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Scientific Societies Fostering Inclusivity in the Life Sciences Through Engagement of Undergraduate Scientists

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Scientific societies serve as communities of practice in which scientists develop many of the skills and connections required for the progression of their careers. For example, scientific societies offer their members opportunities to attend career development programs, gain experience in communicating science, and receive recognition for achievements within their discipline. Programming for undergraduate student members has recently been increasing, both in prevalence and in its range of offerings. The Alliance to Catalyze Change for Equity in STEM Success, ACCESS, a meta-organization seeking equity and inclusivity in life sciences fields, has examined programs and opportunities focused on undergraduates across its member scientific societies to identify common themes, promising practices and challenges. In this article, we share and discuss our findings.

Keywords: undergraduate students, diversity, equity, inclusion, scientific societies, student chapters, STEMM workforce, early-career scientists

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INTRODUCTION

Scientific societies serve as unifying hubs that advance the disciplinary Science, Technology, Engineering, Mathematics, and Medicine (STEMM) communities they represent. They provide long-term, cross-institutional communities for individuals within a scientific discipline which renders them ideal organizations to facilitate networking, collaboration, and mentoring among members (Hulede, 2018; Segarra et al., 2020a; Womack et al., 2020). Scientific societies can also serve as agents of change to promote diversity, equity, and inclusion in their fields of interest. To this point, in 2017, five different professional societies in the life sciences established the Alliance to Catalyze Change for Equity in STEM Success (ACCESS) a meta-organization that brings together the diversity committees of the American Society for Biochemistry and Molecular Biology (ASBMB), the American Society for Cell Biology (ASCB), the American Society for Pharmacology and Experimental Therapeutics (ASPET), the Biophysical Society (BPS), and the Endocrine Society (ES). The purpose of ACCESS is to provide a unified voice through which scientific societies can foster inclusivity in their disciplines by identifying challenges and solutions through shared experiences.

In this review article, ACCESS societies in collaboration with the Association for Southeastern Biologists (ASB), synthesize and discuss their efforts to foster inclusivity in the life sciences through engagement of undergraduate scientists. We also specifically highlight society offerings aiming to engage undergraduates from underrepresented backgrounds (UR) in STEMM. UR backgrounds in STEMM are those whose representation in STEMM disciplines is smaller than their representation in the United States population. For example, women, members of minority racial and ethnic groups (Black/African-American, Hispanic/Latino, Native American or Alaska Native, Native Hawaiian, and other Pacific Islanders), persons with disabilities, and low-income persons are all considered UR in STEMM fields (National Science Foundation, 2019; National Institutes of Health, n.d.). Of the early undergraduate students who intend to earn a degree in STEMM, less than 40% will obtain it; this percentage is even smaller for those from UR backgrounds (Mourad et al., 2018; Ahern-Dodson et al., 2020). Therefore, a big portion of the early talent pool is lost before students earn their baccalaureate degrees (Graham et al., 2013; Casad et al., 2016; Doerschuk et al., 2016; Russell, 2017; Ahern-Dodson et al., 2020). Scientific societies are in a position to help retain this undergraduate talent through early access to their disciplinary learning communities.

Professional and scientific societies foster the advancement of their disciplines and can play an integral role in connecting practitioners with one another, fueling collaborations, and mentoring relationships. Society events and programs are accessible opportunities for undergraduates to network, stay up to date on the newest research discoveries, and gain skills necessary for their future careers inside or outside of academia. While undergraduate institutions may be able to provide some of these resources, many are not able to do so in a discipline-specific way that transcends geographical boundaries. Also, resources may be limited at many undergraduate institutions. This might leave undergraduates searching for opportunities to get involved within their larger scientific community, placing scientific societies in an ideal position to fill this need. Moreover, undergraduates from UR backgrounds may attend institutions where they do not see themselves represented in their department's faculty or in their peers. The importance of seeing successful practitioners that share one's background has been examined in numerous studies, many concluding that access to these role models can help combat feelings of imposter syndrome and self-stereotypes (Asgari et al., 2010; Chemers et al., 2011; Casad et al., 2016). Given that undergraduates are practitioners in-training and may not have developed a secure identity as scientists, they might be more susceptible to feelings of isolation within the scientific community. Becoming part of a larger STEMM community and organization, such as a scientific society, can connect young trainees with role models and near-peers of similar backgrounds in their STEMM disciplines of interest and lessen feelings of isolation, especially for UR STEMM undergraduates (Smith et al., 2021). However, it is also important to note that, while scientific societies can be beneficial, society climate can still expose members to social forces such as marginalization and racism, further highlighting our responsibility to intentionally create inclusive society environments (Solebello et al., 2016; Hays et al., 2021; Huyck et al., 2021; Leibnitz et al., 2021; Segura-Totten et al., 2021).

Scientific self-efficacy, sense of community, and fit are also factors that drive undergraduate student persistence in STEMM (Chemers et al., 2011; Graham et al., 2013; Casad et al., 2016; Doerschuk et al., 2016; Russell, 2017; Gopalan et al., 2018; Ahern-Dodson et al., 2020; Bruthers et al., 2021; Campbell-Montalvo et al., 2021; Smith et al., 2021). However, these factors may be especially difficult to cultivate and develop in UR undergraduates due to discrepancies in common values, cultural isolation, and lack of support (Seymour and Hewitt, 1997; Good et al., 2000). These discrepancies can lead to those from UR backgrounds feeling marginalized; therefore, discouraging them from their aspirations in STEMM (Morales et al., 2020). Multiple lines of research have demonstrated that early research experiences and membership in STEMM learning communities can deepen fellowship and increase persistence in STEMM paths amongst undergraduate students, particularly those of UR backgrounds (Chemers et al., 2011; Graham et al., 2013; Sharp et al., 2014; Casad et al., 2016; Doerschuk et al., 2016; Russell, 2017; Gopalan et al., 2018; Mourad et al., 2018; Ahern-Dodson et al., 2020; Bruthers et al., 2021). Building an identity as a scientist by interacting with a community that includes motivating faculty, staff, and peers leads to an increased number of students who will seek to further their STEMM education by seeking additional training experiences such as graduate school (Eagan et al., 2013). This can particularly be impactful for undergraduates that attend community colleges where STEMM communities and undergraduate research opportunities may be more sparse (Hewlett, 2018).

Taken together, these observations indicate that undergraduates can benefit from the resources available to society members such as networking opportunities, conferencing,

research fellowships, professional development workshops, and achievement award. For this reason, active participation in a professional society can benefit early-career undergraduates by plugging these students into a built-in community of scientists, facilitating their navigating the complex landscape of their chosen scientific discipline (Graham et al., 2013; Matyas et al., 2017; Hulede, 2018; Abernethy et al., 2020; Bruthers and Matyas, 2020; Segarra et al., 2020c; Womack et al., 2020; Bruthers et al., 2021). Using the current literature on the topic to anchor our review, we discuss the undergraduate programming within ACCESS member societies and identify common themes, challenges, and promising practices. Our goal is that this analysis will help us pinpoint gaps in scientific society programming geared toward undergraduates.

SCIENTIFIC SOCIETY ENGAGEMENT OF UNDERGRADUATE SCIENTISTS

While a fair amount of programming for undergraduate members is offered at annual society meetings, with most societies offering discounted membership fees, there are additional opportunities outside of these meetings such as student chapters, and undergraduate research experiences (**Table 1**). Below we describe and discuss the undergraduate programs offered by ACCESS societies and their benefits.

Society Membership Accessibility for Undergraduate Students

By regularly offering affordable membership fees for students, scientific societies hope to foster recruitment and retention of undergraduate members. In 2021, the undergraduate student membership fees in ACCESS societies range from $10–$30 a year. ASBMB and ASPET both charge the least, with an annual fee of $10 for undergraduate students. At the top of the range, ASCB and BPS charge $26 and $25/year, respectively, while the ASB undergraduate membership fee falls in the middle at $20. Some, but not all ACCESS societies offer student members the opportunity to establish a student chapter at their home institution. **Table 2** lists the undergraduate membership fee for each ACCESS society, along with the number of institutions with student chapters, the number of undergraduate members, and the percentage of undergraduate members within the society. Societies with the most undergraduate programming offerings and the most affordable membership fees do not necessarily display the highest levels of undergraduate membership, meaning other factors must be at play. Additional offerings can influence an individual's decision to become a member of a professional society (Markova et al., 2013). These offerings include employment opportunities, professional development workshops, access to recent updates in the field, and spaces for networking (Markova et al., 2013).

Free membership for undergraduates would remove the financial barrier to these students belonging to a scientific society. In the past, at least one ACCESS scientific society has made undergraduate memberships free. However, removing this financial barrier completely did not translate into more undergraduate students becoming regular members. The practice of providing free memberships can also bring on additional costs to societies that can be difficult to sustain, for example, costs related to membership data maintenance and follow up. For societies with a high percentage of undergraduate participants, such as ASB, free undergraduate membership/participation would translate into loss of a large portion of the funds needed for society operations. For these reasons, a model in which undergraduates are charged a nominal fee for membership (**Table 2**) is likely more sustainable. While the nominal undergraduate membership fees collected by societies likely do not fully cover the benefits offered to students, they help offset some of the costs. For ACCESS societies with student chapters, registration can be linked to chapter registration and renewal, a cost that can easily be absorbed by the home academic institution of the chapter. ACCESS societies like ASBMB find that most chapters pay the registration fees either through their institutional department or student life office rather than collecting fees from students.

Undergraduate Student Engagement at Annual Society Meetings

Travel Award

Travel award are funds given to members of a scientific society to either partially or fully cover expenses related to attending annual society meetings. To obtain a travel award, an award application must be completed, usually requiring the applicant's curriculum vitae (CV) or resume, reason for wanting to attend the conference, career aspirations, statement of financial need, and, if an undergraduate student, a letter of support from a faculty member. Additionally, a poster abstract is commonly required, as it is often the case that travel awardees are required to present their research in the form of a poster to be eligible for a travel award. While this is the case, non-presenting students have been shown to benefit from scientific meeting attendance as well (Gopalan et al., 2018). In fact, we identify broadening travel award eligibility to non-presenting students as an opportunity societies have to further foster inclusivity of talent in their discipline.

Travel award allow for undergraduates to attend the annual meeting who may not have been able to do so otherwise. Particularly, those who may come from UR backgrounds may largely benefit from connecting with other practitioners of similar backgrounds and building a network of contacts (Asgari et al., 2010). Receiving a travel award not only benefits the recipient by allowing them to experience a scientific conference, but it also benefits the society by increasing the diversity of meeting attendees.

Attending scientific conferences as a practitioner-in-training can aid undergraduates developing a scientific identity by giving them the opportunity to interact with successful scientists in their discipline. Undergraduate travel award recipients can also put the award on their CV as an achievement, earning the undergraduate awardees an early accomplishment to heighten feelings of belonging and self-efficacy within their scientific community. A recent publication describes ACCESS member societies travel award offerings in detail and also notes travel

TABLE 1 | Summary of programming offered by ACCESS member societies to their undergraduate members as of summer 2021.

ACCESS member society	Travel award	Networking opportunities	Achievement award	Poster sessions	Student chapters	Discounted membership fee	Professional development sessions at conferences	Research fellowships
ASB	X	X	X	X		X	In progress	In progress
ASBMB	X	X	X	X	X	X		
ASCB	X	X		X		X	X	
ASPET	X	X	X	X		X	X	X
BPS	X	X	X	X	X	X		X
ES	X	X				X		

TABLE 2 | Summary of undergraduate membership, dues and student chapters in ACCESS member societies as of summer 2021.

ACCESS member society (no. members)	Professional membership fee	Undergraduate membership fee	Number of institutions with student chapters	Number of undergraduate members	Percentage of undergraduate members
ASB (938)	$50	$20	N/A	264**	51%**
ASBMB (9800)	$160	$10	153	2210	22.6%
ASCB (5363)	$185	$26	N/A	210	3.9%
ASPET (3505)	$180	$10	N/A	115	3.3%
BPS (5358)	$200	$25	38	173	3.2%

***ASB collects academic stage information at the time of annual meeting abstract submission (not during membership registration). For this reason, the estimate provided for "Number of Undergraduate Members" is based on number of undergraduate presenters at the last pre-COVID (in-person) meeting (2019). Likewise, the percentage provided for "Percentage of Undergraduate Members" is based on the percentage of undergraduate presenters at the last pre-COVID (in-person) meeting (2019).*

award for undergraduate scientists with amounts ranging from $400 to $1700 (Segarra et al., 2020c). All ACCESS societies offer undergraduate travel award. Most societies also offer specific programming for award recipients, and we describe this programming below.

Professional Development Sessions and Networking Opportunities at Annual Conferences

Professional development can catalyze an undergraduate's self-efficacy and growth in STEMM disciplines (Helm and Bailey, 2013; Cuker et al., 2016; Doerschuk et al., 2016; Abernethy et al., 2020). Annual society meetings provide an opportunity for undergraduate students to enhance their professional development. ASCB and ASPET both have professional development sessions during their annual meetings that are geared toward undergraduates (**Table 1**). ES also holds an Early Career Forum, which undergraduate students at the conference can attend and obtain orientation in a range of professional development topics. These sessions during annual meetings can facilitate undergraduates networking with others, such as peers and faculty members. Additional opportunities for networking include dedicated spaces for undergraduate students at annual conferences. For example, BPS provides students a lounge at their annual meeting as a dedicated space for them to catch up on missed coursework and connect with peers while attending the BPS annual meeting which is held every spring. BPS also holds a "Pizza Breakfast" event with a guest speaker at their annual meeting, bringing about additional networking opportunities for students. Networking with peers and faculty members increases undergraduates' sense of community, and, in turn, increases the likelihood of them persisting in STEMM (Chemers et al., 2011; Graham et al., 2013; Casad et al., 2016; Doerschuk et al., 2016; Russell, 2017; Gopalan et al., 2018; Ahern-Dodson et al., 2020; Bruthers et al., 2021).

Presentation Opportunities at Annual Conferences

Undergraduate research is an important part of undergraduate education for students in STEMM, and communicating scientific findings is a key skill that scientists must develop. ACCESS societies like ASCB, ASPET, and BPS offer trainees dedicated poster sessions, in addition to poster presentations held on the main exhibit floor, at their annual conferences. These trainee-focused poster sessions are often judged, and poster award are offered to the top performing scientists at different academic levels–including undergraduates (ASCB, n.d.). Undergraduate specific poster sessions could be viewed in a negative light due to the intentional separation of undergraduates from more experienced practitioners. However, literature shows that most undergraduate presenters feel an increase in scientific self-efficacy after presenting at a professional conference, including these trainee-focused sessions (Helm and Bailey, 2013; Walkington et al., 2017; Little, 2020; Segarra et al., 2020a). Programming like poster sessions and award allow students to highlight their work in research and continue to develop their scientific communication skills (Poster Competitions, n.d.).

Student Chapters

Undergraduate membership in a scientific society can provide opportunities beyond attending annual meetings. For example, two ACCESS societies (ASBMB, BPS) enable their student members to establish disciplinary chapters at their home academic institutions that can serve as a place of community for scientists-in-training. Undergraduates can use these chapters as a scaffold for membership and participation in the headquarter

organization. For example, over 80% of ASBMB's current undergraduate members participate in the society through their student chapters. Student chapters can contribute to a society establishing a welcoming environment to its discipline's scientists-in-training. This type of environment has been shown to be vital to undergraduate persistence in STEMM fields (Chemers et al., 2011; Graham et al., 2013; Cuker et al., 2016; Gopalan et al., 2018; Bruthers and Matyas, 2020). Student chapter membership can also allow entry into prestigious academic fraternities such as ASBMB's Chi Omega Lambda which recognizes undergraduate upperclassmen seeking degrees in molecular life sciences. ASBMB also offers numerous achievement award and scholarship opportunities to members of student chapters, which can also be listed as evidence on an undergraduate's CV as a disciplinary honor. Furthermore, BPS offers opportunities for student chapter establishment outside of the United States, providing an international community for early-career scientists. To enhance leadership skills, student chapter members are encouraged to serve on the chapter board at their institutions, where they learn to schedule chapter events, budget funds, lead meetings, and plan attendance to national conferences. Student chapters help provide undergraduates with the resources to build at a scientific community at their home institutions while also gaining leadership and technical skills (Barnes et al., 2021).

Research Programs

Undergraduate research experiences (UREs) have proven themselves to be one of the most valuable approaches to increasing the number of UR students earning degrees in STEMM fields (Doerschuk et al., 2016). These experiences foster students' ability to network and communicate, allow them to gain more research skills, and further their STEMM career aspirations. These opportunities often leave positive, lasting impacts on students and provide them with a number of different life skills (Bruthers and Matyas, 2020). For example, UREs can help develop undergraduate students' self-efficacy and sense of belonging through professional development and positive reinforcement (Mourad et al., 2018). Moreover, UREs can also guide students along their STEMM career paths with support, necessary information, news of novel scientific findings, and the opportunity to receive recognition as a scientist (Eagan et al., 2013). It is pertinent to mention that a majority of URE programming has been delayed or adapted due to the COVID-19 pandemic. For example, in 2020, ASPET had more than an 84% decrease in undergraduate summer research programs held; however, this pushed them to successfully hold their first fully virtual research program (ASPET, 2020).

Alliance to catalyze change for equity in STEM success societies support UREs in a variety of ways. For example, ASBMB furthers the research aspirations of their undergraduate student members by offering $1,000 award to support their research. Furthermore, BPS's Summer Research Program (SRP) was a collaborative effort with the University of North Carolina at Chapel Hill and presented UR undergraduate students with the opportunity to receive a research assistantship. SRP provided participants with graduate-level class work on disciplinary concepts and methods, opportunity to do lab work and research, and programming to facilitate networking and community building. At the end of the program, program alumni transitioned to become "biophysics ambassadors" within BPS and at their universities, enabling them to collectively become a support system for each other as well as others at their home communities. From 2008 to 2017, approximately 100 students were served by this program, many of them successfully transitioned into Kirschstein-NRSA predoctoral fellowships from the National Institutes of Health (NIH) or Graduate Research Fellowship from the National Science Foundation (NSF). SRP ended in 2017 due to lack of funding.

Additionally, ASPET sponsors institutions, as well as individual students, through their Summer Undergraduate Research Fellowship (SURF). This 10-week summer laboratory experience provides mentored research for pharmacology undergraduates and has been strengthening young scientist's professional skills since 1992. Over 90% of its participants remain involved in biomedical sciences after program completion. Through a variety of collaborative activities such as field trips and picnics amongst faculty and peers, SURF drives the development of a strong network of alumni. This expanding network further serves the program as some past participants become mentors for newcomers. Importantly, participation in this program has paved paths for undergraduates to pursue doctoral programs in their SURF laboratory departments (SURF Summer Undergraduate, n.d.; ASPET, 2020).

Other UREs organized by scientific societies for UR undergraduates include the Ecological Society of America's Strategies for Ecology Education, Diversity and Sustainability (SEEDS) Research Fellowship and the American Physiological Society's Short-Term Research Education Program to Increase Diversity in Health-Related Research (STRIDE) (Mourad et al., 2018; Ahern-Dodson et al., 2020; Bruthers and Matyas, 2020). These programs have had positive outcomes in developing strong research skills in their participants (Bruthers and Matyas, 2020). For example, many of the students who participated in STRIDE commented on gaining knowledge in experimental design, data analysis, management, organization, applying statistics and math to experiments, and made note of a number of realities such as the patience and determination that is required when conducting research (Bruthers and Matyas, 2020). Furthermore, STRIDE program participants have adjusted their career aspirations to incorporate clinical research.

Scientific Society Representation in Conferences Attended Predominantly by Undergraduates

Science, technology, engineering, mathematics, and medicine conferences that are directed at undergraduate participation create an opportunity for students to enhance their professional skills in their field while simultaneously strengthening their sense of community. The important skills students obtain from attending these scientific conferences make these events a good place for experiential learning (Gopalan et al., 2018). Most, if not all, conferences allow students to network, to present their

research as talks or in the form of a poster, and to obtain award. Additionally, there are typically panels, professional and scientific workshops, and keynote or plenary speakers geared toward undergraduate scientists (McLaughlin et al., 2009; Hurd et al., 2011; Casad et al., 2016; Gopalan et al., 2018; ABRCMS, n.d.; SACNAS, n.d.; Zarate and Gonzalez, n.d.). Across the United States, the Society for Neuroscience has created many regional, undergraduate specific conferences including SYNAPSE for the southeast, NEURON for the northeast, and MidBrains and mGLuRs for the midwest regions (Frye and Edinger, 2004; Goyette et al., 2007; McLaughlin et al., 2009; Hurd et al., 2011; Wiertelak et al., 2012; Ramos et al., 2020). They provide an intimate setting for students to receive feedback from professionals (Hurd et al., 2011). Furthermore, at ASB's annual meeting, more than 50% of presenters at the 2021 virtual annual meeting were undergraduates. Altogether, the demand for these undergraduate-focused conferences shows that undergraduates want to be connected to disciplinary communities.

At the Annual Biomedical Research Conference for Minority Students (ABRCMS) and the National Diversity in STEM Conference organized by the Society for Advancement of Chicanos/Hispanics and Native Americans in Science (SACNAS), students can network on a larger scale than they do at regional conferences (Casad et al., 2016; Zarate and Gonzalez, n.d.). These conferences have exhibit halls where societies can use exhibit booths as a tool to encourage membership and allow students to network with those in their disciplines. For example, ASCB, ASPET, and BPS have had exhibit booths at ABRCMS and SACNAS in the past. ASCB has also held symposium sessions at both conferences and BPS has held sessions at SACNAS. These sessions facilitate networking and encourage interest from undergraduates in specific STEMM disciplines.

SACNAS also holds a separate "mini-conference" called Community College Day. While it is virtual, the conference provides similar programs to their in-person conference. There are panels, workshops, talks, and presentations, allowing students to learn more about careers in STEMM. Students that attend Community College Day also have the options to present their research and attend a networking lunch with their peers (SACNAS, n.d.). Similarly, ABRCMS has a specific program track for community college students in which they can present research, network, and learn specifics about transitioning to a 4-year university (ABRCMS, n.d.). These specific programs for community college students offer exposure to STEMM careers (ABRCMS, n.d.; SACNAS, n.d.). Inclusion of community college students in ABRCMS ultimately provides societies with exhibit hall representation there like ASCB, ASPET, and BPS, the opportunity of an early introduction to these trainees.

CHALLENGES AND OPPORTUNITIES

Scientific Societies as a Tool to Retain Undergraduate Scientist Talent

While programming from scientific societies allows for undergraduate students to gain confidence, professional skills, and the ability to network, recent studies have uncovered that membership in scientific societies may be more beneficial to some students than others (Morales et al., 2020). Scientific societies can help navigate the barriers to success in STEMM but, oftentimes, UR students who are members of societies still experience marginalization, isolation, and identity stereotypes within the society (Morales et al., 2020). Specific inclusivity and diversity programs within scientific societies can counteract the marginalization and isolation UR members may experience (Maton et al., 2000; Casad et al., 2016; Cuker et al., 2016; Ahern-Dodson et al., 2020; Bruthers and Matyas, 2020; Segarra et al., 2020b; Womack et al., 2020; Starck et al., 2021). The heightened sense of community and self-efficacy undergraduates can feel from involvement in societies can lead to higher retention rates for UR undergraduates (Graham et al., 2013; Casad et al., 2016; Doerschuk et al., 2016; Russell, 2017; Gopalan et al., 2018; Ahern-Dodson et al., 2020; Bruthers et al., 2021). This, in turn, highlights the potential of this type of programming to help decrease the attrition of the UR undergraduate talent pool in the early stages of their education.

Many societies offer opportunities and programs for UR members, such as travel award, to help participants feel integrated into the scientific community, but undergraduate society programs that engage students beyond a society's annual meeting can be limited (Segarra et al., 2020c). When a society creates an inclusive environment, scientists from all backgrounds and career stages feel acknowledged and welcomed in their professional STEMM community. Not only do diverse groups produce innovative solutions and bring fresh perspectives to the discipline (Freeman and Huang, 2014), but having members of diverse career stages can act as an asset to the society and help create a mutualistic relationship between both the society members and the organization itself.

Engaging Community Colleges

Over half of all undergraduates have received some form of education from a community college at one time in their careers (American Association of Community Colleges [AACC], 2017; Schinske et al., 2017). Apart from SACNAS' Community College Day and ABRCMS' specific track for community college attendees, there is a noticeable lack of involvement of community college students in scientific societies. This means societies could easily increase the possibilities for engagement of community college undergraduates. It is important to mention that about 37% of students that enroll in a community college come from families that are financially below the poverty line [Community College Research Center (CCRC), 2021]. This heightens the potential value of society engagement with community college students since economic inequities may have limited the engagement of these students with STEMM.

Early engagement in disciplinary learning communities increases persistence in STEMM (Good et al., 2000; Chemers et al., 2011; Cuker et al., 2016; Doerschuk et al., 2016; Russell, 2017; Ahern-Dodson et al., 2020). Professional scientific societies are well positioned to act as this early-career learning community and impact a large number of undergraduates. This connection might lead to increased opportunities for networking and connections with faculty between 4-year institutions and

community colleges. This connection could then potentially ease the transition from a 2-year institution to 4-year university for the students. The COVID-19 pandemic has presented additional challenges to those with financial disadvantages along with those living in rural areas. Due to the pandemic, there has been a sizable increase in the amount of online conferencing offered by scientific societies, which has posed challenges for undergraduate members in rural areas, who may not have reliable access to the internet. Increases in virtual meetings means access to internet connection is more important than ever [Community College Research Center (CCRC), 2021]. While online meetings make conferences more accessible for many people (due to the lack of travel and decreased cost), scientific societies still must be cognizant of this issue when interacting with community college undergraduates.

As time goes on, more predominantly undergraduate institutions are recognizing and accepting undergraduate research experiences as one of the most direct ways of reinforcing undergraduate students to view themselves as "real scientists." Despite the fact that they are in the beginning stages of their careers, studies show that when undergraduate students have deeper and broader learning experiences in science it increases their chances of persisting in their major and aspiring to complete a post baccalaureate degree (Eagan et al., 2013; Casad et al., 2016; Gopalan et al., 2018; Bruthers et al., 2021). Involvement and support for undergraduate research taking place in community colleges is an approach societies could undertake to aid institutions and students. Currently, the Council on Undergraduate Research (CUR) has made strides toward making UREs more accessible for community college students. Since 2005, CUR has used NSF funding to identify challenges preventing community colleges from offering UREs, while also identifying models for community colleges to implement research experiences into their undergraduate biology curriculum. At over 110 community colleges, CUR has been able to successfully hold workshops that teach community college faculty the most sustainable ways to implement UREs into their curriculum (Council on Undergraduate Research, n.d.).

Students at community colleges play a vital role in the local workforce as they move on to transfer into a 4-year university or begin working. Oftentimes, courses teach students the basics of a research project, but students do not always have the chance to apply their knowledge (Cejda and Hensel, 2009). These students are highly motivated and need undergraduate research experience to put them on the same competitive level as other students when they transfer to a 4-year institution (Coggins, 2011; Hensel, 2011). This experience would also help them transition to a 4-year institution by increasing their scientific identity and self-efficacy, but to support the undergraduates in the community college system, societies must first support the faculty. Faculty need support in writing and finding grants to support the development of UREs (Cejda and Hensel, 2009). This is a place where scientific societies could assist community college faculty members, by creating relevant programming in areas like grant writing.

Creating Additional Opportunities to Recognize Undergraduate Excellence

Scholarships and society award can both provide undergraduates with recognition and/or support, oftentimes paving paths for further professional development in STEMM fields (Matyas et al., 2017). Examples of society scholarships include ASBMB's Marion B. Sewer Distinguished Scholarship which is awarded to an undergraduate student who is of a UR background. This scholarship provides up to $2,000 for a student's tuition at an undergraduate institution [ASBMB's Marion B. Sewer Distinguished Scholarship, (n.d.)]. Similarly, ASPET offers the Dolores C. Shockley Poster Award, which recognizes UR scientists and includes an undergraduate category.

Robust Assessment of Undergraduate Program Outcomes

While many life sciences professional societies have increased the range of undergraduate programming they offer, the majority continue to lack measurable outcomes for this programming (Matyas et al., 2017). Without a way to measure the effectiveness of their undergraduate programs, societies lack data that could be used to iteratively optimize program implementation in ways that ensure the desired goals are being met. The American Physiological Society (APS) demonstrates ways in which scientific societies can articulate programming objectives and assess their achievement. For example, through the use of entry and exit surveys for undergraduate research fellowships since 2016, APS has been able to consistently track the most beneficial elements and make informed adjustments to the program when needed (Bruthers et al., 2021).

Expanding Undergraduate Mentorship Programs

Mentorship is another important component of creating community and increasing retention in STEMM for undergraduates (Good et al., 2000; Chemers et al., 2011; Cuker et al., 2016; Doerschuk et al., 2016; Russell, 2017; Ahern-Dodson et al., 2020). The lack of undergraduate mentorship programs in the life sciences has created a gap that scientific societies are perfectly positioned to fill in ways that transcend geographical barriers. More robust mentoring programs could be designed to highlight STEMM professions outside of academia, exposing students to a wider range of possible careers in their fields of interest. Within smaller academic institutions, it may be harder to discover all possible career paths within STEMM, including those in industry. Scientific societies have the ability to offer mentors of diverse career backgrounds as a resource to interested undergraduates.

Societies can look to the Society for Freshwater Science (SFS)'s Instars Mentoring Program (IMP), where undergraduates are mentored by graduate students during their annual meeting. While this program is not long term, it does connect undergraduates with an individual at a more advanced career stage within their discipline. The students are also guided through the annual meeting which lessens confusion and

overwhelming feelings that come with attending a large conference. Undergraduate student participants in the IMP report that this program reinforced their career and education aspirations in their discipline (Abernethy et al., 2020). Comparable programs are organized by ASCB and ASPET at their annual meetings, called "Multiplying Participants Accomplishing Career Transitions (M-PACT)" and "Partnering for Success," respectively.

Creating Opportunities for Non-presenting Students at Annual Conferences

While undergraduate attendance at annual society meetings has been shown to be beneficial to non-presenting students (Gopalan et al., 2018), most societies require that students applying for travel award present their research at these conferences. This might present a barrier for non-presenting undergraduates who are early on in their STEMM careers and desiring to experience their disciplines of interest and connect with practitioners in these fields at a deeper level. For this reason, societies should consider adjusting the eligibility criteria for undergraduates applying for their resources and programming, to ensure they are not excluding those early-on in their STEMM careers. Societies may also consider hosting hybrid sessions at their conferences, so that undergraduates who are not in attendance can connect remotely and benefit from relevant content, increasing awareness for the resources provided by the society to undergraduates.

Meeting the Needs of Recent Graduates Experiencing Career Transitions

Similarly, most societies require that students applying for travel award or other programs identify a specific career stage (e.g., undergraduate, graduate student, and postdoctoral trainee) and an academic affiliation (Segarra et al., 2020c). This might present a barrier for recent graduates who desire to stay connected with their disciplines but might be transitioning between jobs or positions. By reassessing applicant requirements for their program offerings, societies can help make these opportunities more inclusive of those who might need them most.

CONCLUSION

Evidence shows that the implementation of specific STEMM-focused undergraduate programming can have positive outcomes such as increases in students' sense of community and scientific identity. This, in turn, can increase retention rates among undergraduate scientists at their home institutions (Asgari et al., 2010; Chemers et al., 2011; Graham et al., 2013; Casad et al., 2016; Doerschuk et al., 2016; Russell, 2017; Gopalan et al., 2018; Ahern-Dodson et al., 2020; Bruthers et al., 2021). This highlights an opportunity scientific societies have to leverage their resources and networks in the service of the next generation of scientists at the undergraduate level. ACCESS societies are striving to find ways to expand professional development options for undergraduate scientists, making sure to be inclusive of and nurture their future workforce.

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