think they should continue to have these programs. (Undergraduate premed with clinical research plans)

APS should know that the STRIDE opportunity is a true blessing. When you have a disadvantaged background, you have no exposure to these careers. Step 1 was submitting my STRIDE application. That led to publishing research which propelled me forward into a research career and understanding of how science works. (MD/PhD student)

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AUTHOR CONTRIBUTIONS

C.B.B. and M.L.M. conceived and designed research; C.B.B. and M.L.M. performed experiments; M.L.M. analyzed data; C.B.B. and M.L.M. interpreted results of experiments; M.L.M. prepared figures; C.B.B. and M.L.M. drafted manuscript; C.B.B. and M.L.M. edited and revised manuscript; C.B.B. and M.L.M. approved final version of manuscript.

DISCLOSURES

C. B. Bruthers is an employee of APS. M. Matyas is a retired APS employee and currently serves as a consultant to APS.

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