Who are we now? A demographic assessment of three evolution societies

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ABSTRACT

Scientific societies have the potential to catalyze support for communities that have been historically excluded from science. Many of these societies have formed committees to propose and administer initiatives to promote the career and well-being of their members, with a special emphasis on racial and ethnic minorities. Yet, these societies are rarely armed with data to inform their proposals. Three of the evolution societies (American Society of Naturalists, "ASN"; Society of Systematic Biologists, "SSB"; Society for the Study of Evolution, "SSE") have also formed Diversity, Equity, and Inclusion committees in the last few years. As a first step in determining the needs of the societies, these committees collected data on the demographic characteristics of the societies' constituents by surveying the attendants of the Evolution 2019 meeting. Here, we report the proportions for different demographic groups in attendance at the meeting and compare these proportions to the demographics of recipients of Ph.D. degrees either in evolutionary biology or in the broader life sciences, as well as population demographics of the USA. Our results indicate that historically excluded groups are still underrepresented across US-based evolutionary biology professional societies. We explore whether demographic composition differs at different professional stages and find that representation for women and LGBTQ+ members decreases as career stage progresses. We also find some evidence for heterogeneity across societies in terms of racial composition. Finally, we discuss the caveats and limitations of our procedures. Our results will serve to inform future efforts to collect demographic data at the society levels, which should in turn be used to design and implement evidence-based initiatives for inclusion and equity. This report should be a starting point for systematic efforts to characterize ever-changing representation in evolutionary biology and to work towards inclusion of all groups.

INTRODUCTION

In recent years, organizations from businesses to nonprofits to universities have made concerted efforts to increase diversity among their ranks. But what, exactly, are these entities pursuing? The concept of diversity includes “all of the ways in which people differ, including primary characteristics such as age, race, gender, ethnicity, mental and physical abilities, and sexual orientation; and secondary characteristics such as nationality, education, income, religion, work experience, language skills, geographic location, family status, communication style, military experience, learning style, economic background, and work style" (Williams 2013). Demographically underrepresented students are often underrecognized innovators in science (Hofstra et al. 2020), and increasing the diversity of business teams improves decision making and business outcomes (Phillips et al. 2009; Díaz-García et al. 2013; Nathan and Lee 2013). More importantly, individuals of all identities and backgrounds should be able to pursue their interests and career goals without encountering systematic barriers to success. STEM (science, technology, engineering and mathematics) fields continue to lack representation of women and minorities (Ginther and Kahn 2009; Riegle-Crumb et al. 2019). On the other hand, initiatives to increase and sustain diversity in STEM fields are receiving renewed and expanding interest.

Scientific societies have the potential to provide a community and a sense of belonging to individuals who may otherwise lack mentorship or close colleagues. Professional societies of all fields also play an enormous role in the distribution of financial and human resources across professional communities and can facilitate the membership, mentorship, and support of a diverse range of individuals. Despite the clear importance of scientific societies to the scientific community and the growing awareness of the positive consequences of diversity, we still know little about their composition. Women and minorities tend to be underrepresented in scientific publishing (Ceci and Williams 2011; Bonham and Stefan 2017; Shen et al. 2018), are cited less often (Huang et al. 2020), are more likely to be have their papers rejected (Fox and Paine 2019, Hagan 2020), and are especially vulnerable to unprofessional peer-review (Silbiger and Stubler 2019). Women are also invited to serve as editorial board members (Mauleón et al. 2013; Cho et al. 2014; Helmer et al. 2017; Fox et al. 2019; Liévano-Latorre et al. 2020), reviewers (Helmer et al. 2017), and perspective piece authors for peer-reviewed journals (Baucom et al. 2019) at a lower frequency than men. While publication and reviewing rates are important proxies for who is producing and evaluating scientific content, these metrics alone are poor predictors of diversity in the scientific community because publishing and reviewing are just two of the many steps involved in the scientific enterprise.

Efforts to characterize the demographics of the work force in the life sciences do exist. The National Science Foundation (NSF) compiles data on all Ph.D. recipients every year and tallies the gender and racial identity of recipients (Kang 2018). NSF also tabulates Ph.D. recipients by discipline, including various STEM and humanities fields. By contrast, scientific societies rarely follow this lead, and when they do, they do not typically publicly release information regarding their membership demographics.

Scientific societies have recently begun to focus on promoting membership diversity. Roughly half of ecology and evolutionary biology scientific societies, as well as those scientific societies that count evolutionary biologists among their membership, have formed committees to promote diversity and inclusion within the last 10 years (Appendix 1). Three of the major evolution societies (American Society of Naturalists or ASN, Society of Systematic Biologists or SSB, and Society for the Study of Evolution or SSE) jointly run the yearly Evolution conference and have been part of this trend. SSE established a Diversity Committee in 2016, and the ASN Diversity Committee was established in 2018. SSB formed a Diversity, Equity, and Inclusion Committee in 2019. All three committees share a common goal: to determine the steps needed for each society to effectively recruit and support a diverse membership across career stages.

Diversity initiatives lacking assessment of the composition of the society they represent, while well-intended, are poorly equipped to serve their constituents. Initiatives by societies to promote diversity, equity and inclusion must be evidence-based so that limited resources can be allocated most effectively. As more diversity programs are put in place across all realms of the scientific enterprise, it is necessary to assess the demographic composition of both our societies and the subsets of society memberships that participate in society activities. We found that these self-evaluation efforts are rare in scientific societies. In the cases where data have been collected, they have not clearly been used to inform development of focused policies (See 'Precedents' below). The lack of concrete data poses an issue: despite the proliferation of diversity committees in scientific societies, the target audience which these committees serve is undefined. The committees of ASN, SSB, and SSE face this challenge as well. While each society is able to formulate plans for the future and promote activities to foster what they each consider a diverse environment, in the absence of quantitative data, these efforts are not informed by the composition of the representative society and may ultimately amount solely to good intentions.

Here we aim to pave the way toward data-informed policy by reporting and analyzing the outcome of an SSE and ASN Diversity Committee-conducted survey of attendees of Evolution 2019. These data are self-reported and focus on demographics of meeting attendees, who are largely members of ASN, SSB, and SSE. Our survey provides a population estimate for the demographic composition of the evolutionary biology community as a whole, enabling us to ask two critical questions: (*i*) How do the demographics of our community compare to the demographics of the USA as a whole (U.S. Census Bureau QuickFacts: United States)? and (*ii*) Do the three evolutionary biology societies (ASN, SSB, and SSE) differ in their representation? The data presented here can be used to develop systematic data-collection methods that will shape both conference programming and society initiatives moving forward.

PRECEDENTS

To our knowledge, there have been few efforts to collect demographic data either on the membership of evolutionary biology societies or of attendees at their conferences. Alternatively, these data may be collected but not released to the membership. As of 2020, we are aware of six scientific societies which have systematically compiled demographic data on their constituents and made these data available. First, the American Chemistry Society (ACS) inferred gender identity by name from the list of their members using a computational pipeline (Shishkova et al. 2017). Their results indicate that the majority of their membership identifies as men and that the young and mid-career investigator award recipients reflect the gender distribution of the society. By contrast, plenary lectures and senior awards are heavily skewed towards men relative to society membership (Shishkova et al. 2017). Second, the Mycological Society of America (MSA) is collecting demographic data in an ongoing self-assessment (Branco and Vellinga 2015; Cheke et al. 2018). MSA used the online survey platform SurveyMonkey to collect self-reported data from membership. The MSA assessment revealed that leadership positions had been mostly occupied by men and that the majority of senior society members identified as men, although men and women were equally represented at earlier career stages. Third, the Society for Freshwater Science (SFS) emailed their members to inquire about their opinions “concerning members’ attitudes toward diversity, equity, and inclusivity” (Abernethy et al. 2020) and surveyed gender, racial/ethnic minority, and disability identity among their members. Fourth, the Entomological Society of America (Entsoc) used an outside firm to conduct a survey of members in 2016. The survey collected data about gender as well as information about sexual orientation, race, ethnicity, and country of residency (Evangelista et al. 2020). Fifth, Débarre et al (2018) reported the gender composition of three evolution societies—ASN, SSE, and the European Society for Evolutionary Biology (ESEB) — and compared these data to symposia organizers in evolutionary biology. The average proportion of women invited to symposia was positively correlated with the proportion of women among the organizers, and tended to be higher for events whose organizers considered gender during the invitation process, and in instances in which Equal Opportunity guidelines were announced. Finally, the UK-based Palaeontological Association (PalAss) conducted a survey of its membership with the help of a private consulting firm in 2017/2018. Their survey was the most comprehensive of the six efforts, addressing gender, racial/ethnic minority, country of residency, career stage, sexual orientation, disability status, and history of family leave, among other questions (Gill and Parigen Limited 2018). We note that this is not an exhaustive list, but these examples show that there is a need for quantitative data on many facets of society composition. The five surveys from the biology societies (MSA, SFS, PalAss, EntSoc, and SSE/ASN/ESEB) revealed low representation of historically underrepresented groups (women and minoritized genders, minorities, LGBTQ+, people with disabilities) relative to society at large. These efforts in self-assessment, albeit rare and generally episodic rather than ongoing, have the potential to inform critical areas of improvement within each scientific society.

RESULTS

During the registration period for Evolution 2019 (February-June 2019), conference registrants were invited to participate in a survey to assess the demographic composition of the three societies that organize and attend the Evolution meetings: ASN, SSB, and SSE. We recorded the responses using software from Qualtrics (Provo, UT). The collection was registered and approved under IRB Study 17-3258 at the University of North Carolina. The survey consisted of seven questions aimed to determine society composition in terms of gender, sexual orientation, race, disability status, and career stage (Appendix 2). This sampling approach was approved by the Executive Councils of ASN, SSB, SSE, and by the Evolution 2019 organizing committee. We note that respondents to this survey represent a non-random sample of members of the three societies, as well as a non-random sample of meeting attendees. This survey did not collect information on country of residency or origin. With the origins of all three societies in the USA, society membership has remained consistently biased toward overrepresentation of American members (averaging 75% USA-based at SSE from 2009-2020 [SSE, pers. comm.], and 66% USA-based at ASN from 2004-2020 [ASN, pers. comm.]). We thus compare representation in societies with US society composition as a whole, including 2019 US census data (U.S. Census Bureau QuickFacts) and 2018 data from the National Science Foundation on all US PhD recipients (Kang, K. 2018). The survey was promoted by social media and by including the link in the SSE newsletter, with reminder emails to conference registrants. We refrain from analyzing and reporting instances in which survey respondents might be involuntarily de-anonymized.

We obtained 852 responses to the survey. The majority of respondents belonged to SSE (680), followed by ASN (264) and SSB (189). Many individuals belonged to more than one society (Figure 1), which creates non-independence of observations, while forty-three respondents did not specify affiliation with any society. We note that, due the smaller number of respondents per society, our ability to detect significant deviations between larger populations and affiliates of ASN and/or SSB may be limited for all tests. Respondents represented all stages of professional development (undergraduate: 34; graduate student: 326, postdoc: 169, pre-tenure faculty: 109, tenured faculty: 160, non-tenure track faculty: 16, nonacademic professional: 10). The median year for Ph.D. graduation among individuals who had completed their Ph.D. was 2007. On average, women who responded to the survey received their Ph.D. more recently than the men who responded ($Median_{women}$ = 2009; $Median_{men}$ = 2005; Wilcoxon rank-sum test with continuity correction; W = 29,161; *P* = 0.014; Figure 2). With these data in hand, we examined three axes of diversity: (*i*) gender and sexual orientation identity; (*ii*) racial/ethnic minority identity; and (*iii*) disability identity.

(*i*) Gender and sexual orientation identity

Question #1. What is the gender representation in the evolutionary biology professional societies?

Women are underrepresented in many STEM fields (Ginther and Kahn 2009; McCullough 2020). We thus calculated the proportion of respondents identifying as women in each of the three societies and compared them to the proportion of women in the U.S. census (50.8% in 2019; (U.S. Census Bureau QuickFacts: United States). Table 1 shows the proportion of respondents by gender, excluding counts of non-binary, gender fluid, gender neutral, or gender non-conforming respondents to maintain anonymity. The proportions of women in ASN and SSE respondents are larger than that of the US census when including members that belong to more than one society or that belong only to SSE (Table S1). The proportions of women respondents in SSB are similar to the census (Table S1).

The three societies have similar gender composition (pairwise comparisons between the three societies allowing overlap: all $X^2 < 0.771$, df = 1, $P > 0.380$; with no overlap: all $X^2 < 0.826$, df = 1, $P > 0.364$), and we pooled the results for our subsequent analyses. Women were a majority of the respondents of the survey (55.9%). In general, the proportion of women among the respondents was higher than the proportion of women in the US census (Table S1; $\chi^2 = 11.835$, $P = 5.813 \times 10^{-4}$), higher than the proportion of life sciences Ph.D. recipients who are women (51.7% data from 2019; Table S1; $\chi^2 = 7.727$, df = 1, $P = 0.005$), and higher than the proportion of women who obtained a Ph.D. in evolutionary biology in 2019 (47.1%; Table S1: $\chi^2 = 6.7534$, $P = 0.009$).

More in-depth analyses showed differences in gender composition across professional stages. Nearly twice as many women graduate students as men responded to the survey (201 vs. 114). The majorities of the postdoc and untenured respondents were also women (Figure 2A; Table S2). On the other hand, more tenured faculty respondents identified as men (87) than as women (71). We thus investigated the career-stage transition at which this switch in woman/man ratio occurred. We found a systematic decline in the proportion of women as career stage progressed (Figure 3A). Table S3 shows all the pairwise comparisons. The largest differences in the relative frequency of women occurred in the transition between graduate students (63.81%) to postdoc (53.80%; $X^2 = 4.154$, df=1, P = 0.042), and from untenured (59.8%) to tenured professors (44.94%; $X^2 = 5.07$, df=1, P = 0.02). This result suggests that for evolutionary biology (and similar disciplines), tenure might be a critical transition either in the age structure, in the retention of women in the field, or both. A similar phenomenon has been observed across all academic fields, including other STEM disciplines and the humanities (Jacobs and Winslow 2004; Blickenstaff 2005; Winslow and Davis 2016; Rissler et al. 2020).

This sampling also revealed the presence of non-binary members in the three societies: 1.5% of the survey respondents of the three societies identified as non-binary, gender fluid, gender neutral or gender non-conforming. The surveys from MSA, SFS, and the evolution societies indicate that this group of scientists is a contributing demographic throughout the life sciences.

Question #2. <u>What is the representation of the LGBTQ+ community in the societies?</u>

An additional group that has been historically excluded in science is the LGBTQ+ community (Freeman 2018, 2020; Sansone and Carpenter 2020). We compared LGBTQ+ representation in the evolution societies, as identified by the question regarding sexual orientation, to the national estimate for the USA. Note that the options for this question included “lesbian, gay, bisexual, pansexual, or asexual” (Appendix 2); we refer to this category as LGBTQ+ because it is currently a widely accepted term, although our question did not refer to trans- or cisgender identity. We found no differences in the proportion of LGBTQ+ survey respondents among the three societies when we included overlapping members (pairwise comparisons between the three societies allowing overlap: all $X^2 < 0.412$, df = 1, $P > 0.521$) or members that belong to only one society ($X^2 < 0.108$, df = 1, $P >$ 0.742), so we pooled the data for all subsequent analyses. Table S4 shows the counts of respondents who identify as LGBTQ+ and heterosexual for each society. We compared the pooled data to the proportion of LGBTQ+ individuals in the USA, which is nationally estimated at 4.9% (Youth Risk Behavior System data 2017; Smith et al. 2019). Combined, 16.12% of respondents for the three societies identify as LGBTQ+, roughly ~3X greater than the national population estimate ($X^2 = 241.17$, df = 1, $P < 1 \times 10^{-10}$).

As is the case when examining representation of people who identify as women, LGBTQ+ individuals may be differentially represented at different professional stages (Hughes 2018). For the three societies together, 33% of grad student respondents, 11% of postdocs, 14% of untenured faculty, and 7% of tenured faculty identified as LGBTQ+ (Figure 3B, Table S5). Pairwise comparisons suggested marked differences in the proportional composition of LGBTQ+ individuals at different professional stages (grad students vs. postdocs: $X^2 = 26.458$, df = 1, $P = 2.694 \times 10^{-7}$; grad students vs. untenured faculty: $X^2 = 12.741$, df = 1, $P = 3.578 \times 10^{-4}$; grad students vs. tenured faculty: $X^2 = 35.071$, df = 1, $P = 3.179 \times 10^{-9}$; Figure 2B). Notably, representation of LGBTQ+ postdocs and untenured ($X^2 =$ 0.597, df = 1, P =0.440) or tenured faculty did not differ ($X^2 = 0.594$, df = 1, $P = 0.441$), which suggests that LGBTQ+ scientists are less represented at post- vs. pre-graduation stages. Because there is no centralized data collection on the sexual orientation of Ph.D. recipients, we cannot compare our data to the broader category of life sciences Ph.D. recipients.

(*ii*) Racial/ethnic minority identity

Question #3. What is the representation of historically excluded racial and ethnic minorities in the societies?

We next assessed whether historically excluded minorities are underrepresented in the three societies (Table 2, Table S6). The survey assessed racial and ethnic minority status with the following question options: Black; Hispanic; South, Southeastern, or Eastern Asian; Indigenous (including Native American, Native Hawaiian and Pacific Islander); and multiracial (Appendix 2). When all minorities are considered in aggregate, ASN shows a lower proportion of minority representation (11.88%) than SSE (17.67%) or SSB (20.74%; pairwise comparisons in Table S7). These differences, however, only appear when these racial and ethnic groups were considered in aggregate, and when respondents that belong to more than one society are included. When only members that belong to a single society are considered, we found no difference in representation among societies ($X^2 < 0.058$, df = 1, P > 0.810; Table S7). We note that 28% of the URM members of the three societies belong to more than one society which is lower than the proportion of white-non-Hispanics that belong to more than one society (40.9%; $X^2 = 7.75$, $P = 0.005$).

The proportions of SSB and SSE respondents who identify as Hispanic (14.55% and 13.88%, respectively) are larger than that of ASN (6.90% in Table 2, $X^2 > 5.95$, $P < 0.015$; all pairwise comparisons in Table S7). By contrast, the proportion of respondents who identify as Black or multiracial is similar across the three societies (<3% in all cases, Table 2; all pairwise comparisons in Table S7).

Similar to our analyses of gender identity, we studied whether representation of racial/ethnic minorities in the evolution societies was on par with that of life sciences Ph.D. recipients in the USA. The proportion of the tri-society respondents who identified as Hispanic (12.47%) was higher than the proportion who received Ph.D. degrees in the life sciences (9.40%, Kang 2018; $X^2 = 7.527$, df = 1, $P = 0.006$) but not significantly higher than the proportion who received Ph.D. degrees in evolutionary biology (7.80%; $X^2 = 2.863$, df = 1, $P = 0.090$). We note that the power differs for these two comparisons: 0.76 vs. 0.49, respectively (calculated with the R package *pwr*, Champely et al. 2018). These comparisons are limited because our survey does not allow us to differentiate between US-based Hispanic respondents and respondents from outside the

USA. Similarly, the proportion of Black respondents (1.08%) was lower than the proportion of Black Americans who received a Ph.D. in the life sciences (4.32%, Kang 2018; $X^2 = 19.645$, df = 1, $P = 9.32 \times 10^{-6}$) but on par with the proportion of Black Americans who received a Ph.D. in evolutionary biology (1.56%; $X^2 = 0.036$, df = 1, $P = 0.850$).

Next, we studied whether historically excluded racial/ethnic minorities were represented at similar proportions at different professional stages. The only minority category that had a sufficient sample size for this type of analysis was Hispanic respondents. We found no substantial decrease in proportional composition at any professional stage (prop.test: $X^2 < 1.032$, df = 1, $P > 0.310$ in all pairwise comparisons), suggesting no major change in proportion of Hispanic membership between particular professional stages. This result is consistent when data are pooled or unpooled across societies.

(*iii*) Disability identity

Question #4. What is the representation of people with disabilities in the membership of the evolution societies?

Finally, we studied the representation of people with disabilities in the three societies. For this report, we pooled the data for the three societies to maintain anonymity. 10.8% of the survey respondents reported some type of disability. Table S8 shows the breakdown by disability. This proportion is lower than some estimates of the US national average (26%, Okoro 2018) and is closer to more conservative national estimates (12.8%; US Census, Hamrick 2019; $X^2 = 2.878$, df = 1, $P = 0.090$). The proportion of Ph.D. recipients in biological sciences with disabilities (7.15%) is lower than the proportion of US citizens with disabilities (12.8%, US Census, Hamrick 2019; prop.test: $X^2 = 225.8$, df = 1, $P < 1 \times 10^{-10}$). Finally, we found that the proportion of respondents with disability in our survey was higher than the proportion of biological sciences Ph.D. recipients from the same group (prop.test: $X^2 = 13.991$, df = 1, $P = 1.837 \times 10^{-4}$).

Fine-scale analysis of disability types indicates that the reported representation of different disabilities is not uniform. Our survey shows that the three most common disabilities in the evolution societies are related to hearing (1.78%), vision (1.54%), and mobility (~1%). We compared these to NSF estimates (2017, NCSES 2019). The proportion of respondents with hearing disabilities are similar in the evolution societies and the broader biological sciences (prop.test: X^2 = 3.6852, df = 1, P = 0.055), but lower than the proportion in the US population (X^2 = 7.4693, df = 1, P = 0.006). The proportion of respondents with visual disabilities in the survey is similar to that reported in the biological sciences (X^2= 3.614, df = 1, P = 0.057) and the US population (X^2= 2.084, df = 1, P = 0.149). Similarly, mobility disabilities are equally represented in the evolution societies and the broader biological sciences (X^2= 0.277, df = 1, P = 0.599), but are underrepresented in the evolution societies relative to the US population (X^2 = 47.585, df = 1, $P < 1 \times 10^{-10}$). Comparisons among different career stages show no evidence for a change in representation of respondents with disabilities when all disabilities are pooled together (X^2 < 1.402, df = 1, P > 0.236; all pairwise comparisons in Table S9). We did not conduct similar analyses for each type of reported disability to preserve anonymity of participants.

Our results suggest that societies should invest in conference accommodations for individuals who have visual or hearing impairments, and also consider ways to support evolutionary biologists with chronic mobility difficulties.

DISCUSSION

Caveats and limitations

Like all sampling schemes, ours has limitations. A first and obvious caveat to our findings is that we did not survey society memberships directly but instead surveyed conference registrants. Not all members attend the annual meeting; particular groups might be less likely to attend meetings because of financial difficulties or other reasons. Thus, our pool of respondents is a non-random sample of both society membership and of conference attendees. Second, our metrics are limited in that they do not include all axes of diversity (e.g., socioeconomic, veteran, and international status). Third, internet surveys tend to have systematic biases, with some demographics more likely to respond to the call than others (Jang and Vorderstrasse 2019). One suggestive indication of such a pattern in our results is that women appear to have answered the survey at higher rates than men. While our survey responses would suggest a higher proportion of women faculty, society membership data from 2018 show that women do not represent a majority

(Débarre et al. 2018). By contrast, representation of graduate students and postdocs in our sample, while high, is similar to that observed in society membership data.

There are also differences in gender representation at the faculty level between the 2019 conference attendants and the membership data. Three possible and non-mutually exclusive factors might account for this pattern. First, the society composition might have changed between when we circulated our survey and the last time membership was scored. Memberships of the three societies do change yearly and are associated with registration to the annual meeting; nonetheless, such a rapid change is unlikely. Second, and more plausibly, faculty who identify as women were more likely to respond than faculty who identify as men. The same response rate enrichment might also apply to racial/ethnic minorities, individuals that identify with the LGBTQ+ community, and individuals with disabilities, as they may feel a greater inclination to have their presence counted. Third, there may be age stratification in willingness to share personal information, including gender, sexual orientation, and disability identity. Only a full assessment of the complete membership of each society will determine what biases exist in our sample. However, such efforts will require members of overrepresented groups to respond to surveys at a similar rate as members of underrepresented groups. A comparison of society-wide data with that of the meeting attendees will be valuable for identifying any groups that may be less likely to attend conferences and will inform development of evidence-based plans for improving inclusivity and accessibility at meetings.

An additional limitation is that our study is not longitudinal. We find differences in demographic representation at different professional stages that are more pronounced at the faculty level. This finding may be explained by changing larger cultural norms, changing STEM or professional society cultural norms, and/or by attrition of particular groups as professional development proceeds (i.e., a leaky pipeline). The comparison of proportions at a single point in time assumes individuals at different stages of professional development have experienced comparable personal and professional barriers at each stage through time. This is not always the case. For example, broad societal change occurring during the last few decades may enable younger biologists to publicly embrace their identities in a way that differs from senior biologists. On the other hand, there might be a true leaky pipeline in which historically excluded groups suffer from attrition at a higher rate than overrepresented groups as their careers advance. Our current data only allow us to identify a pattern consistent with a decrease in representation as professional stage advances, but not whether or not attrition is occurring. Importantly, these two possibilities are not mutually exclusive (Shaw and Stanton 2012). Longitudinal data are needed to assess the potential influence of a leaky pipeline affecting multiple historically excluded groups in evolutionary biology.

Additional aspects of diversity that are not present in our survey must be explored. An important limitation is that our sampling does not include many important categories of self-assessment. For example, the questionnaire did not directly assess the prevalence of depression or other mental illness, which is the most common disability in other society surveys (e.g., PalAss; Gill and Parigen Limited 2018). We also lack assessment of socioeconomic diversity, despite the widespread understanding that generational wealth differs among racial/ethnic minorities (Gale et al. 2020) and the likely barrier this disparity poses to continuation in STEM. Finally, our survey did not address the international composition of the three societies by asking respondents to identify their country of residence. This is an important component of society membership and must be addressed in future surveys. All three societies started as US-based entities. Indeed, representation of SSE membership has varied from 66-79% US-based since 2009 (averaging 75%; SSE, pers. comm.), while representation of ASN is 61-76% US-based (average 66%; ASN, pers. comm.). Through concerted effort of the societies, the impact of the societies abroad may increase over time. We note that obtaining responses from a breadth of international locations will complicate comparison of society composition with broader national (or international) demographics. This potential increased representation by international members will pose an important decision for the diversity committees of ASN, SSB, and SSE: whether promoting increased international representation is part of their mission, or whether they will focus on diversity at the domestic level.

Future directions

Here we estimated the demographic composition of the three major US-based evolution societies within and across career stages. It is clear that there are segments of this population that are underrepresented. This result follows trends also observed in the life sciences and across STEM fields at large. Representation of historically excluded demographic groups among the members of the three societies may increase through focused societal support, including mentorship opportunities. Our goal with this perspective is to start a self-reflective assessment of the composition of scientific societies to advance these efforts. This assessment must be revisited over time, as society turnover can be rapid. Future assessments should also include a formal study on intersectionality, as identity interactions are an important component that we have not addressed here. Doing so will require a significant commitment from scientific societies to periodically evaluate their demographic composition, but it may be the most effective way to ensure diversity initiatives are well-designed and produce meaningful outcomes. Our societies are currently in the process of obtaining demographic data for their full memberships, which will enable broader comparisons between meeting demographics and society demographics.

One noteworthy finding from our dataset is that when all historically excluded racial/ethnic minorities are combined, their proportional representation is similar across societies. Nonetheless, fine-scale examination reveals that although these proportions are similar, some significant variation exists among societies. This pattern suggests that the needs of historically excluded racial/ethnic minorities from each society may differ and should be frequently revisited. Moreover, categories like 'Hispanic' are likely too broad to capture true cultural and ethnic diversity. Similarly, while the total proportion of members with disabilities is on par with US national estimates, there is detectable variation among different forms of disability. That is, representation for individuals with certain disabilities are proportionate to the frequency in the USA population, while individuals with other disabilities are notably underrepresented. These findings highlight the impossibility and impracticality of a single "one size fits all" approach and the necessity of advancing multiple complementary initiatives to promote diversity, inclusion, and equity. Hidden diversity is likely present in overrepresented identities as well (e.g. 'White', 'heterosexual'). We note that overrepresented identities are largely ignored in the presentation of demographic data, and thus treated as a default category by which "diversity" is defined in opposition. Future analyses of membership data should incorporate analyses of overrepresented and underrepresented groups alike.

Diversity initiatives do not always result in effective change. In particular, it remains to be seen whether the composition of diversity committees and their actions successfully address the core issues faced by members of professional societies. Although many scientific societies discuss diversity and inclusion regularly, little prior self-assessment has occurred to formally evaluate the composition and needs of constituent communities. Collecting demographics may not necessarily lead to actionable items, but we will not know without making that effort. We contend that arming society diversity committees with data will allow them to represent members' needs better, and to propose meaningful evidence-based actions for the promotion and inclusion of underrepresented groups.

With data in hand, equity, inclusion, and diversity priorities may be set by society leadership. Importantly, the routes societies take to pursue equity and inclusion should depend on the mission of each society and existing membership. Information on the groups that are underrepresented in each society can guide precise efforts to align society composition at all career stages with relevant populations; e.g., with the demographics of recipients of higher degrees in life sciences, or with demographics of Ph.D. recipients in evolutionary biology more specifically. This information can guide mentorship plans to retain, mentor, and promote members of the societies. Importantly, these approaches are not mutually exclusive, but do require different plans of action and different target audiences.

Diversity, Equity, and Inclusion committees have proliferated in all realms of business, academia, and industry. While their goals are certainly always positive, without data, they run the risk of becoming irrelevant, or worse, an example of ineffective policy and self-congratulatory tokenism. This perspective should be viewed as an opportunity to foster systematic data collection and thus to assess whether and for whom leaky pipelines exist, whether representation of membership—and not only meeting attendants—is on par with national averages, and where non-US society members call home. Recursive data collection is an essential mechanism for scientific societies and their diversity committees to formulate and revisit policies that advance their larger missions.

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FIGURE LEGENDS

FIGURE 1. Membership overlap between the three societies. The size of each circle in the Venn diagram is not proportional to the number of respondents.

FIGURE 2. Year of Ph.D. completion among survey respondents by gender. This figure includes only respondents identifying as men or women, as fine-scale analysis of gender minorities by year of Ph.D. would involuntarily identify respondents. Vertical solid lines show the mean; vertical dashed lines show the 95% confidence interval.

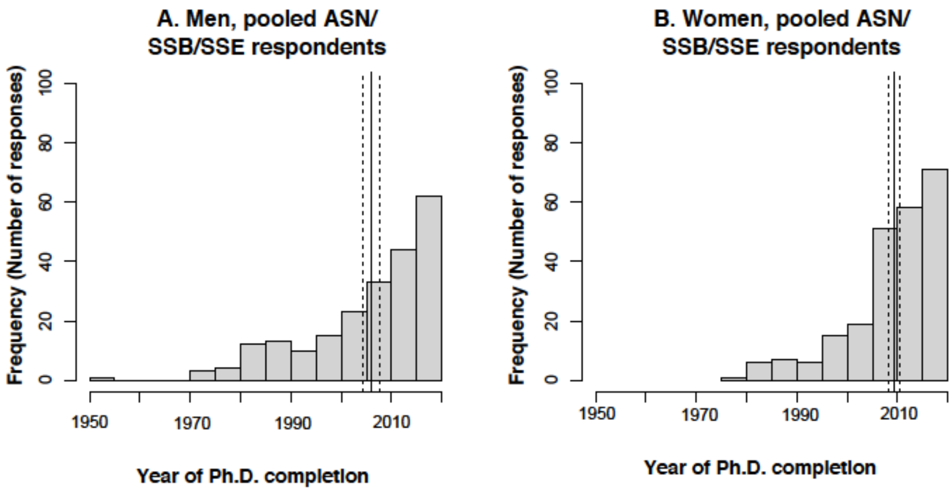
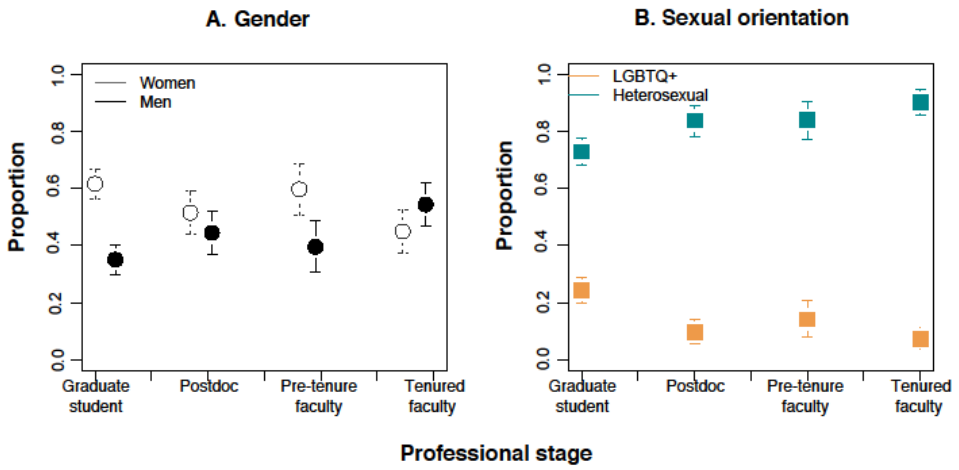


FIGURE 3. Representation across different stages of professional development by gender. Similar to Figure 2, non-binary respondents are not shown to maintain anonymity. **A.** Gender. Gray empty circles: women; black filled circles: men. **B**. Sexual orientation. Yellow: LGBTQ+, green: heterosexual. Bars show the Bayesian confidence intervals of the proportion calculated with the R package *binom* (Dorai-Raj 2015) and plotted with the R package *gplots* (Warnes et al. 2020). The same data in table format are shown in Tables S2, S3, and S4.



TABLES

TABLE 1. Gender representation in the three evolution societies. Individuals who identify as non-binary and other minoritized genders are intentionally not represented, to preserve anonymity.

	Women	**Men**	**Total**	**Proportion of women respondents**
ASN	33	22	55	0.6
ASN, SSE	90	68	158	0.57
ASN, SSB	3	2	5	0.6
ASN, SSB, SSE	22	19	41	0.54
None	28	19	47	0.6
SSE	222	160	382	0.58
SSB	30	29	59	0.51
SSB, SSE	41	37	78	0.53
Total	469	356	825	

TABLE 2. Racial/ethnic representation in the societies. To preserve anonymity, percentages and binomial CIs in parentheses are reported. "Indigenous" includes responses from two survey options: American Indian, Alaskan Native, First Nations, Indigenous or Aboriginal; and Native Hawaiian or other Pacific Islander. Census proportions come from U.S. Census Bureau QuickFacts. "South/East Asian" refers to South, East, and Southeast Asian respondents. Bayesian confidence intervals of the proportion were calculated with the R package *binom* (Dorai-Raj 2015) and plotted with the R package *gplots* (Warnes et al. 2020). To keep the identity of all respondents anonymous, proportions lower than 1.5% are noted as '<1.5%'. Confidence intervals for the census proportions are not shown because they are almost identical to the point estimates. $^{\$}$refers to 'Asian alone' in NSF and the census; $^{\#}$refers to 'more than one race' in NSF and the census. Comparison datasets are from 2019 (U.S. Census Bureau QuickFacts) and Ph.D. recipients in 2019 (Kang 2018). Table S6 shows the data, separating individuals that belong to more than one society.

		Racial/ethnic group					
Group	**N**	**Indigenous**	**Black or African American**	**Multiracial**	**South/East Asian**	**Hispanic**	**White**
US population	~320M	1.5	13.4	2.8#	5.9$	18.5	76.3
Life Sciences Ph.D. recipients	6,380	<1.5	4.32	3.573668	12.68$	9.40	67.76
Evolutionary biology Ph.D. recipients	192	0	1.5625	6.25#	7.29$	7.81	76.04
ASN	261	<1.5	<1.5	4.39 (2.08-6.91)	6.68 (3.80-9.75)	6.89 (4.10-10.20)	79.96 (75.08-84.72)
SSB	188	<1.5	2.9 (~1-5.32)	2.38 (~1-4.57)	5.92 (3.21-8.82)	14.55 (9.68-19.63)	71.16 (64.68-77.53)
SSE	668	<1.5	<1.5	3.21 (1.94-4.57)	8.30 (6.25-10.41)	13.38 (10.84-15.98)	70.78 (67.32-74.20)

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