

## ARTICLE

# Diversity of Graduates from Bachelor's, Master's and Doctoral Degree Neuroscience Programs in the United States

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The demography of United States graduates from science, technology, engineering, and math (STEM) degree programs is well-understood; however, data particularly describing the gender and ethnic diversity of graduates of neuroscience programs has not been analyzed, limiting our knowledge of specific areas where diversity and fair representation are lacking. Using over 30 years of data from the National Center for Education Statistics, we documented the demography of neuroscience graduates from bachelor's, master's, and doctoral degree programs. Recent graduation trends indicate greater numbers of female graduates from bachelor's and graduate degree programs. White (non-Hispanic) males and females

represent the largest group of graduates while Asian/Pacific Islanders represent the largest non-White group of graduates. Although the number of underrepresented minorities graduating from neuroscience degree programs at every level has increased in recent years, they still lag compared to White (non-Hispanic) and Asian/Pacific Islanders. These data provide valuable information that can be used to promote greater diversity among neuroscience graduates by higher education faculty and administrators and federal funding agencies.

*Key words: diversity; neuroscience; STEM; underrepresented minorities; women*

Recent census data indicates that racial/ethnic minority groups represent approximately 25% of the United States (U.S.) general population (U.S. Census Bureau; [www.census.gov/quickfacts/](http://www.census.gov/quickfacts/)). However, it is well-established that the demography of college students and graduates in the U.S. does not reflect the gender, racial, and ethnic diversity of the general population (Musu-Gillette et al., 2016). The small percentage of college graduates from underrepresented minority (URM) groups has been attributed to many factors including those related to cost, social pressures, pre-college preparation, lack of mentorship and guidance, as well as lack of equity and opportunity (Brown, 2000; Wilson, 2000; Gonzales, 2006; Chang et al., 2011). Similar barriers have led to a lack of URM groups as well as female graduates specifically in the science, technology, engineering, and math (STEM) fields (Turner and Thompson, 1993; Brown, 2000; Barone, 2011; Ceci et al., 2011, 2014). Research and programmatic efforts have been established by agencies such as the National Science Foundation (NSF) (James and Singer, 2016), National Institutes of Health (Margherio et al., 2016; Valentine et al., 2016), Howard Hughes Medical Institute (Asai and Bauerle, 2016) as well as college and university faculty (Hurtado et al., 2008; Hurtado et al., 2011; Chang et al., 2014; Estrada et al., 2016) to increase college enrollment, retention, and graduation among URM groups and women in STEM fields.

While quantitative analysis demonstrating reduced college graduation rates in the STEM fields among women and URM groups has been previously performed (NSF, 2017), specific analysis of neuroscience trainees is lacking at both undergraduate and graduate levels. Hence, to document the current and historical demography of neuroscience graduates at bachelor's, master's, and

doctoral degree levels, we analyzed quantitative data from the U.S. Department of Education (DOE) spanning more than 30 years. Considering the consistent growth in the number of neuroscience programs and graduates (Ramos et al., 2011; 2016a), our results are valuable for faculty, staff, and institutional administrators at colleges and universities as well as for U.S. funding agencies. In addition, recognizing that a diverse neuroscience research workforce is crucial for scientific discovery and innovation (Smith 1992, 1993; Nelson and Bramer 2010; Nishi et al., 2016), our data are important for identifying the extent of diversity throughout the neuroscience training pipeline (Crowley et al., 2004). We hope to stimulate discussion on this important subject which may contribute to the creation of novel initiatives to reduce disparities in URM participation and graduation in neuroscience programs. Finally, our data analysis will contribute to direct efforts to increase opportunities for diverse neuroscience graduates to become faculty members in neuroscience programs and departments to teach and mentor the next generation of neuroscientists.

## MATERIALS AND METHODS

U.S. colleges and universities are federally-mandated by the DOE to report data relating to all programs offered at all degree levels (bachelor's, master's, doctoral, etc.) including the number, sex, and demography of graduates. Therefore, we used data from the DOE National Center for Education Statistics (NCES; <https://nces.ed.gov/>) to estimate the number of institutions with undergraduate and graduate neuroscience programs, according to methods previously described (Ramos et al., 2011, 2016ab; Grisham et al., 2016). Briefly, we searched the Integrated Postsecondary Education Data System (IPEDS) database

of NCES for the colleges and universities with undergraduate programs listed in this database by the term “neuro” in the program name which included: 1] Neuroanatomy, 2] Neurobiology & Anatomy, 3] Neurobiology & Behavior, 4] Neurobiology & Neurosciences, Other, 5] Neuropharmacology, 6] Neuroscience. Although Electroneurodiagnostic/Electroencephalographic Technology/Technologist was also identified as a program category under our search, data from this category were excluded because no undergraduate programs were identified. Data obtained and annotated included: 1] number of graduates of each program and 2] all demographic data of graduates including gender and race. Database searches were performed in February 2017 and included data from the 1980-2015 in 5-year intervals. The strengths and limitations of using data from this database have been discussed previously (Ramos et al., 2011, 2016a).

In the following text, we use the term “neuroscience programs” when we refer to any of the neuroscience-related programs identified using our database search.

Data were annotated and descriptive statistics performed using Microsoft Excel. Tables and graphs were created using Excel and SigmaPlot (V10; Systat Inc.).

## RESULTS

We identified U.S. institutions with neuroscience programs at undergraduate, master’s, and doctoral degree levels and obtained the number and demography of graduates from all identified programs. As shown in Appendix Table 1, the number of total graduates from neuroscience programs at all educational levels has grown substantially over the period sampled. In particular, in 1980 there were fewer than 100 neuroscience graduates at any educational level. Remarkably, by 2015 there were more than 5000, 200, and 700 neuroscience graduates from undergraduate, master’s, and doctoral degree programs, respectively. We found that the distribution of female graduates from neuroscience programs at undergraduate and graduate degree levels has varied across the period examined. For example, less than 50% of all neuroscience graduates from bachelor’s (1990 and 1995), master’s (1980-1985 and 1995-2000), and doctoral (1980-2000) degree level programs were female prior to 2000 (Fig. 1, Appendix Table 1). However, beginning in 2000 and continuing to the most recent available data (2015), female graduates make up over 50% of graduates from undergraduate neuroscience programs. Moreover, since 2010, greater than 50% of graduates from neuroscience programs at master’s and doctoral degree levels were earned by females. In light of the fact that the total number of graduates from all neuroscience programs have grown, these data demonstrate that as of 2015, female neuroscience graduates outnumber male graduates at all degree levels.

The IPEDS database also includes information about the race/ethnicity of graduates from 1995-2015 including the following categories: 1] Black (non-Hispanic), 2] American Indian or Alaska Native, 3] Asian or Pacific Islander, 4] Hispanic, 5] White (non-Hispanic). The

percentage of neuroscience graduates belonging to these different race/ethnic and gender groups from programs at all degree levels is found in Appendix Tables 2 and 3. Several categories such as Race/ethnicity Unknown, Nonresident Alien, Two or More Races, have been grouped together as these categories were not always present in the NCES datasets over the years examined.

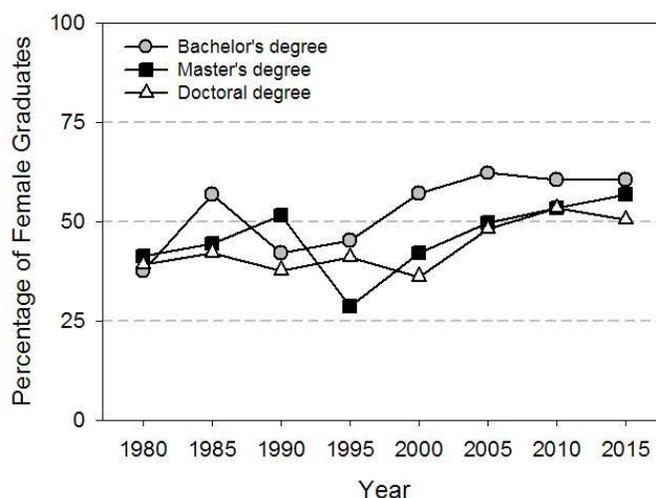


Figure 1. Percentage of female graduates of neuroscience programs at bachelor’s, master’s, and doctoral degree levels from 1980-2015.

We observed differences in the number of bachelor’s degree level neuroscience graduates from different racial/ethnic groups (Fig. 2, Appendix Tables 2-3). From 1995-2015, White (non-Hispanic) males (50%) and females (60%) represented the largest percentage of bachelor’s degree level graduates from neuroscience programs among the total number of male and female graduates, respectively. Interestingly, in recent years the percentage of White (non-Hispanic) graduates has decreased for both males and females particularly compared to levels seen in 1995 and 2000 despite increases in the total number of male/female graduates. Asian/Pacific Islander males and females represented the largest percentage (~20%) of non-White bachelor’s degree level graduates and showed 10% higher number of graduates than URM groups. Thus, Black (non-Hispanic) males and females as well as Hispanic males and females represented only a small percentage of graduates (~4% and ~8%, respectively) throughout the period examined despite the fact that the total number of male/female graduates has consistently and substantially grown. Interestingly, the percentage of Hispanic male and female graduates from bachelor’s level programs reached their highest levels in 2015. American Indian/Alaska Native males and females represented less than 1% of bachelor’s degree graduates throughout the analyzed period.

The percentage of graduates from master’s (Fig. 3, Appendix Tables 2-3) and doctoral (Fig. 4, Appendix Tables 2-3) degree programs in neuroscience from 1995-2015 was also analyzed. White (non-Hispanic) males

(55%) and females (60%) represented the largest percentage of master's and doctoral degree level graduates from neuroscience programs. Interestingly, the percentage of White male and female graduates from master's programs as well as White female graduates

consistent increases in the total number of male/female graduates from these programs. Similar to graduates at bachelor's degree level programs, American Indian/Alaska Native males and females generally represented <1% of master's and doctoral degree graduates from 1995-2015.

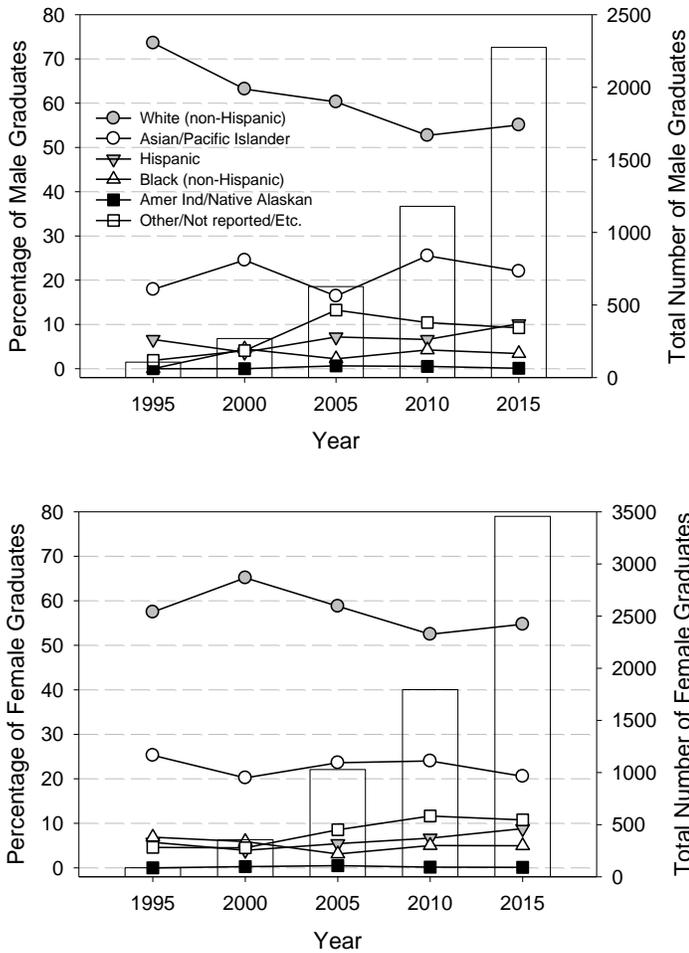


Figure 2. Demography of male (top) and female (bottom) graduates from bachelor's level neuroscience programs from 1995-2015. Lines correspond to left-side axis (percentage of male/female graduates). Bars correspond to right-side axis (total number of male/female graduates).

from doctoral programs has fluctuated  $\pm 10\%$  across the documented period despite the fact that the total number of male/female graduates from masters and doctoral degree programs has consistently increased. The percentage of White (non-Hispanic) male graduates from doctoral programs has seen a steadier decline since 1995 with the exception of a modest increase in 2015 back to  $\sim 60\%$ . Compared to differences seen for graduates of bachelor's level programs, the differences in the percentage of graduates between Asian/Pacific Islanders and Black and Hispanic graduates was not considerable for master's or doctoral level programs. However, even for master's or doctoral degree level programs, Asian/Pacific Islander females consistently had greater percentages of graduates compared to URM females. In general, the percentage of URM graduates from neuroscience master's and doctoral degree programs has remained similar despite the

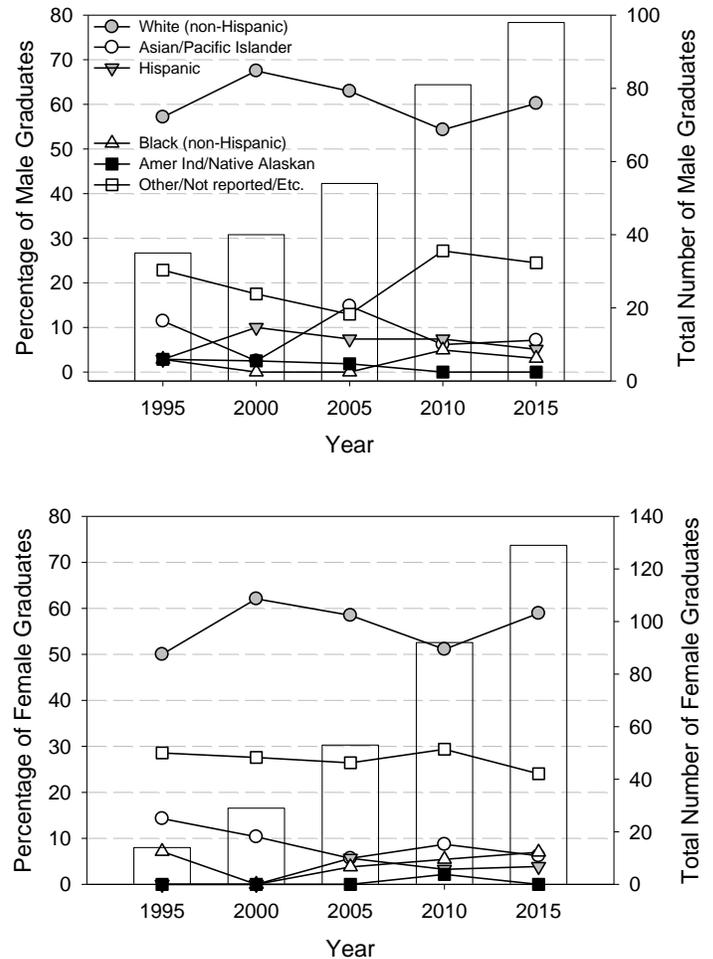


Figure 3. Demography of male (top) and female (bottom) graduates from master's level neuroscience programs from 1995-2015. Lines correspond to left-side axis (percentage of male/female graduates). Bars correspond to right-side axis (total number of male/female graduates).

## DISCUSSION

In this report, we present novel analysis describing the demography of graduates from neuroscience programs at bachelor's, master's, and doctoral degree levels in the US. First, we document the historical context of the growth in neuroscience graduates across all degree levels. We have observed a consistent trend of female graduates outnumbering male graduates particularly at the bachelor's and master's degree levels. At the doctoral level, males and females graduated at equal rates by 2015 compared to rates prior to 2005. Thus, although there is general growth in the number of neuroscience graduates across all degree levels, female graduates now outnumber male graduates. These data are consistent with those observed for female graduates in the biological sciences, in general (NSF, 2017). In contrast, these data are different than those for STEM fields such as computer science and engineering,

where male graduates (>80%) considerably outnumber female graduates (NSF, 2017). Based on our results, an important area for future research may include determining factors and perceptions that draw women to pursue an undergraduate and/or graduate degree in neuroscience compared to other disciplines (Ceci et al., 2011, 2014; Haak, 2002; Smith, 1992, 1993; Ramos et al., 2016a).

Our findings of robust graduation of females from doctoral neuroscience programs is at odds with the percentage of female neuroscience faculty members at U.S. colleges and universities. In particular, survey results found that only 29% of tenure-track neuroscience faculty are female (Sved and Society for Neuroscience, 2013). Furthermore, only 23% of neuroscience full-professors were females. This is despite our findings that female graduates have constituted over 30% of doctoral level graduates since 1980 and that female graduates have constituted nearly half or more than half of all doctoral level neuroscience graduates since 2005. These data exemplify the “leaky pipeline” female neuroscientist face as they navigate from graduate school and postdoctoral fellowships to a faculty position (Ceci et al., 2011, 2014; Joels and Mason, 2014). It is well-recognized that personal and social pressures also affect women achieving faculty status in addition to professional and institutional barriers (Williams and Ceci, 2012).

We also analyzed the racial/ethnic diversity of neuroscience graduates at bachelor’s, master’s, and doctoral degree levels. White (non-Hispanic) male and female neuroscience graduates substantially outnumber all other groups at all degree levels and throughout the period examined and the percentage of White (non-Hispanic) graduates has remained high alongside the general growth in the total number of neuroscience graduates at all degree levels. In addition, Asian/Pacific Islander males and females in neuroscience bachelor’s programs graduate at much higher rates than all other non-White groups. Thus, while only representing ~6% of the general U.S. population (Census Bureau; www.census.gov/quickfacts/), Asian/Pacific Islander graduates are well-represented among undergraduate neuroscience graduates. These data are consistent with similar analyses for Asian graduates from computer science and engineering programs (NSF, 2017). An important caveat to our results is that although our data includes both Asians and Pacific Islanders together, we understand that there are many countries with very different cultures included in this broad category and the number of graduates from among these different countries likely differs substantially. Nevertheless, an important area for future research is understanding those cultural (familial, etc.) and historical factors that influence these groups of students to pursue undergraduate and graduate neuroscience training. For example, Hsin and Xie (2014) recently argued that academic success among Asian Americans was due to greater academic effort and beliefs regarding the relationship between academic effort and achievement. Thus, Asians have a culture emphasizing education as a mechanism for upward social mobility (Hsin and Xie, 2014).

Like all the STEM fields in general, we observed that URM graduates represent a small number of neuroscience graduates across all degree levels and throughout the period examined. Thus, given the large increases in total neuroscience graduates at all levels, the fact that we observe little change in the percentage of URM graduates in neuroscience indicates that URMs continue to be

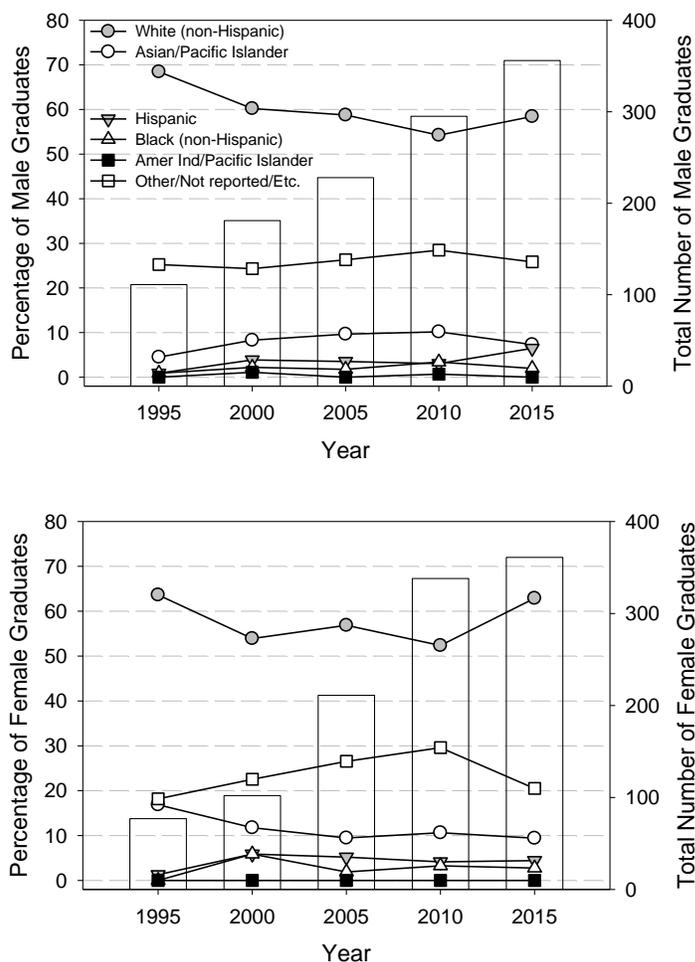


Figure 4. Demography of male (top) and female (bottom) graduates from doctoral level neuroscience programs from 1995-2015.

underrepresented in neuroscience compared to their presence among the U.S. general population. Factors that keep URM students from pursuing and/or obtaining a neuroscience degree are important areas for future investigation and possible initiatives may focus on increasing social and academic support for URM students. Early exposure to neuroscientists that can serve as role models, provide mentoring, and learning/research opportunities in neuroscience are other approaches to attract a more diverse neuroscience student body.

Our analysis reflects current trends in the demography of neuroscience graduates. For instance, we show a trend and a steady increase in the number of female graduates from neuroscience programs at both undergraduate and graduate degree levels. In contrast, despite consistent increases in the total number of neuroscience graduates at

all degree levels, there have not been major changes in the percentages of graduates from among the different racial/ethnic groups whose data are available on the IPEDS database. For example, URM graduates have consistently represented a small percentage of graduates at all degree levels. This is despite the fact that raw numbers of Black and Hispanic graduates at bachelor's and graduate programs have increased, though the total number of graduates in these degree programs have also consistently increased. This is an important point to take in consideration when assessing the success of federally-funded programs focusing on increasing URM representation in the STEM fields.

Based on our results, we predict that the percentage of female graduates across the different degree levels will likely continue to grow consistent with general trends showing increases in neuroscience graduates as well as increases in the number of new neuroscience programs that are established. Quantitative support for this prediction come from data in a recent study, where we demonstrated that undergraduate neuroscience graduates outnumber graduates from most, if not all, other undergraduate life sciences majors offered at many institutions (Ramos et al., 2016a).

Based on modest changes in the percentage of URM neuroscience graduates despite the substantial growth in total number of neuroscience graduates, we also predict that without major changes in the recruitment and/or retention of URM students, the percentages of graduates from among these racial/ethnic groups will continue grow but remain at low levels relative to White (non-hispanic) graduates. Future studies should aim to continue tracking the demography of neuroscience graduates to evaluate these predictions.

Despite its novelty and quantitative nature, our results are limited in that we have data only from those institutions identified by our search of the IPEDS database for programs with the term "neuro" in the program name. This omits institutions with programs that are listed by different categories (e.g., Interdisciplinary Studies) as well as programs where neuroscience is a *concentration* rather than a formal major. Despite this limitation, using this approach we still identified hundreds of programs at the undergraduate and graduate degree levels as well as thousands of graduates. Other approaches generally used to collect these types of data, such as surveys, often yield smaller datasets and rely heavily on the number of survey responders and the veracity of responses. Thus, our analysis includes more quantitative data than has previously been examined.

Another caveat of our results relates to the relatively large numbers of graduates in our "Other/Not reported/Etc." category which also includes graduates who identify as belonging to two or more races (in 2010 and 2015 datasets). It is difficult to determine why individual graduates choose to not to report their race/ethnicity or what race/ethnicity they identify with when they report "Other." In the case of data found in 2010 and 2015 datasets, we cannot determine which two or more races/ethnicities that graduates identify with, among those

who responded in this way. For these reasons, we combined these data into one category and recognize that an important open question relates to the identity of these graduates as well as how these data would alter the percentages we observed for the other categories.

In the context of continued numbers of neuroscience programs and graduates, our data are relevant to faculty and administration at institutions with existing neuroscience programs who should seek to recruit and retain a diverse student body. In addition, our findings are also relevant to those institutions seeking to create new neuroscience programs as well as the broader neuroscience community. Moreover, we show that participation is high among women in neuroscience programs. However, as is the case for all STEM fields, increasing participation from URM groups to pursue training in neuroscience will be critical to producing a diverse neuroscience research workforce that will drive innovation and discovery to treat neurological disorders (Crowley et al., 2004; Nishi et al., 2016). In this regard, diversity can provide unique approaches to solutions in research, institutional programs, and collaborative projects. In addition, understanding trends in the demography of neuroscience graduates will help produce a diverse faculty of future neuroscience educators (Weekes, 2012; Whittaker and Montgomery, 2012).

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**Appendix Table 1.** Number of male and female graduates of neuroscience programs at the bachelor's (Bach), master's (Mast), and doctoral (PhD) degree levels from 1995-2015.

	Male Grads	Female Grads	Total Grads
Year	Bach	Bach	Bach
1980	40	24	64
1985	54	71	125
1990	58	42	100
1995	106	87	193
2000	269	356	625
2005	627	1029	1656
2010	1180	1794	2974
2015	2275	3457	5732

	Male Grads	Female Grads	Total Grads
Year	Mast	Mast	Mast
1980	10	7	17
1985	5	4	9
1990	17	18	35
1995	35	14	49
2000	40	29	69
2005	54	53	107
2010	81	92	173
2015	98	129	227

	Male Grads	Female Grads	Total Grads
Year	PhD	PhD	PhD
1980	25	16	41
1985	33	24	57
1990	53	32	85
1995	111	77	188
2000	181	102	283
2005	228	211	439
2010	295	338	633
2015	355	361	716

**Appendix Table 2.** Percentage of female neuroscience graduates from different races from 1995-2015 at the bachelor's (Bach), master's (Mast), and doctoral (PhD) degree levels.

Year of Graduation	1995	2000	2005	2010	2015
Award level	Bach	Bach	Bach	Bach	Bach
Total N Graduates	87	356	1029	1795	3457
% Blacks (non-Hispanic)	6.90	5.90	3.11	5.01	4.98
% Asian/Pacific Islander	25.29	20.22	23.62	24.01	20.57
% Hispanic	5.75	3.93	5.44	6.69	8.82
% White (non-Hispanic)	57.47	65.17	58.79	52.48	54.73
% Amer Indian/Alaskan Native	0.00	0.28	0.49	0.17	0.12
Unknown/ Not reported	4.60	4.50	8.55	11.64	10.79
Award level	Mast	Mast	Mast	Mast	Mast
Total N Graduates	14	29	53	92	129
% Blacks (non-Hispanic)	7.14	0.00	3.77	5.43	6.98
% Asian/Pacific Islander	14.29	10.34	5.66	8.70	6.20
% Hispanic	0.00	0.00	5.66	3.26	3.88
% White (non-Hispanic)	50.00	62.07	58.49	51.09	58.91
% Amer Indian/Alaskan Native	0.00	0.00	0.00	2.17	0.00
Unknown/ Not reported	28.57	27.59	26.42	29.35	24.03
Award level	PhD	PhD	PhD	PhD	PhD
Total N Graduates	77	102	211	338	361
% Blacks (non-Hispanic)	0.00	5.88	1.90	3.25	2.77
% Asian/Pacific Islander	16.88	11.76	9.48	10.65	9.42
% Hispanic	1.30	5.88	5.21	4.14	4.43
% White (non-Hispanic)	63.64	53.92	56.87	52.37	62.88
% Amer Indian/Alaskan Native	0.00	0.00	0.00	0.00	0.00
Unknown/ Not reported	18.18	22.55	26.54	29.59	20.50

**Appendix Table 3.** Percentage of male neuroscience graduates from different races from 1995-2015 at the bachelor's (Bach), master's (Mast), and doctoral (PhD) degree levels.

Year of Graduation	1995	2000	2005	2010	2015
Award level	Bach	Bach	Bach	Bach	Bach
Total N Graduates	106	269	627	1180	2275
% Blacks (non-Hispanic)	0.00	4.46	2.23	4.24	3.43
% Asian/Pacific Islander	17.92	24.54	16.43	25.51	22.02
% Hispanic	6.60	3.72	7.18	6.61	10.15
% White (non-Hispanic)	73.58	63.20	60.29	52.71	55.08
% Amer Indian/Alaskan Native	0.00	0.00	0.64	0.51	0.09
Unknown/ Not reported	1.89	4.09	13.24	10.42	9.23
Award level	Mast	Mast	Mast	Mast	Mast
Total N Graduates	35	40	54	81	98
% Blacks (non-Hispanic)	2.86	0.00	0.00	4.94	3.06
% Asian/Pacific Islander	11.43	2.50	14.81	6.17	7.14
% Hispanic	2.86	10.00	7.41	7.41	5.10
% White (non-Hispanic)	57.14	67.50	62.96	54.32	60.20
% Amer Indian/Alaskan Native	2.86	2.50	1.85	0.00	0.00
Unknown/ Not reported	22.85	17.50	12.96	27.16	24.49
Award level	PhD	PhD	PhD	PhD	PhD
Total N Graduates	111	181	228	295	356
% Blacks (non-Hispanic)	0.90	2.21	1.75	3.39	1.97
% Asian/Pacific Islander	4.50	8.29	9.65	10.17	7.30
% Hispanic	0.90	3.87	3.51	3.05	6.46
% White (non-Hispanic)	68.47	60.22	58.77	54.24	58.43
% Amer Indian/Alaskan Native	0.00	1.10	0.00	0.68	0.00
Unknown/ Not reported	25.23	24.31	26.32	28.47	25.84