

HOW WE TEACH | *Generalizable Education Research*

Monitoring undergraduate student needs and activities at Experimental Biology: APS pilot survey

Nicole L. Nichols,¹ Daria V. Ilatovskaya,² and  Marsha L. Matyas³

¹Department of Biomedical Sciences, University of Missouri, Columbia, Missouri; ²Department of Physiology, Medical College of Wisconsin, Milwaukee, Wisconsin; and ³Education Office, American Physiological Society, Bethesda, Maryland

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Nichols NL, Ilatovskaya DV, Matyas ML. Monitoring undergraduate student needs and activities at Experimental Biology: APS pilot survey. *Adv Physiol Educ* 41: 186–193, 2017; doi:10.1152/advan.00182.2016.—Life science professional societies play important roles for undergraduates in their fields and increasingly offer membership, fellowships, and awards for undergraduate students. However, the overall impacts of society-student interactions have not been well studied. Here, we sought to develop and test a pilot survey of undergraduate students to determine how they got involved in research and in presenting at the Experimental Biology (EB) meeting, what they gained from the scientific and career development sessions at the meeting, and how the American Physiological Society (APS) can best support and engage undergraduate students. This survey was administered in 2014 and 2015 to undergraduate students who submitted physiology abstracts for and attended EB. More than 150 students responded (38% response rate). Respondents were demographically representative of undergraduate students majoring in life sciences in the United States. Most students (72%) became involved in research through a summer research program or college course. They attended a variety of EB sessions, including poster sessions and symposia, and found them useful. Undergraduate students interacted with established researchers at multiple venues. Students recommended that APS provide more research fellowships (25%) and keep in touch with students via both e-mail (46%) and social media (37%). Our results indicate that APS' EB undergraduate activities are valued by students and are effective in helping them have a positive scientific meeting experience. These results also guided the development of a

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PROFESSIONAL SOCIETIES play an important role in both the training and professional socialization of future science, technology, engineering, and mathematics (STEM) professionals (11). They traditionally have engaged and supported career researchers, educators, and advanced trainees (graduate students and postdoctoral fellows) in their scientific fields. For many societies, these groups have comprised the bulk of their membership and been the primary targets for their publications, awards, meetings, and other services. However, some societies have also focused on undergraduate students. Recent evidence indicates that, over the past decade, life science professional societies have increased their emphasis on undergraduate education. According to a study of 26 life science professional societies, there have been significant

increases since 2008 in the number of societies that offer a specific membership category for undergraduate students, provide undergraduate student research awards and travel grants to attend their meetings, and sponsor student clubs or chapters (10). The number of societies providing disciplinary teaching resources and undergraduate faculty awards for teaching and mentoring excellence has increased significantly as well (10).

The American Physiological Society (APS) is one of the life science professional societies that have increased their emphasis on undergraduate education. Over the past 16 yr, APS has dramatically increased its outreach to and support of undergraduate student involvement in physiology. Major initiatives include the following:

- APS Undergraduate Summer Research Fellowships. In 2000, APS funded 12 undergraduate summer research fellows to do research in the laboratories of APS members. With additional APS and federal support, APS now provides >90 summer research fellowships for undergraduate students annually, including targeted awards for students from groups underrepresented in science.
- Undergraduate Teaching Resources. In 2003, APS launched a database-driven digital library of teaching resources, the APS Archive of Teaching Resources (now the Life Science Teaching Resource Community, www.lifescitrc.org), including nearly 7,000 peer-reviewed undergraduate teaching resources.
- Undergraduate Sessions at Experimental Biology (EB). In 2004, APS launched multiple activities to support undergraduate students at its annual meeting, EB. These included giving its first undergraduate research awards, holding an annual undergraduate poster session, and inviting students to an Undergraduate Orientation Session.
- In 2009, APS established an undergraduate membership category.
- In 2016, APS began encouraging members to give undergraduate physiology research awards at their campus undergraduate poster sessions.
- The APS governing Council also charged its Trainee Advisory Committee (TAC) with monitoring the needs of undergraduate students engaged in physiology research. The TAC includes graduate students and postdoctoral fellows from each APS disciplinary section (cardiovascular, respiratory, etc.) and advises the Council on matters related to trainees at all levels.

Address for reprint requests and other correspondence: M. L. Matyas, Director of Education Programs, American Physiological Society, 9650 Rockville Pike, Bethesda, MD 20814 (e-mail: mmatyas@the-aps.org).

The involvement of professional societies with undergraduate students has important impacts. First, professional societies provide additional opportunities for undergraduate students to engage in research by providing society-funded summer research fellowships. The Matyas et al. study (10) found that 52% of life science professional societies (including APS) give summer research fellowships to undergraduate students. Undergraduate research experiences have been shown to increase students' understanding of science, confidence in their science abilities, and skills, independence, motivation, course participation, and awareness of science careers (8, 9, 13, 14). They also help students decide on a STEM career and increase their expectations of earning PhDs (9, 13). Importantly, these findings are true for diverse groups, including both men and women, both minority and majority students, and both STEM and non-STEM majors (13, 16). In fact, recent national initiatives on undergraduate education have recommended that all undergraduate students have an authentic research experience as part of their science courses (1).

Scientific societies also impact the psychosocial development and career mentoring of trainees, especially through professional socialization (11). Although societies cannot and should not mentor in place of the research advisor, they provide venues where scientists learn how to interact productively and establish collaborations. Psychosocial mentoring activities enhance students' self-concepts and their social interactions with their professional environment (7). For example, presenting at a national meeting offers students opportunities to discuss their research with other students and with both national and international researchers. It also provides them with critical perspectives on how new scientific findings are initially shared among researchers and how their own research findings contribute to the overall research field. They also can hone their professional networking skills and identify colleagues for future collaborations. Unfortunately, many undergraduate students who are engaged in research do not have this type of experience. They present their research at an on-campus symposium but do not see the massive, interactive sharing of new information that occurs at large national or international meetings. Considering the demonstrated impacts of having an undergraduate research experience, the impacts of also having a scientific meeting experience merit further study.

Our study sought to begin addressing this issue. With increasing numbers of undergraduate students attending EB and participating in APS undergraduate-focused sessions (e.g., orientation, poster sessions, and award competitions), the TAC developed a feedback survey tailored to undergraduates attending professional meetings. The feedback provided would both identify undergraduate student needs and document the success of EB in meeting those needs.

The purpose of the present study was twofold. First, we sought to develop and test a pilot survey of undergraduate students attending EB to determine how they got involved in research and in presenting at EB, what they gained from the scientific and career development sessions at the meeting, and how APS and other professional societies can best support and engage undergraduate students. Second, we planned to use the data from the pilot survey to create an improved survey for use in future years.

METHODS

Survey development. The pilot survey was developed collaboratively by TAC members and APS staff and is provided in the Supplemental Material (Supplemental Table S1).¹ The team discussed the goals of the APS EB undergraduate activities (described above) and developed questions to probe how undergraduate students became involved in research and presenting at EB and what they felt they gained from these activities and the EB meeting overall. Since this was the first survey of undergraduates attending APS sessions at EB, we included not only multiple-choice questions but also numerous open-ended questions and options to add "other" responses for multiple-choice questions. We hoped that the open-ended responses would identify additional questions or multiple-choice question options that should be included in future surveys.

Target audience. In the EB abstract submission process, undergraduate students identified not only the society to which the abstract was being submitted but also whether or not they were an undergraduate student and were the first author on the abstract. Students who met all three criteria (abstracts submitted to APS, undergraduate student, and abstract first author) were invited to attend the undergraduate orientation session, participate in the undergraduate poster session, and serve as a member of an annual TAC Undergraduate Advisory Board. Attendance at the Orientation Session was assessed by a "head count" of attendees at the start of the session. The minimum counts are reported here; therefore, the response rates are at least the percentages shown. For the poster session, an exact count of the number of posters presented was tallied. For the Advisory Board Survey, an exact number of responses was tallied. As shown in Table 1, participation rates in all three activities were good. These activities were in addition to the normal activities of presenting their poster or presentation in a regular scientific session; attending lectures, symposia, and workshops; and visiting exhibits. In addition, each undergraduate student presenting a first author poster in physiology at EB was sent a packet of information containing details on what to expect at the EB meeting.

Survey administration. The survey was administered securely through either Hosted Survey.com (2014) or SurveyMonkey.com (2015). All target audience students received an individual e-mail invitation to serve as a member of the TAC Undergraduate Advisory Board. The invitation described how the data would be used (e.g., program evaluation and improvement or publication of reports) and

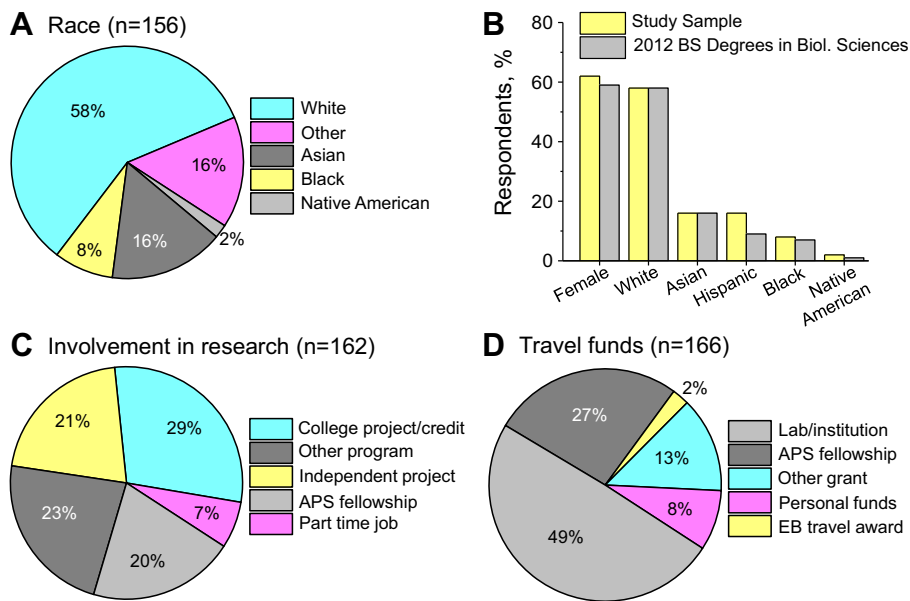
¹ Supplemental Material for this article is available at the *Advances in Physiology Education* website.

Table 1. Participation rates in American Physiological Society undergraduate sessions by year

Session	2014 (n = 180)		2015 (n = 219)		Total (n = 399)	
	Number who attended/responded	Rate, %	Number who attended/responded	Rate, %	Number who attended/responded	Rate, %
Undergraduate orientation session	>100	56	>110	50	>210	>53
Undergraduate poster session	136	75	122	56	289	72
Undergraduate advisory board survey	64	36	87	40	151	38

n, Total number.

Fig. 1. Comparison of Experimental Biology (EB) meeting (2014 and 2015) undergraduate student survey responses on demographics, involvement in research, and sources of travel funds. *A*: percentage of undergraduate respondents by racial group. *B*: comparative demographics of study sample and United States 2012 Bachelor degree recipients in biological sciences. *C*: summary of the undergraduate students' involvement in research presented at the EB meeting (in %). *D*: distribution of the funding source type that supported student's travel to the EB meeting (in %). Survey results shown were combined for 2014 and 2015; the distribution of survey respondents by reported parameters were similar in both survey years (2014 and 2015). Percentages may not total 100% due to rounding.



that reports would not include student names or institutions. Students received the e-mail invitation at the close of the 2014 and 2015 EB meeting and had 2–3 wk to complete the survey. Multiple reminders were sent to nonrespondents. Incentives were provided, including a letter and certificate of appreciation for serving on the advisory board as well as entry into a drawing for a gift card for those responding by the initial deadline. APS staff processed the incentives. Response rates (38%) were somewhat higher than generally expected for an e-mail survey (15). Student names and e-mails were removed from the data before analysis, and all data were stored on secure servers. This study was part of the evaluation component of three federally funded undergraduate summer research programs (2–4), all of which have been designated as exempt from Institution Review Board approval (Exemption 1) by the Federation of American Societies for Experimental Biology (FASEB) Institutional Review Board exemption review panel.

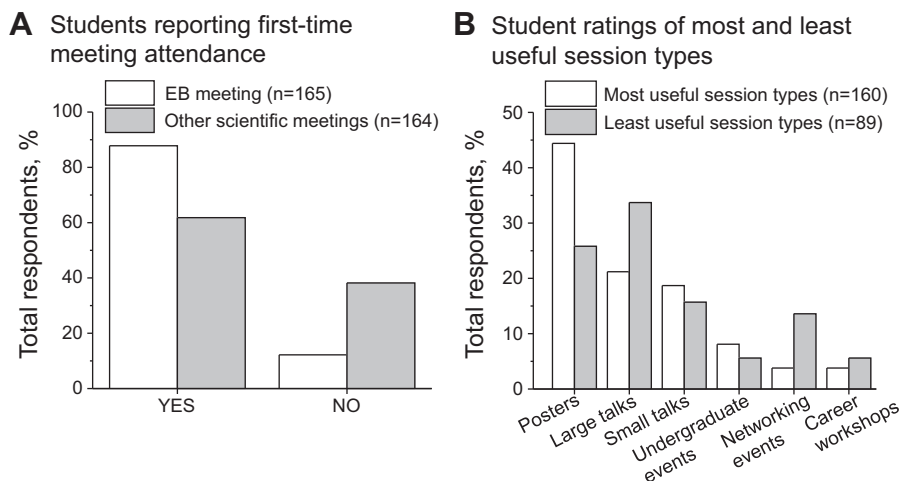
Data analyses. The goals of the analyses were twofold. First, we sought to determine whether the APS undergraduate activities were effective. Second, we sought to identify necessary revisions in the pilot survey to provide a more robust and useful instrument to use in future years. Analyses were conducted by TAC members and APS staff. Results for some of the multiple-choice questions are shown in Figs. 1 and 2, where responses to open-ended questions are provided

in Supplemental Tables S2–S5 or included in the RESULTS section in the text. Percentages were tabulated for multiple-choice questions. “Other” responses were coded by multiple team members, and if similar responses were written by more than one respondent they were included as a line item in the result tables. For open-ended questions, the same process was used where responses were reviewed at the most granular level (i.e., individual responses). Team members discussed responses that could be collapsed into a broader category. For example, one student suggested that undergraduates be included in giving oral presentations to make the EB meeting more beneficial for undergraduate students, while a second student suggested that larger/simpler scientific symposia specifically for undergraduates would be beneficial. Both were collapsed to “add undergraduate scientific symposia/oral presentations” (Supplemental Table S5).

RESULTS

Demographic data. Demographic data (sex, ethnicity, and race) provided an overview of the survey respondents. The majority of respondents were women (62% for both years). In terms of ethnicity, only 13% of respondents self-identified as Hispanic, with 74% responding “Not Hispanic” and 13%

Fig. 2. Comparison of EB meeting (2014 and 2015) undergraduate student survey responses for meeting attendance and students' feedback for the EB meeting sessions. *A*: undergraduate students reporting first-time attendance of a scientific meeting or the EB meeting (in %). *B*: distribution of most and least useful EB sessions (by type) as indicated by the surveyed undergraduate students. Survey results shown were combined for 2014 and 2015; the distribution of survey respondents by reported parameters were similar in both survey years (2014 and 2015).



declining to answer. In terms of racial groups, more than half of the respondents were White, with smaller proportions of Asian and Black/African American students and a small number of Native American/American Indian students (Fig. 1A). Because of the small sample sizes for some racial and ethnic groups, we did not perform subsequent analyses by sex, ethnicity, and/or race on the remaining questions. All results below are for the combined data for 2014 and 2015 unless otherwise noted.

The demographics of the survey respondents were largely representative of undergraduate students majoring in biological sciences. As shown in Fig. 1B, compared with the most recent data available, 2012 Bachelor degree recipients in biological sciences (12), the study sample distribution was very similar in terms of both sex and racial group. Hispanic students were overrepresented in the present study, probably reflecting the participation of APS student fellows in targeted summer research programs for underrepresented students including the Short-Term Research Education Program to Increase Diversity in Health-Related Research, Short-Term Education Program for Underrepresented Persons Fellowship, and Integrative Organismal Systems Physiology Fellowship.

Research engagement and travel support. The survey also gathered information on 1) how students became involved in research, 2) how they became interested in attending EB, 3) how they paid for their travel to EB, 4) whether this was their first time attending EB or any other scientific meeting, and 5) whether they received the premeeting information packet and found it useful.

Nearly half of the respondents reported that they became involved in research through APS or other research fellowship programs (Fig. 1C). Course or college projects engaged another 29% of respondents in research activities, and 21% did research through independent projects (Fig. 1C). The majority of respondents (74%) were encouraged to attend EB by their host laboratory principal investigator or institution. A few respondents (19%) were encouraged to attend EB as part of their APS summer research internships. About 1–3% of respondents were encouraged to attend EB through FASEB/EB Travel Awards, other grants/scholarships, or personal funds/family. Approximately half of all respondents received financial support for their travel to EB from their host laboratory principal investigator or institution where they did their research (Fig. 1D). More than a quarter of respondents received travel support from an APS undergraduate summer research fellowship (Fig. 1D).

For the majority of respondents, this was the first time they attended a scientific meeting and their first time attending the EB meeting (Fig. 2A). Respondents also reported previous attendance at the American Biomedical Research Conference for Minority Students, local/regional physiological meetings, Society for the Advancement of Chicanos and Native Americans in Science annual meeting, National Conferences on Undergraduate Education, and/or nonphysiology meetings.

When asked about the packet of premeeting information, more than half of the respondents remembered receiving the packet and found its contents useful (52%), whereas 29% did not remember receiving the packet. Few students reported that they either received the packet but did not find its contents useful (8%), there was too much information or it contained badly organized information (8%), or they would prefer an app

for their smart phones (3%). Some respondents offered specific suggestions for information that undergraduates should receive in the future:

- “Everything that was sent was useful. The only downside was the timing it was sent. Travel plans were made early to get cheaper air/hotel fares. Receiving the info packet 6 weeks prior to EB was a little late.”
- “Packet not received; concept and structure of meeting not well understood at first; receiving a list of posters/presentations in advance would have allowed me to plan in advance.”
- “It was useful, but I think a suggested outline or itinerary would help.”

EB meeting experience. In regards to the EB meeting experience, the survey gathered information on 1) what kind of sessions respondents attended at the meeting, 2) which sessions were most and least useful and why, 3) what kind of sessions they would like to see at future EB meetings, and 4) whether and when they interacted with other scientists at the meeting. Nearly all respondents attended general poster sessions (96%), and the majority attended the APS undergraduate poster session on Sunday (80%). Most respondents attended at least one symposium or smaller lecture (77%). More than half of respondents attended the large or plenary lectures (56%) and social events (e.g., receptions, luncheons, and dinners) (57%). Few respondents attended the Nobel laureate talk and student networking session on the last day of the meeting. When asked which sessions were most and least useful, respondents described the poster sessions as most useful and the large talks as least useful (Fig. 2B). Remarkably, the large talks were reported to be the second most useful, whereas poster sessions were reported to be the second least useful (Fig. 2B). Some respondents offered specific reasons for why they found sessions to be useful or not. Many felt that the poster sessions provided good networking opportunities or honed presentation skills. Comments included the following:

- “Met many new individuals, networked”
- “Gained most personal connections”
- “Researchers specific to my research interest asked some very insightful questions”
- “I was able to present my research and hear feedback and tips”
- “Exercise in how to present”
- “They allowed me to talk to others who shared similar interests and had suggestions for my research”

The problems cited concerning poster sessions were typically organizational or situational. Comments included the following:

- “Couldn’t interact with the researcher [when they were away from their poster]”
- “There were too many in one crowded location; it was often overwhelming and hard to learn in that environment”
- “Only had two people come to my poster”
- “Not many people came to talk who were able to offer helpful suggestions or offer connections in the field”
- “A lot to see and hard to find the posters that were relevant to me”

Respondents often reported that small sessions were more useful than larger ones. Comments included the following:

- “They were brief, focused talks”
- “The speaker could go in depth but remain on point in that amount of time, and I could attend many sessions without losing interest”
- “Easier to interact/ask questions”

Often, respondents found the larger sessions overwhelming in some way. Comments included the following:

- “Sometimes hard to follow a bad speaker”
- “Although their research abstracts were very fascinating, I was unable to understand anything that was said”

At these sessions, students potentially had the opportunity to interact with other scientists in attendance. All respondents reported getting the opportunity to network and discuss research one on one with others. The large majority of respondents indicated that these interactions most often occurred at the undergraduate and regular poster sessions (Supplemental Table S2). A minority of respondents met scientists networking via their mentor, at award ceremonies, or the exhibits/vendors (Supplemental Table S2). About a third of students reported that they had no suggestions for other sessions they would like to see at EB. Other students suggested offering more undergraduate sessions, networking opportunities, undergraduate presentations, and career development sessions and medically related sessions and adding new sessions, such as live demonstrations of research methods and protocols.

Future improvements. In an attempt to deduce whether EB was a worthwhile experience for undergraduate researchers and how APS EB activities can be improved for undergraduates, the survey included questions regarding 1) whether they hoped to come back to EB in the future, 2) how APS can support undergraduates involved in research, 3) how APS can involve undergraduates in APS, 4) what sessions or activities APS could offer that would benefit undergraduate students, 5) how APS can keep in contact with undergraduate students in the future, and 6) how APS can meet undergraduates’ needs. The large majority of respondents (89%) wished to return to EB in the future. A quarter of respondents suggested that APS provide more summer fellowships and advertise these fellowships more extensively (17%) (Supplemental Table S3).

About a third of respondents encouraged APS to recruit students directly via APS members to increase APS undergraduate student involvement, as APS members can play a key role in undergraduate students’ careers (Supplemental Table S4). Other suggestions to increase APS undergraduate involvement ranged from providing mentors for undergraduate students (in this case, research host mentors), offering free membership and/or meeting registration discounts, offering free journal subscriptions, and highlighting APS undergraduate members via a newsletter or journal article (Supplemental Table S4). About a third of respondents had no suggestions for meeting sessions or activities APS could offer that would benefit undergraduates, whereas other students’ suggestions ranged from providing more undergraduate mixers/networking to offering sessions with graduate/medical school recruiters and highlighting the most useful events for undergraduates in the program (Supplemental Table S5).

When asked to suggest effective ways for APS to keep in contact with students during and after their undergraduate years, most respondents recommended using e-mail (46%) or social media (37%). Very few suggested a research blog or surveys (2%). Finally, most respondents reported that no additional efforts by APS are needed to meet their needs (68%). The few suggestions offered were similar to other suggestions above, including providing more information for graduate and medical programs (5%), more networking events (2%), more presentations opportunities (1%), etc.

In addition to providing data on student perceptions and needs, the survey used in 2014–2015 provided data for the development of a more succinct and organized survey. We assessed the usefulness of each question, identified additional response options for multiple-choice questions, and identified additional questions to be asked based on the responses to the open-ended questions. A revised survey is provided in Supplemental Table S6. This revised survey was distributed to undergraduates attending EB 2016, and the data obtained after EB 2016 is being used to analyze and validate the revised survey.

DISCUSSION

The present study sought to test a pilot survey that would characterize the undergraduate students presenting physiology posters at the APS annual meeting, EB, in terms of how they became engaged in research and presenting at the meeting, how they perceived the meeting’s activities and sessions, and how APS can continue to engage and support undergraduate students in physiology research. Results of the pilot survey not only informed the further development of a revised survey instrument but also provided useful insights on professional society communications with students before and after the meeting, the critical role of research hosts in students’ scientific meeting experience, ideas for helping students select and make the most of EB sessions, and ways to help professional societies maintain connection with undergraduate students after the meeting ends. Each of these insights and proposed actions that they suggest are discussed below, along with broader implications for life science professional society interactions with undergraduate students.

Survey development. The pilot survey included 12 multiple-choice questions (with options to add an “other” response on most) and 14 open-ended questions (Supplemental Table S1). The analysis of the 2014–2015 data allowed us to streamline the survey in several ways. We added additional demographic questions to assist with more in-depth analysis (e.g., student major, year in school, and specific APS program, if applicable) (Supplemental Table S6). In addition, we reduced the number of open-ended questions from 14 to 5, none of which are required questions. This will provide students with opportunities to comment but will reduce the overall amount of time needed to complete the survey. Finally, multiple-choice questions now include those response options suggested by multiple students on the 2014 and 2015 surveys. In future survey years, survey responses will be analyzed and performed by sex, ethnicity, and race.

APS communications with students. More than 60% of the students responding to our survey had never been to a scientific meeting before and nearly 90% had never attended EB (Fig.

2A). Student comments suggest that, despite receiving a pre-meeting information packet and attending an undergraduate orientation, many students found the meeting overwhelming. Some asked for more information on the structure and overall concept of the meeting and others wanted us to suggest an itinerary. Instead of viewing the program as a wealth of options, some undergraduates found it to be a vast list of choices to be made with little context. Even the poster sessions, where students were ready to present their work, presented unexpected challenges for the novice. One student was unpleasantly surprised at the crowded and noisy poster sessions. Another was displeased that the scientist that s/he wanted to talk to was not at his/her poster. Others were disappointed at the small number of people who visited their posters, with one student particularly noting that not all the visitors were from his/her field. All of these are typical of large meeting poster sessions but were not anticipated by some of the students.

All of these findings suggest that professional societies and students' research hosts need to spend additional time and effort to prepare students for scientific meetings and coach them through their first large meeting experiences. As a result of these survey responses, APS already has implemented changes in, for example, communication with undergraduate students and/or research mentors. In response to student suggestions, APS is sending the premeeting information packet earlier. More information on how to structure one's meeting schedule were included in the 2016 EB materials. In 2016, a new EB app for mobile phones also made searching and constructing one's schedule easier.

The role of research hosts. As noted above, the student's research host can play a major role in preparing him/her for a scientific meeting, from providing feedback on abstracts and draft posters to scheduling poster presentation practice and providing information to help the student navigate a large scientific meeting. When they arrive at the meeting, the research host can facilitate professional networking for the student. Unfortunately, our survey findings suggest that mentors did not play a key role in student networking, with "networking via mentor" noted by only 4% of respondents as a way to interact with other scientists at the meeting (Supplemental Table S2). It was not clear from the survey whether this indicated 1) their research host did not attend the meeting, 2) their research host did not have a strong network of colleagues at the meeting, or 3) their research host did not try to engage the undergraduate student in networking. Clearly, however, if the research host is in attendance and has a network of colleagues at the meeting, engaging the student in professional networking would be of benefit to him/her. The present study suggests that professional societies should work with research hosts to increase their plans and/or skills in engaging undergraduate students in networking opportunities at meetings.

Helping students make the most of EB sessions. APS undergraduate activities at EB are attracting a diverse group of undergraduate students that are demographically representative of biological sciences majors at United States institutions (Fig. 1, A and B) and are attending their first scientific meeting (Fig. 2A). APS seeks to make their experience a positive, informative, and encouraging one that promotes their interests in research and builds their presentation and networking skills. In the present study, students reported mixed experiences about sessions they attended at the EB meeting. For example, some

students rated poster sessions and large talks as very useful, whereas others found them less useful (Fig. 2B). It was not clear from the current study whether these findings correlate with first time meeting/EB meeting attendance, but they suggest two future actions: 1) the revised survey will be structured to more easily allow analysis of session usefulness ratings by previous meeting experience and 2) information packets and orientation session presentations should discuss what to expect at the different session types in considerable detail.

We were not surprised to learn that few students attended the Nobel laureate lecture (Fig. 2B). This session is on the last afternoon of the meeting (Wednesday) and, due to the frequent overlap of EB with undergraduate class schedules and/or finals week, most students leave the meeting on Monday or Tuesday.

When students were asked what sessions APS could implement at the EB meeting that would benefit undergraduate students, most respondents had no suggestions (Supplemental Table S5). However, some responses focused on offering opportunities to interact with graduate and medical school recruiters. Currently, the undergraduate poster session includes a "presession" period where undergraduates can talk to representatives from numerous graduate programs. However, medical school personnel involved with student admissions are not generally present. This suggests that APS could invite medical school admissions personnel to the "presession" period and provide opportunities for them to interact with the undergraduate students.

Helping undergraduate students engage in research. When asked how APS can support undergraduate students in research, respondents offered limited responses (Supplemental Table S3). Their primary requests were to offer more summer research fellowships and travel grants and to advertise these opportunities more widely. Interestingly, students did not recommend larger stipends for summer research programs. While about half of life science professional societies currently offer summer research fellowships for undergraduate students (10), they could consider focusing increased efforts and funding at assuring that all undergraduate students engage in authentic research experiences.

Promoting undergraduate student involvement in APS. APS has an undergraduate membership category, but, to date, APS has not actively recruited undergraduates to become members other than among those who attend EB and/or are engaged in physiology research projects. However, with the rapid growth of undergraduate physiology major programs in the United States (17), the opportunity to work with faculty members and program directors to increase undergraduate involvement in APS has great potential. In the current survey, nearly a third of respondents felt that the most effective approach for recruiting undergraduates to become APS members is through their college professors.

Some respondents (21%) encouraged APS to offer free undergraduate membership and/or discounted meeting registration (Supplemental Table S4). While APS does not offer free membership or meeting registration, the cost for undergraduate students is minimal (\$10 for first year membership and \$20 for EB registration). By comparison, graduate students pay \$20 for membership and \$85 for EB registration, and full members pay \$90 for membership and \$400 for EB registration. Students in APS fellowship programs receive free membership as well as EB registration. Thus, undergraduate mem-

bership is still considerably affordable and there are many benefits of being a member including lower EB registration costs as a member versus a nonmember.

Respondents also encouraged APS to highlight the accomplishments of undergraduate students in its publications and newsletters to increase undergraduate student involvement (Supplemental Table S4). Currently, APS publishes articles highlighting those students who win APS summer research fellowships (5, 6). APS research hosts could be invited to feature students working in their laboratories on the APS website or social media. Several APS committees have discussed the possibility of publishing a journal of undergraduate research, and now that the number of physiology majors is increasing nationally, this possibility should be reexamined. In addition, APS publishes an Undergraduate Researcher Blog at the Life Science Teaching Resource Community site (<http://blog.lifescitrc.org/ugresearch/>), where undergraduate researchers can discuss their current research or interesting articles they have read. In general, professional societies should look for ways to recognize undergraduate student achievement in their specific fields to promote continued student engagement and career interest.

Conclusions. Over the past decade, APS has greatly expanded its outreach to undergraduates through both its summer research fellowships and its annual meeting/EB activities. The present study suggests that many of these activities have value to the undergraduate student participants and their suggestions for improving these activities were minor program improvements rather than significant revisions. This study also provided data to revise and improve the undergraduate EB advisory board survey to allow greater granularity of data and analysis of data across subgroups (sex, race/ethnicity, previous meeting attendance, institution type, etc.). This study also suggests that both the professional society and the students' research hosts play critical roles in helping students have a positive professional development experience at large scientific meetings.

For all life science professional societies, undergraduate students represent the next generation of practitioners in their fields and members in their organizations. Monitoring and promoting these students' engagement in the field and their needs as emerging scientists is a natural charge for societies. However, the needs of undergraduate students may not always be obvious and may change over time. It is important to establish reliable and robust routes of communication to provide feedback on ongoing undergraduate initiatives and gather evaluative data on new initiatives. Addressing the concerns and needs and celebrating the triumphs of the next generation is only possible if we listen to its voice.

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This study describes a multiyear, ongoing effort by the American Physiological Society (APS) Trainee Advisory Committee (TAC) to assess and respond to the needs of undergraduate students engaged in physiology research. Many TAC members were involved in the development and dissemination of the survey instrument and in reading drafts of the manuscripts. Two committee chairs led the TAC from 2013 to 2016: Jennifer Sasser (University of Mississippi Medical Center) and Erica A. Dale (University of California-Los Angeles). The following TAC members contributed to the project by helping develop survey questions, reviewing draft data analyses, and/or reviewing manuscripts: Christopher T. Banek (University of Minnesota), Jessica Bradley (University of the Incarnate Word School of Osteopathic Medicine), Aaron K. Bunker (Morningside College), Steven Wesley Copp (Kansas State

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DISCLOSURES

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AUTHOR CONTRIBUTIONS

N.L.N., D.V.I., and M.L.M. conceived and designed research; N.L.N., D.V.I., and M.L.M. analyzed data; N.L.N., D.V.I., and M.L.M. interpreted results of experiments; N.L.N., D.V.I., and M.L.M. drafted manuscript; N.L.N., D.V.I., and M.L.M. edited and revised manuscript; N.L.N., D.V.I., and M.L.M. approved final version of manuscript; D.V.I. prepared figures; M.L.M. performed experiments.

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