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Quantitative Indicators of Continued Growth in Undergraduate Neuroscience Education in the US

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There is both anecdotal and quantitative evidence that undergraduate neuroscience education has grown substantially in the US. Therefore, efforts to continue to track changes in undergraduate neuroscience education are important. Here we provide quantitative data that both public and private institutions are creating new undergraduate neuroscience programs. In addition, we demonstrate that the number of graduates from undergraduate neuroscience programs continues to increase compared to graduates from other life sciences programs. These data are important to faculty and administrators at institutions that currently have or seek to establish new undergraduate neuroscience programs.

Key words: neuroscience programs; neuroscience majors; neuroscience graduates; life science programs

A number of quantitative measures can be used to assess growth in a given academic field including undergraduate neuroscience. For example, one can simply document the number of institutions that offer an undergraduate degree in neuroscience. This metric can serve as an important indicator of the number of institutions that have committed a substantial level of institutional resources to neuroscience education in addition to efforts to receive approval from state accrediting agencies, institutional curriculum committees, etc. Likewise, determining the number of student-majors/graduates in an undergraduate program can serve as an indicator of the level of interest/popularity of the program. However, the number of majors/graduates in a given program should be evaluated relative to the size of the institution or in the context of other majors at the institution.

Using the measures described above, the first quantitative analysis of undergraduate neuroscience education in the US was performed using data from the 2008-2009 academic year (AY; Ramos et al., 2011). Since then, we and others have updated these analyses (Ramos et al., 2016a; Pinard-Welyczko et al., 2017) which has indicated growth in both the number of neuroscience programs and graduates. Efforts to continue to track changes in undergraduate neuroscience education are important. In the present report, we use previous and novel analyses to demonstrate continued increases in the number of undergraduate neuroscience programs as well as increases in the number of neuroscience graduates. These data are relevant to faculty and administrators at institutions with existing undergraduate neuroscience programs as well as institutions seeking to establish new neuroscience programs.

MATERIALS AND METHODS
The Department of Education (ED) requires that all US colleges and universities report data relating to all programs (i.e., formal majors) offered at all degree levels (e.g., bachelor's, master's, doctoral, certificate, etc.) including the
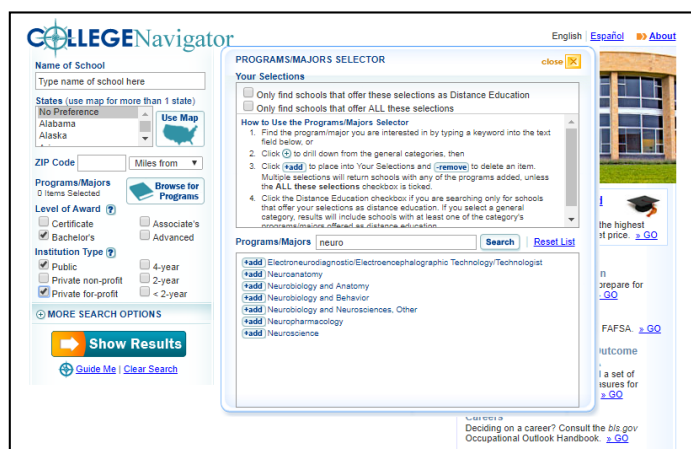

Figure 1. Screen shot of College Navigator database of the US NCES.

number and demography of all graduates from all programs. These data are made available publicly via the ED National Center for Education Statistics (NCES; https://nces.ed.gov). We used data from this NCES database for all analyses described below according to methods previously described (Ramos et al., 2011; Ramos et al., 2016a). Briefly, institutions with undergraduate neuroscience programs were identified and a number of institutional and program details were recorded including: 1) institution type (public vs. private), 2) number and types of programs in the "*Biological and Biomedical Sciences,*" 3) number of graduates of each program. Database searches were performed in February 2019 and include data from the 2017-2018 academic year. Using the search term "neuro" in the *College Navigator* database (Figure 1) of NCES for undergraduate programs returns the following program categories which were used in the analyses described below: 1) Neuroanatomy, 2) Neurobiology & Anatomy, 3) Neurobiology & Behavior, 4) Neurobiology & Neurosciences, Other, 5) Neuropharmacology, 6) Neuro-science. The program

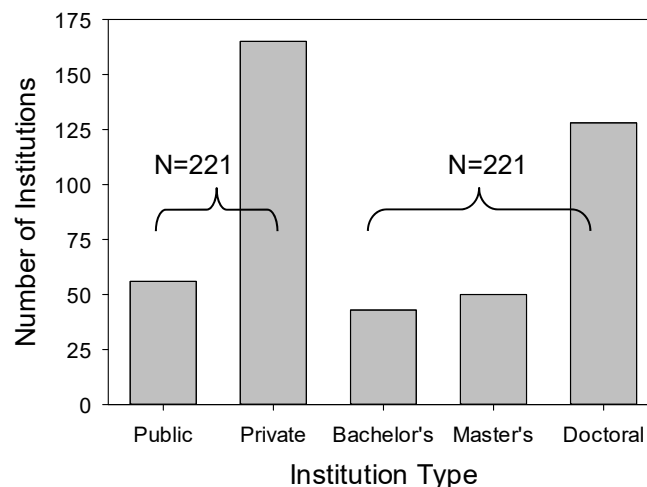| State	# of Institutions	# Public	# Private
Alabama	1	1	0
Arizona	2	2	0
Arkansas	2	0	2
California	15	6	9
Colorado	4	2	2
Connecticut	4	0	4
Delaware	2	2	0
District of Columbia	2	0	2
Florida	2	0	2
Georgia	6	2	4
Illinois	10	1	9
Indiana	9	4	5
Iowa	8	1	7
Kentucky	3	2	1
Louisiana	3	0	3
Maine	4	0	4
Maryland	1	0	1
Massachusetts	17	0	17
Michigan	7	6	1
Minnesota	7	1	6
Mississippi	1	0	1
Missouri	3	0	3
Montana	1	1	0
Nebraska	2	1	1
Nevada	1	1	0
New Hampshire	4	2	2
New Jersey	2	0	2
New York	17	2	15
North Carolina	3	1	2
Ohio	14	5	9
Oregon	2	0	2
Pennsylvania	26	2	24
Puerto Rico	1	0	1
Rhode Island	1	0	1
South Carolina	1	0	1
Tennessee	5	0	5
Texas	7	2	5
Utah	2	0	2
Vermont	4	1	3
Virginia	5	3	2
Washington	4	3	1
Wisconsin	6	2	4

Table 1. Distribution of institutions in our dataset (N=221) according to state or territory as well as public vs. private.

category Electroneurodiagnostic / Electroencephalographic Technology / Technologist was also identified using the search term "neuro" but data from this category were not included because no undergraduate programs were identified. The strengths and limitations of using data from this database have been discussed previously (Ramos et al., 2011; Ramos et al., 2016a).

RESULTS

A total of 221 unique institutions with 223 undergraduate "neuro" programs in one of the categories described above were identified using this approach indicating a dramatic increase (40.7%) compared to the 157 institutions previously identified using data from the 2013-2014 academic year (Ramos et al., 2016a). In the following text, we use the general term "neuroscience program" when we refer to the undergraduate neuroscience-related programs (majors) identified using our database search. Only data from those 221 identified institutions are included in the analyses described below. University of Cincinnati and University of Southern California were identified as each having 2 undergraduate neuroscience programs and data from these two programs at each respective institution were combined for subsequent analyses.

We first examined institutional characteristics of institutions with undergraduate neuroscience programs found in our dataset. As shown in Table 1 and Figure 2, we identified institutions with undergraduate neuroscience programs in forty of fifty states as well as in Washington DC and Puerto Rico. Pennsylvania had the largest number of institutions (n=26) in our dataset followed by New York and Massachusetts (both n=17). Seven states and Puerto Rico each had one institution in our dataset. As shown in Figure 2, the majority (n=165; 74.66%) of institutions identified by our search are private institutions. In addition, we found that the majority (n=128; 57.91%) of these institutions are doctoral degree granting (PhD in any discipline) compared to those that exclusively grant bachelor's degrees (n=43; 22.93%) or up to master's degrees (n=50;

Figure 2. Distribution of institutions in our dataset (N=221) according to whether public vs. private as well as highest degree offered in any discipline.
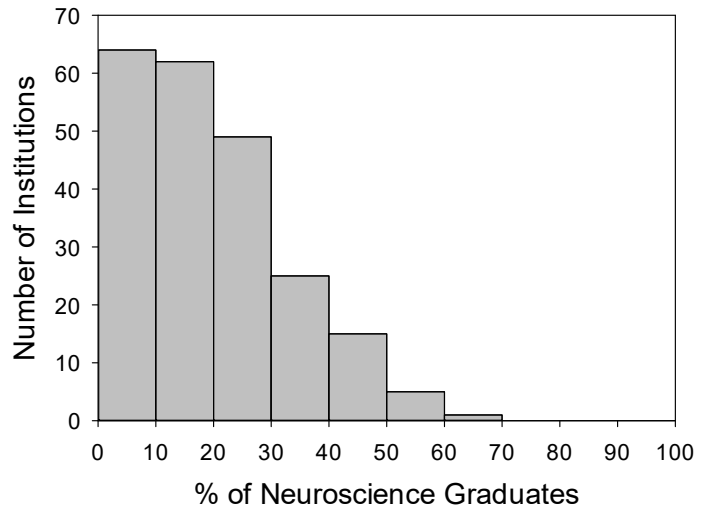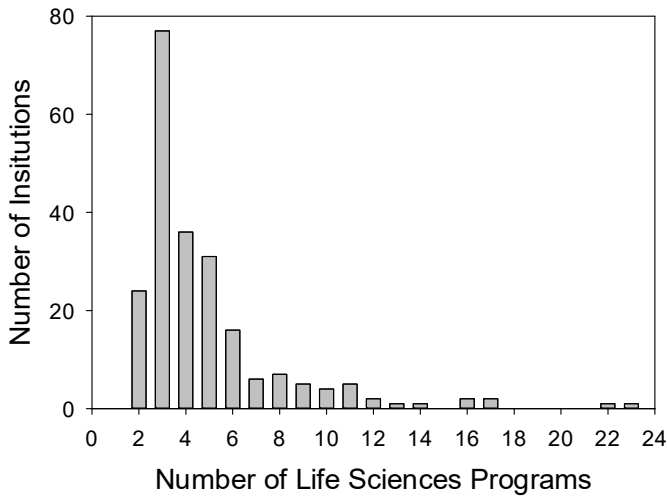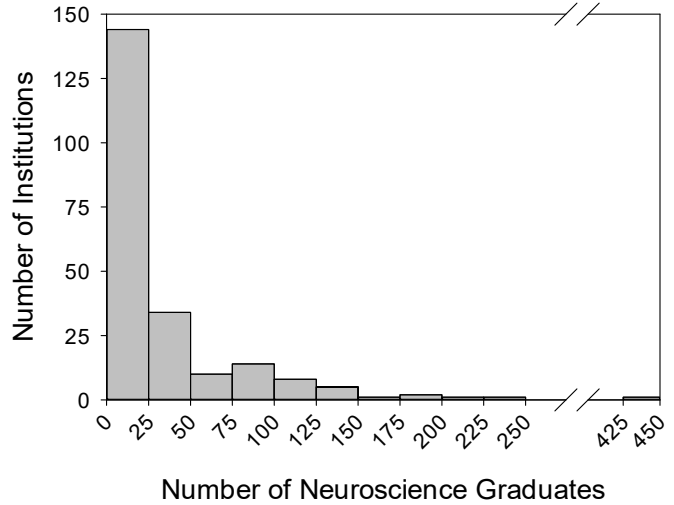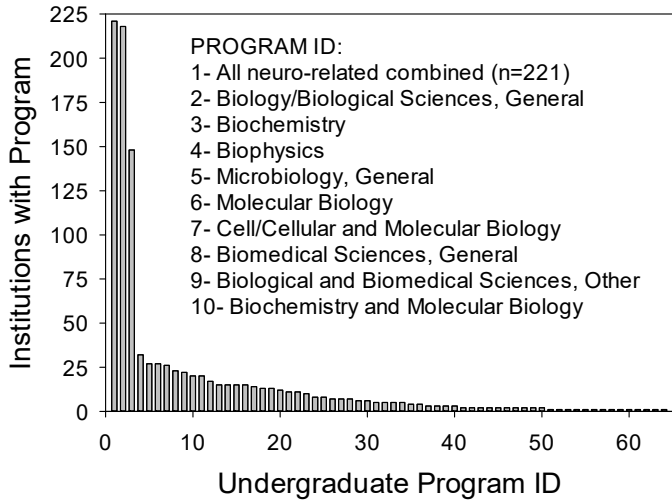
Figure 3. Top panel. Distribution of undergraduate life science programs offered at institutions in our dataset. Bottom panel. Total number of undergraduate life sciences programs (including neuroscience) offered at institutions in our dataset.

Figure 4. Top panel, distribution of the number of undergraduate neuroscience graduates (bin size 25) among institutions in our dataset. Bottom panel, distribution of the percentage of undergraduate neuroscience graduates (bin size 10%) relative to total graduates of all life science programs.

22.62%; masters in any discipline) institutions. Finally, our dataset of 221 institutions with undergraduate neuroscience programs included 9 women-only institutions.

All undergraduate neuroscience programs are listed by the US ED within a much broader category of life sciences programs. Excluding neuroscience-related programs, we identified 63 different programs that are also found in one or more of the institutions that had an undergraduate neuroscience program. Exemplar programs identified in these analyses included Biochemistry, Molecular Biology, Evolutionary Biology, etc. Figure 3 (upper panel) illustrates the number of institutions that offered any of the 63 other majors identified and the top ten most common majors offered by an institution are listed. From this chart it is evident, that excepting neuroscience, relatively few life science programs are offered in common at institutions in our dataset. This point is further illustrated in Figure 3 (lower panel), where the total number of undergraduate life sciences programs (including neuroscience) offered by each institution in our dataset is presented. These data indicate

that the majority of institutions offer only three undergraduate life science programs (i.e., two programs other than neuroscience).

Analyses were performed to assess the number of graduates of neuroscience programs from each of the 221 institutions in our dataset. A total number of 7208 neuroscience majors graduated from the institutions in our dataset in the AY 2017-2018 with an average of 32.61 graduates per institution. However, as shown in Figure 4 (top panel), the majority (147; 66.52%) of institutions in our dataset had 25 or fewer graduates in that year. Only 19 institutions had 100 or more graduates and only 3 institutions had more than 200 graduates. The proportion of neuroscience graduates to total number of life science program graduates was computed and illustrated in Figure 4 (bottom panel). These data indicate that neuroscience majors represent a broad number of the total majors among all life sciences programs. However, we did identify 47 institutions where greater than a third or more of all life
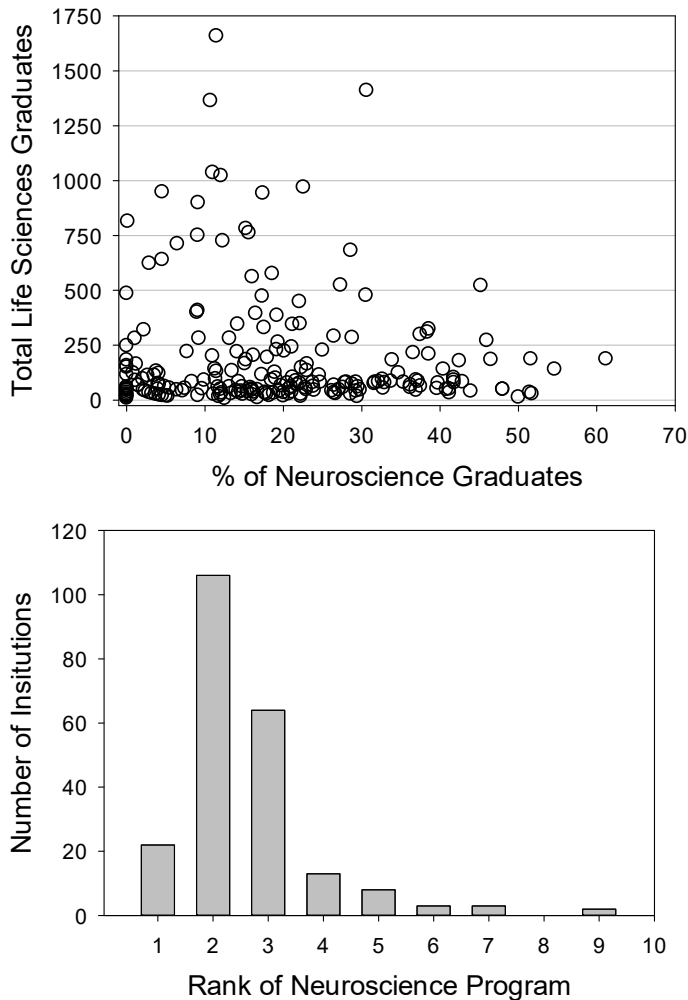
Figure 5. Top panel, Relationship between total number of life sciences graduates and percentage of this total that were neuroscience graduates. Bottom panel, Rank of neuroscience program relative to all other life science programs at each institution.

sciences majors were neuroscience majors and six institutions where neuroscience majors made up 50% or more of all life sciences majors.

The analyses described above may be confounded by differences in the number of total graduates in all life sciences programs as well as the number of other life science programs offered by institutions in our dataset. Figure 5 (top panel), illustrates the relationship between total number of life sciences graduates and the percentage of this total that were neuroscience graduates for each institution in our dataset. These data broadly indicate that neuroscience majors represent a modest percentage of graduates at institutions with large total undergraduate life science majors (~500 graduates). In addition, those institutions where neuroscience graduates represented 40% or greater of the total number of life sciences graduates generally had 250 or fewer total life science graduates.

In order to understand how neuroscience majors are distributed across the other life science programs at each institution, we rank-ordered the number of graduates across

all life science majors at each institution in our dataset.

Figure 5 (bottom panel) shows the rank of neuroscience graduates relative of other life science graduates and demonstrates that neuroscience majors ranked first in 22 institutions and ranked second in 106 institutions in our dataset. Finally, in Figure 6 we illustrate the relationship between rank of the neuroscience program relative to the total number of undergraduate life science programs offered at an institution across all 221 institutions in our dataset. The most numerous observations included institutions that offered three total programs and where neuroscience ranked either third (n=37; red bubble) or second (n=36; blue bubble) in number of graduates. In addition, we found institutions that have more than 20 life science programs where neuroscience ranked third, as well as institutions that offered 10 or more programs where neuroscience ranked ninth. These data demonstrate the breadth of rankings of neuroscience programs across institutions that offer varying numbers of life sciences programs.

Nine women-only (or primarily women) institutions were present in our dataset which allowed for similar analyses described above of this particular cohort of academic institutions (Agnes Scott College, Barnard College, Cedar Crest College, Mount Holyoke College, Scripps College, Simmons University, Smith College, Wellesley College, Wesleyan College). Although all of these institutions were private, the highest degree-offered (in any subject) varied including some that offered doctoral (n=3), masters (n=4), or bachelors-only degree programs (n=2). The number of life sciences programs (excluding neuroscience) offered at these institutions ranged from 1-7 (mean=3.56) and the number of neuroscience graduates in AY 2017-2018 ranged from 4-38 (mean = 18) which represented a percentage of total life science majors ranging from 20-51% (mean=33.28%). Consistent with these analyses we found that the undergraduate neuroscience program ranked either first (3 of 9), second (5 of 9), or third (1 of 9) among
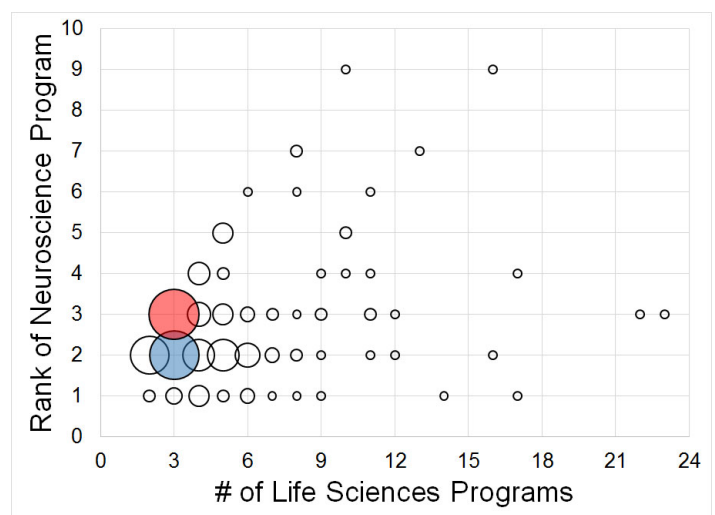

Figure 6. Relationship between rank of the neuroscience program relative to the total number of undergraduate life science programs offered at an institution. Size of bubble-corresponds to number of institutions. Red bubble equal to 37, blue bubble equal to 36, and smallest bubbles equal to 1 institution.

all other life sciences program offered at these institutions. Together, these data provide novel understanding of undergraduate neuroscience programs at women's only institutions.

DISCUSSION

In the present report, we provide quantitative indicators demonstrating that there has been continued growth in undergraduate neuroscience education. First, we show that the number of institutions with undergraduate neuroscience programs has increased since earlier measures using similar methods. For example, Ramos and colleagues reported the presence of 111 undergraduate neuroscience programs for AY 2008-2009 (Ramos et al., 2011) and then 157 undergraduate neuroscience programs for AY 2013-2014 (Ramos et al., 2016a). Thus, our current observation of 221 institutions with programs for AY 2017-2018 represents continued and substantial growth. Interestingly, new programs have been primarily established at private institutions (45 new programs compared to AY 2013-2014) versus new programs established at public institutions (19 new programs compared to AY 2013-2014). When considered in the context of other life science programs, these data indicate that institutions are investing resources to create new, and sustain existing, undergraduate neuroscience programs over more traditional life sciences programs. For example, using our quantitative approach, we found evidence that there currently exist more undergraduate neuroscience programs in the US than there are undergraduate programs in disciplines such as microbiology, molecular biology, or genetics. These are important data for the higher education community.

In the present report, we also examine changes in the number of graduating neuroscience majors. These data demonstrate continued increases in the total number of graduates compared to earlier reports using similar methods (Ramos et al., 2011; 2016a; 2017). Furthermore, neuroscience majors outnumber majors from most other life science majors at institutions in our database. In some cases, neuroscience majors represent the majority of total life science majors at a given institution. Taken together, these data demonstrate the current popularity of the undergraduate neuroscience major.

In the present report, we provide novel data on undergraduate neuroscience programs found at women-only institutions. Data specific to this cohort of institutions closely matches the aggregate results for the larger dataset, indicating the popularity of the neuroscience major among female undergraduates. Moreover, these novel analyses also provide motivation to examine other groups of institutions primarily serving specific student populations such as historically black colleges. (Note that Xavier University of Louisiana and Delaware State University were the only historically black colleges in our dataset limiting the analyses that could be performed.) Continuing to track data for these groups of institutions will be an important area of exploration for the undergraduate neuroscience education community and is in line with efforts to understand female and under-representative minority student participation in science, technology, engineering and math (James &

Singer; 2016; Margherio et al., 2016; Valentine et al., 2016; National Science Foundation 2017; Ramos et al., 2017;).

The strengths and limitations of our quantitative approach to determine the number of programs and graduates has been previously discussed (Ramos et al., 2011; 2016a). Compared to surveys or questionnaires which are vulnerable to low response rate, our approach uses data reported directly from institutions to the federal government. It remains unclear what approach, besides using data from NCES, would be better to identify new neuroscience programs from among the hundreds of institutions in the US. Note that using this approach, we identified a total of 221 programs in AY 2017-2018 which included data from 64 institutions with new programs compared to similar analyses performed with AY 2013-2014. Given the large number of programs created in the short span of time, it will be important to follow this rapid growth in future studies.

Increases in undergraduate neuroscience programs and graduates should drive efforts in the neuroscience education community to better understand these students. Specific open questions in this area include what students find so interesting about neuroscience compared to other academic programs and how a neuroscience degree will help them achieve their professional goals. Recent survey data (Gaudier-Diaz et al., 2019) suggests that answers to these questions can vary according to student demographics (e.g., male vs female, first generation college student) as well as the institutional characteristics (public vs private). Other reports have documented that neuroscience majors include those with future plans to pursue graduate school as well as those seeking to become a physician (Prichard 2015; Ramos et al., 2016b). Educational innovation in neuroscience will move more quickly and better serve more students as answers to these questions become clear.

We hope that our results will be of interest to the undergraduate neuroscience education community including faculty and administrators at institutions with existing neuroscience programs as well as institutions seeking to establish new programs. Our data suggest that neuroscience programs are largely popular at diverse institutions including public, private, primarily-undergraduate, and women-only institutions. Thus, institutions seeking to establish new programs can likely anticipate good participation among their life sciences student body.

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